Intentional Traumatic Brain Injury in Ontario, Canada

by

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Abstract

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Violence and traumatic brain injury (TBI) are two major public health concerns. This thesis is comprised of three different research topics; the epidemiology of intentional TBI in Ontario, discharge against medical advice (DAMA) as an undesirable outcome of acute stage, and functional changes after receiving rehabilitation care. To study these areas, three different datasets from the Canadian Institute for Health Information (CIHI) were used.

The first epidemiological study on intentional TBI identified 1,409 (8.0%) intentional TBIs and 16,211 (92.0%) unintentional TBIs. Of the intentional TBIs, 389 (27.6%) were self-inflicted TBI (Si-TBI) and 1,020 (72.4%) were other-inflicted TBI (Oi-TBI). The most common causes of Si-TBI were “jumping from high places” and “firearms”. Major causes of Oi-TBI were ‘fight and brawl’ and “struck by objects”. Si-TBI was associated with younger age, female gender, and having a history of alcohol/drug abuse. Oi-TBI was also associated with younger age and having an alcohol/drug abuse history and also with male gender. The second study on discharge against medical advice found that 446 (2.84%) TBI patients left hospitals without medical advice. DAMA was significantly associated with intentional injuries in those with self-inflicted TBI and other-inflicted

TBI. DAMA was also associated with younger age and a history of alcohol/drug abuse. Using univariate analyses, the third study found that people with intentional TBI had significantly lower FIM gains in the motor area and significantly lower relative function gains (as measured by Montebello Rehabilitation Factor Score) in the cognitive area. Multivariate analyses of the same data showed that intentional TBI was also associated with lower cognitive relative gains, while controlling for age, gender, alcohol/abuse history, and other demographic and clinical variables. Persons with intentional TBI were found to be less likely to be discharged home, controlling for other relevant confounders.

In conclusion, a person who has been injured due to assault or suicidal attempt may need more individualized care as they may be at greater risk for adverse rehabilitation outcomes. These findings regarding people with intentional TBI provide a basis for enhancing efforts on prevention of violence-related TBI and DAMA, and also for improving rehabilitation programs and discharge plans for this vulnerable population.

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List of Abbreviations

Abbreviations	Description
AIS	Abbreviated Injury Scale
aOR	adjusted odds ratio
CDC	The Centers for Disease Control and Prevention
CDS	Comprehensive Data Set
CIHI	Canadian Institute for Health Information
DAD	Discharge Abstract Database
DAMA	Discharge against medical advice
E-Codes	External cause of injury codes
FIM	Functional Independence Measure
FSA	Forward Sortation Area
GOS	Glasgow Outcome Scale
IBIA	The International Brain Injury Association
ICD-9-CM	International Classification of Disease, 9 th revision, Clinical modification
IQR	Inter quartile range
ISS	Injury severity score
LOS	Length of Stay
MDS	Minimal Data Set
MOHLTC	Ministry of Health and Long-Term Care
MRFS	Montebello Rehabilitation Factor Scores
NRS	National Rehabilitation Reporting System
Oi-TBI	Other-inflicted traumatic brain injury
OTR	Ontario Trauma Registry
RCG	Rehabilitation client group
SD	Standard deviation
SES	Socioeconomic status
Si-TBI	Self-inflicted traumatic brain injury
TBI	Traumatic brain injury
TBIMS	Traumatic Brain Injury Model System
WHO	World Health Organization

CHAPTER 1

Introduction

1.1. Introduction

Traumatic brain injury (TBI) is defined as “damage to brain tissue caused by external mechanical forces as evidenced by loss of consciousness due to brain trauma, post-traumatic amnesia, skull fracture, or objective neurological findings that can be reasonably attributed to TBI on physical examination or mental status examination” (Traumatic Brain Injury Model Systems National Data Center, 1997). The Centers for Disease Control and Prevention (CDC) previously described TBI as a ‘silent epidemic’ and reported that TBI occurs at 8 times the incidence of breast cancer and 34 times the incidence of HIV/AIDS each year (2001).

The International Brain Injury Association (IBIA) stated : a brain injury is a public health concern that demands on-going epidemiological study, increased efforts to prevent injuries from occurring, and research to advance medical options and therapeutic interventions” (IBIA, 2005). TBI is also a major cause of death and permanent disability for young adults in Canada (CIHI, 2002; Colantonio et al., 2008). Even a mild injury can lead to disabling symptoms and conditions (Binder, 1997; O’Connor, 2005). The economic burden in terms of health is also considerable (McGarry et al., 2002). Typically, global incidence rates are highest in young adult population due to motor vehicle accidents, and tend to increase again in the older adult population due to falls. (Pickett et al., 2004; Colantonio et al., 2009a; Corrigan et al., 2010)

1.2 Epidemiology of TBI in Canada

In Canada, TBI is more common than breast cancer, HIV/AIDS, spinal cord injury and multiple sclerosis combined (Colantonio et al., 2009b). In the U.S. prevalence of TBI is estimated at 2% of the population. (National Center for Injury Prevention and Control, 2006). A CIHI report indicated 18,000 hospitalizations in Canada annually for TBI thus it has a significant impact on the health care system (CIHI, 2006). In 2006 alone, there were over 17,000 emergency room visits and/or hospitalizations for TBI in Ontario alone (Colantonio et al., 2009c).

There have been epidemiological studies of TBI in Canada in the peer-reviewed literature (Snow et al. 1988; Pickett, Simpson & Brison, 2004; Zygun et al., 2005; deGuise et al., 2008; Colantonio et al., 2008; Colantonio et al., 2010). Zygun et al. (2005) investigated severe TBI in the Calgary Health Region. The TBI incidence rate in that study was 11.4 per 100,000 population, with a mean age of 44 years among survivors. Young males and older adults were at increased risk for acquiring severe TBI; the incidence of TBI was significantly higher for males at all ages.

According to Pickett et al.'s study (2004), based on the Minimal Data Set (MDS) and Comprehensive Data Set (CDS) of the Ontario Trauma Registry (OTR), the incidence of TBI based on hospital admissions declined over time and males had higher injury rates than females for each age group. The leading causes of head injury, according to the CDS—which documents serious injuries—were transport incidents (58.0%), falls (28.3%), injury purposely inflicted by another person (5.8%), self-inflicted injury (2.3%),

and struck by/against (2.5%). Intentional injuries (injury purposely inflicted by another person or self-inflicted injury) were the third leading cause of TBI (MDS: 6.8%; CDS: 8.1%) in this data set based on serious admissions to lead trauma hospitals in Ontario. Hospitalization rates for head injury also declined over time, from 85.3 per 100,000 in the fiscal year of 1994 to 62.7 per 100,000 in 1998 (Pickett et al., 2004). The decline in hospitalizations for TBI in Canada has been found particularly in the young adult population from 1992 to 2001 (Colantonio et al., 2009a). A recent study however showed that when emergency room visits were captured as well as hospitalizations, the number and rate of TBI has actually been increasing with falls (41.6%) as the major cause. Approximately 11% of emergency room and/or hospitalizations were TBIs due to intentional injury (CIHI, 2001; Colantonio et al., 2010). A recent study in the United States also reported 11 % of all TBI cases to be from intentional causes (Corrigan et al., 2010).

1.3. Violence

In the *World Report on Violence and Health*, The World Health Organization (WHO, 2002) defined violence as “the intentional use of physical force or power, threatened or actual, against oneself, another person, or against a group or community that either results in or has a high likelihood of resulting in injury, death, psychological harm, maldevelopment or deprivation”. Interpersonal violence is frequently accompanied by head injury. A study reported that blows to the head or face had higher association with interpersonal violence than injuries in other body parts (Wu et al., 2010). It has been suggested, however, that intentional injuries due to violence should be approached from a

public health perspective rather than from a criminal justice point of view (Madonik, 2004). Suicidal injuries, a type of intrapersonal violence, resulted in about 874,000 deaths annually (WHO, 2002). Injuries due to suicidal attempts are serious and negatively impact the workforce and the health care system (CIHI, 2004). As a result, the WHO has recommended work to define priorities for, and supports research on, the causes, consequences, costs and prevention of violence (WHO, 2002; Krug, 2004).

1.4. Outcomes following TBI

There have been an extensive number of studies on outcomes after the acute stage of TBI, that include in-hospital deaths, readmissions, discharge destinations, and length of stay. However, an outcome that has not been fully studied in TBI research is discharge against medical advice (DAMA). Studies on DAMA have frequently been conducted for persons with psychiatric disorders and those who visited emergency departments. This work should be extended to the TBI population as this population is highly vulnerable to adverse outcomes.

DAMA is defined as leaving hospital before the treating physician recommends discharge (Alfandre, 2009; Hwang, Li, Gupta, Chien, & Martin, 2003). A Canadian Institute for Health Information (CIHI) report showed that 1% of all patients in Canada, an estimated 20,000 in number, were discharged against medical advice annually (CIHI, 2001). DAMA is problematic for physicians and patients alike, and is considered a performance indicator of hospital management (Pennycook, McNaughton, & Hogg, 1992; Devitt, Devitt, & Dewan, 2000). This type of discharge situation has been reported to adversely

affect health outcomes for patients, result in hospital readmissions (Pennycook et al., 1992; Gerbasi & Simon, 2003; Hwang et al., 2003; Franks, Meldrum, & Fiscella, 2006; Fiscella, Meldrum, & Barnett, 2007), and lead to frustration of clinicians in the provision of needed care (Duñó, Pousa, Sans, Tolosa, & Ruiz, 2003).

Functional recovery and discharge destinations are also major outcomes of rehabilitation. The FIM[®] instrument (“FIM”) is the most widely used measurement to examine efficiency of rehabilitation intervention at personal and institutional levels. The FIM is also utilized in large databases such as the Traumatic Brain Injury Model System (TBIMS) in the U.S. and the National Rehabilitation Reporting System (NRS) in Canada. According to Willemse-van Son and colleagues’ (2007) systematic review on the prognostic factors of long-term functioning following TBI, older age, pre-injury unemployment, pre-injury substance abuse and more disability at rehabilitation discharge were major predictors of long-term functioning. In terms of violent injury as a cause of TBI, the authors reported mixed results from three studies examining violent injury as a predictor of long-term disability and productivity; two of those studies found a relationship with negative outcomes while the third study did not. These studies did not use a standardized measure such as Functional Independence Measure (FIM).

Butcher et al.’s (2009) systematic review found that patients with TBI due to assault injuries had better Glasgow Outcome Scale (GOS) scores at 6 months compared to patients with TBI due to falls. This is largely due to the focal injuries of the assault related injuries; This result was different from the results of a study conducted by

Wenden, Crawford, Wade, King, and Moss (1998). The latter study reported that patients with TBI caused by assault had worse outcomes at 6 months post injury when measured by the Rivermead Head Injury Follow Up Questionnaire.

Hart, Bogner, Whyte, and Polansky (2003) studied blame attribution among accidental and violence-related TBI groups and found that the blame of others, a risk of adverse psychological outcome, was strongest in patients with violence-related TBI. Esselman, Dikmen, Bell, and Temkin's (2004) study on discharge disposition after TBI revealed that individuals with violence-related TBI were less likely to be discharged home than to a rehabilitation setting. Funding source was an important factor influencing discharge destinations following TBI.

To date, there is no peer-reviewed literature on comprehensive inpatient rehabilitation outcomes of intentional TBI compared to unintentional TBI based on the Canadian population. Thus, to understand violence-related injury as a prognostic factor, research in this area still requires large prospective studies.

1.5 Data sources for brain injury studies in Canada

Many studies with large sample sizes had been conducted using trauma registries designed to collect personal, clinical and administrative information on a regular basis. In Canada, commonly used databases include the Ontario Trauma Registry (OTR), National Rehabilitation Reporting System (NRS), and Discharge Abstract Database (DAD).

The Ontario Trauma Registry (OTR) was developed to provide comprehensive, accurate and timely population based information about injury in Ontario. This validated provincial database was designed to identify, describe and quantify traumatic injury in Ontario, including types of injury and risk factors (Garber, Hebert, Wells, & Yelle, 1996; McGuire, Burright, Williams, & Donovanick, 1998). This database has been utilized in the author's previous studies (Kim, Colantonio, & Chipman, 2006; Kim & Colantonio, 2008) and in other studies.

The OTR was designed to provide a scientific basis to facilitate injury prevention programs and to evaluate preventive measures and legislative changes. It was also intended to aid in making decisions regarding resource allocation. The registry consists of three databases: the Comprehensive Data Set (CDS), the Minimal Data Set (MDS), and the Death Data Set (DDS) (CIHI, 2001) which is based on death data from the Office of the Chief Coroner of Ontario.

The CDS provides clinical data information on severe injuries and fatalities from 11 lead trauma hospitals across 14 sites. This is an official government data source on major trauma admissions in the region and it determines the funding given to each trauma centre. Individuals are entered into the database if their injury severity score (ISS) exceeds 12, regardless of whether the person is admitted to a hospital, dies in an emergency department, or is transferred from another hospital. The CDS was utilized in the study in Chapter 2.

The MDS, utilized in Chapter 3, was developed to provide comprehensive, accurate and timely population-based information about injuries in Ontario. The MDS also includes demographic, clinical, and managerial information on all patients admitted to acute care hospitals in Ontario. It draws upon the Discharge Abstract Database (DAD), which contains detailed records of all acute care hospitals admissions from over 200 publicly funded hospitals in Ontario since 1963 (CIHI, 2007). The DAD contains variables such as initial injury severity, mechanism of injury and administrative and clinical data for all hospital discharges and day surgeries.

The DDS contains information on all injury deaths in the province. The dataset includes the large percentage of injured persons who die before admission to the hospital and therefore supplements data contributing to death and is linked to the OTR data. Data from the registry provides information on death type, death factors, involvements and environments. The classification of death type pertains to the action, force, instrument or disease, which caused the death (CIHI, 2001).

The National Rehabilitation Reporting Systems (NRS) was used in chapter 4 and was developed to collect, process, and analyze data on adult inpatient rehabilitation services and to support management decision-making at the facility, regional, and provincial/territorial levels (CIHI, 2008). It contains data on adult patients admitted to hospitals with designated rehabilitation beds. The NRS is an assessment system; thus, it has little or no information on the treatment/service given to the patient. The NRS also lacks information about the initial injury severity, such as GCS, ISS or mechanism of

injury. The NRS does not provide variables for etiology of injury, such as ICD E-codes. The NRS needs to be linked with other trauma databases, such as the Discharge Abstract Database (DAD), in order to obtain mechanism of injury data.

1.6. Study objectives

Considering the review of violence and TBI presented in Sections 1.3-1.4, the main objectives of this thesis were as follows:

- A) To develop a risk profile for individuals who have experienced intentional TBI in Ontario using the Comprehensive Data Set (CDS) of the Ontario Trauma Registry (OTR);
- B) To develop a risk profile of people with TBI who leave hospital against medical advice in Ontario using the Minimal Data Set (MDS) of the OTR;
- C) To profile the characteristics and outcomes of TBI patients receiving in-patient rehabilitation using the National Rehabilitation Reporting System (NRS) by injury intention.

Stemming from the primary objectives, there are 8 secondary objectives:

- A1) To describe and compare the pre-injury demographic, injury-related characteristics of self-inflicted TBI, other-inflicted TBI and unintentional TBI;
- A2) To compare the temporal characteristics of the three TBI groups;
- A3) To examine the associations with self-inflicted TBI and other-inflicted TBI as a main outcome using possible independent factors derived from the comparison analysis among the three TBI groups.

- B1) To develop a risk profile of people with TBI who are discharged against medical advice
- B2) To examine whether injury intention (unintentional versus intentional) was a significant predictor of DAMA;
- C1) To provide a demographic, clinical and functional profile of adults with intentional TBI who received in-hospital rehabilitation in Canada
- C2) To compare rehabilitation outcomes of persons with intentional TBI (absolute and relative functional changes, discharge destinations) with outcomes of persons with unintentional TBI
- C3) To examine intentional injury as an independent potential predictor of rehabilitation outcomes (functional change, measured by absolute and relative FIM gains, and discharge destination) while controlling for relevant possibly confounding demographic and clinical factors

1.7. Roadmap

The roadmap for this thesis is based on the three primary objectives described above. There are five chapters: a general introduction (Chapter 1), three distinct research articles formatted for publication (Chapter 2, 3 and 4), and a final discussion (Chapter 5). Objectives A, B and C are presented in Chapters 2, 3 and 4 respectively. Additionally, three appendices are presented following Chapter 5. Figure 1.1 shows a graphical representation of the thesis format which includes information of how the data sources were used.

- Chapter 1. Introduction
- Chapter 2. The first article examined the nature and extent of intentional TBI in Ontario. This paper, published at the Journal of Trauma (Kim & Colantonio, 2008), was the first of its kind in Canada.
- Chapter 3. The second paper examined intentional TBI as an important risk factor for discharge against medical advice, an important outcome in acute care and is accepted for publication at the Journal of Trauma.
- Chapter 4. The third paper studied rehabilitation outcomes following intentional TBI compared with unintentional TBI which has been submitted to the Journal of Head Trauma Rehabilitation.
- Chapter 5. Discussion
- Appendix A: E CODE CATEGORIES FOR THE OTR (CIHI, 2002)
- Appendix B: Discharge outcomes from the MDS OTR (CIHI, 2002)
- Appendix C: Comparison of the referral sources between merged NRS and original NRS (year of 2001-2006, age less than 65)

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CHAPTER 2

Intentional Traumatic Brain Injury in Ontario, Canada:

Epidemiology and Risk Factors

Kim, H., & Colantonio, A. (2008). Intentional traumatic brain injury in Ontario. *Journal of Trauma: Injury, Infection and Critical Care*, 65, 1287-1292.

2.1. Abstract

Background: Violence and traumatic brain injury (TBI) are two major public health concerns. This violence-related TBI, however, has not been studied in Canada and there is little literature on a profile of risk factors and injury severity regarding TBI because of self-inflicted/suicidal and assault/homicidal injuries compared with unintentional TBI.

Methods: Cross-sectional study using the comprehensive data set (CDS) of Ontario trauma registry (OTR) from 1993 to 2001. Setting: Data from a large trauma registry were used to assess demographic and injury-related characteristics, injury severity and incident time associated with TBI that were either caused unintentionally, were self-inflicted or resulted from an assault. **Results:** This study identified 1,409 (8.0%) intentional TBIs and 16,211 (92.0%) unintentional TBIs. Of the intentional TBIs, 389 (27.6%) was self-inflicted TBI (Si-TBI) and 1,020 (72.4%) was other-inflicted TBI (Oi-TBI). The most common cause of Si-TBI was “jumping from high places” (32.1%), followed by “firearms” (30.6%). About half of Oi-TBI was because of “fight and brawl” (48.3%), followed by “struck by objects” (26.1%). Si-TBI was associated with younger age, female gender, and having more alcohol/drug abuse history. For Oi-TBI, younger age, male gender, and having more alcohol/drug abuse history were independently

associated. **Conclusion:** This research provides the first comprehensive overview of intentional TBI based on Canadian data. The CDS of the OTR provided the ability to identify who is at risk for intentional TBI. Prevention programs and more targeted rehabilitation services should be designed for this vulnerable population.

Key Words: Epidemiology, Traumatic brain injury, Intentional, Self-inflicted, Assault.

2.2. Introduction

Traumatic brain injury (TBI) is a major cause of death and disability in young adults in Canada (CIHI, 2002). This type of injury can result in disabling conditions, even after mild injury. It is associated with profound disruption in the lives of victims and their caregivers. TBI can cause many kinds of physical, cognitive, and behavioral/emotional impairments (International Brain Injury Association, 2005) (Woo and Nesathurai, 2000; Pickett, Simpson, Brison, 2004). Poor mental health was observed for young adults after TBI (Colantonio, Dawson and McLellan, 1998). The economic burden of hospital care for TBI was also reported to be enormous; ‘intracranial injury’ and ‘fractured skull’, were the second (\$ 55.5 million) and the sixth (\$16.0 million) most responsible diagnoses among all injuries hospitalized in Ontario between April 1,1999 and March 31, 2000 (CIHI, 2002).

Traumatic brain injury (TBI) resulting from violence is a major issue in public health (Gerhart, Mellick and Weintraub, 2003; Hanks et al, 2003). The World Health Organization (WHO) defines violence as the “intentional use of physical force or power, threatened or actual, against oneself, another person, or against a group or community,

that either results in or has a high likelihood of resulting in injury, death, psychological harm, maldevelopment or deprivation” (Krug et al, 2002). The definition encompasses interpersonal as well as intrapersonal violence.

Socio-demographic factors such as male gender, ethnic minority, lower level of education, unemployment and single marital status have been associated with intentional TBI. Alcohol and drug use have also been identified as important factors resulting in violent TBI (Bushnik et al, 2003). TBI caused intentionally through methods such as self-inflicted or assault have also shown increased injury severity, higher level of caregiver burden and decreased community reintegration (Gerhart, Mellick and Weintraub, 2003; Hanks et al, 2003). Although Canadian government reports indicate that 6-8% of TBI is due to intentional causes, there are no published comprehensive reports in peer reviewed journals on intentional TBI in Canada, whose health care system and cultural makeup is very different from the US. It is crucial to improve our understanding and awareness of TBI due to violence, either self-inflicted or other-inflicted, to better inform preventive efforts and help improve targeted rehabilitation services. For instance, Sosin, Snizek and Waxweiler (1995) reported the success of preventive efforts for TBI due to motor vehicle accidents but a failure to prevent TBI due to firearms. It was also noted that penetrating injury has increasingly important implications for research, treatment and prevention of TBI in US. Although the incidence of violence has increased in Canada over the last 2 decades, violence related TBI has been understudied in Canada so far. As well, there is little published literature on profiles of risk factors and injury severity regarding TBI due to self-infliction/suicidal and assault/homicidal TBI compared to unintentional TBI.

Overall, the epidemiology of intentional TBI needs to be better understood, particularly in relation to unintentional TBI.

2.3. Research objectives

The overall objective of this study was to develop a risk profile for individuals who have experienced intentional TBI in Ontario between 1993-2001 using an available data source, the Ontario Trauma Registry (OTR). More specifically, this study aimed to:

1. Describe and compare the pre-injury demographic, injury-related characteristics of self-inflicted TBI, other-inflicted TBI and unintentional TBI;
2. Compare the temporal characteristics of the three TBI groups;
3. Examine the associations with self-inflicted TBI and other-inflicted TBI as a main outcome using possible independent factors derived from the comparison analysis among the three TBI groups.

2.4. Methods

2.4.1 Design: This study involved secondary analysis of cross-sectional data, the Comprehensive Data Set of the OTR, based on hospital discharge abstracts in Ontario.

2.4.2. Data Source: The OTR was developed to provide comprehensive, accurate and timely population based information about injury in Ontario. This validated (Garber et al, 1996; McGuire et al, 1998) provincial database was designed to identify, describe and quantify traumatic injury in Ontario, including risk factors and type of injury. It was designed to provide a scientific basis to facilitate injury prevention programs and to evaluate preventive measures and legislative changes. It was also intended to aid in

decisions regarding resource allocation. The registry consists of three databases, the Minimal Data Set (MDS), the Comprehensive Data Set (CDS) and the Death Data Set (DDS) (CIHI, 2001). This study focuses on the use of the CDS because it contains more information on diagnoses and co-morbidities.

The CDS provides clinical data information on severe injuries and fatalities from the specialized 11 lead trauma hospitals across 14 sites. This is an official government data source on major trauma admissions in the region and it determines the funding given to each trauma centre. Individuals are entered into the database if their ISS exceeds 12, regardless of whether the person is admitted to a hospital, dies in an emergency department, or is transferred from another hospital.

2.4.3. Case selection: The cases were included if they had the following: the International Classification of Disease, 9th revision, Clinical modification (ICD-9-CM) codes for head injury: 800.0-801.9 (fracture of the vault of the skull), 803.0-804.9 (other and unqualified skull fracture), 850.0-854.1 (intracranial injury including concussion, laceration, and hemorrhage) (CIHI, 2004). The fiscal year runs from April 1 through March 31. This study used data from April 1, 1993 to March 31, 2001. Eligible cases from the OTR were of ages 16 years and over, hospitalized in lead trauma hospitals with ISS >12. This study excluded (1) burn injury, (2) legal intervention such as gunshot from police, (3) undetermined cases as to whether the event was accidental or intentional. Intentional injuries were coded as ICD E-codes; injuries between E950 and E959 were classified as self-inflicted/suicide; injuries coded between E960 and E969 were classified

as assaults/homicide, and injuries with E-Codes of E800 through E949 were classified as unintentional.

2.4.4. Variables Measured:

1. Pre-injury demographic characteristics: age, gender, alcohol/drug abuse history as co-morbidities.
2. Injury-related characteristics: mechanisms of injury as recorded by external cause of injury (E Code), types of injury (blunt/penetrating), incident time, Injury Severity Score (ISS) and Length of Stay (LOS) and in-hospital death at discharge.
3. Outcome variables: Self-inflicted TBI (Si-TBI) and Other-inflicted TBI (Oi-TBI).

2.4.5. Data Analyses

1. Descriptive statistics utilized in this study included frequency distributions and measures of central tendency, which were used to examine the distribution of key variables of intentional TBI (Si-TBI and Oi-TBI) and unintentional TBI, such as pre-injury demographic characteristics, and injury-related characteristics. Independent t-tests, One-Way ANOVA for continuous variables and Chi-square test for nominal variables were used to determine the differences of key variables among the three TBI groups.
2. Multivariate logistic regression analyses were conducted with a significant value of $p < 0.05$ to examine risk factors of intentional TBIs (Si-TBI and Oi-TBI), with and without the in-hospital deaths: this variable may or may not affect shorter LOS and higher ISS.

2.5. Results

During the fiscal years 1993 through 2001, there were 1409 (8.0%) intentional TBI and 17620 (92.0%) unintentional TBI in the CDS of the OTR. Of the intentional TBIs, 389 (27.6%) was Self-inflicted TBI and 1020 (72.4%) was Oi-TBI. Overall, there was a 21.1% increase in the intentional TBI population from the beginning to the end of the study period. During this period, Si-TBI admissions increased by 15%, and Oi-TBI admissions increased by 29.3%.

Table 2.1: Pre-injury demographic characteristics

	Self-inflicted (N=389)	Other-inflicted (n=1020)	Unintentional TBI (n=16211)	p-value
Age at Injury				
Mean(SD)	39.3 (16.3)	35.1 (13.9)	47.4 (22.0)	< 0.001
Age Groups (n,%)				
16 - 24	72 (18.5)	271 (26.6)	3250 (20.0)	< 0.001
25 - 34	99 (25.4)	286 (28.0)	2552 (15.7)	
35 - 44	98 (25.2)	243 (23.8)	2344 (14.5)	
45 - 54	55 (14.1)	125 (12.3)	1937 (11.9)	
55 - 64	26 (6.7)	52 (5.1)	1600 (9.9)	
≥ 65	39 (10.0)	43 (4.2)	4528 (27.9)	
Gender (n,%)				
Male	285 (73.3)	924 (90.6)	11272 (69.5)	< 0.001
Female	104 (26.7)	95 (9.3)	4937 (30.5)	
Ratio	2.7 : 1	9.7 : 1	2.3 : 1	
Alcohol/drug abuse				
Yes	47 (12.1)	105 (10.3)	1173 (7.2)	< 0.001
No	342 (87.9)	914 (89.7)	15026 (92.7)	

Note. SD: Standard deviation, One-Way ANOVA for Age at injury, Chi-square test for Age groups, Gender, and Alcohol/drug abuse history.

Pre-injury demographic characteristics

As can be seen in Table 2.1, the mean ages of the two intentional TBI groups were much younger than unintentional TBI group ($p < 0.001$). Of the intentional TBI groups, the age

groups of 25-34 represented the highest occurrence among the age groups. The intentional TBI occurrence decreased across older age groups.

The ratio of males to female was 2.3:1 for unintentional TBI as compared to 2.7:1 for Si-TBI and 9.7:1 for Oi-TBI. Female victims were not as prevalent in the Oi-TBI group (9.3%), as compared to 26.7 % for Si-TBI group and 30.5% for unintentional TBI group. Females sustaining intentional TBI comprised 14.1% (n=199) of the intentional TBI groups. About 12 % of Si-TBI patients had the most frequent alcohol/drug abuse history, followed by 10 % of Oi-TBI and 7% of unintentional TBI ($p<0.001$).

Injury-related characteristics

Types of injury

As can be seen in Table 2.2, the major type of injury was blunt injury for all TBI groups. However, penetrating injury occurred more frequently for the two intentional TBI groups, compared to only 0.3% of unintentional TBI. Among the penetrating injuries (n=276), 86.0% occurred for intentional TBI.

Table 2.2: Types of injury by TBI groups

	Self-inflicted (n=389)	Other-inflicted (n=1020)	Unintentional TBI (n=16211)	p-value
Type of injury (n,%)				
Blunt	260 (66.8)	871 (85.6)	16147 (99.7)	< 0.001
Penetrating	129 (33.2)	147 (14.4)	45 (0.3)	

* Chi-square test for Type of injury

Mechanisms of injury

Figures 2.1 and 2.2 show detailed information of mechanisms of injury for both intentional TBI groups. There were different profiles on mechanisms of injury between the two intentional TBI groups.

Figure 2.1: Mechanisms of Self-inflicted TBI (n=389)

Self-inflicted TBI: The most common cause of Self-inflicted TBI was ‘jumping from high places’ (n=125, 32.1%), followed by ‘firearms’ (n=119, 30.6%), and ‘jumping before moving objects’ (n=53, 13.6%). Hanging (n=62, 15.9%) and other means (n=30, 7.7%) were the least common causes for this group. For male victims, firearms (n=113, 39.6%) and jumping from high places (n=75, 26.3%) were the most common causes. For female victims, however, ‘jumping from high place’ (n=50, 48.1%) and ‘jumping before moving objects’ (n=27, 26.0%) were the most frequent mechanisms of injury.

Figure 2.2: Mechanisms of Other-inflicted TBI (n=1020)

Other-inflicted TBI: About half of Other-inflicted TBI was due to fight and brawl (n=493, 48.3%), followed by ‘struck by objects’ (n=266, 26.1%); these were also the two major causes of injury for both genders. Firearm injury (n=80, 7.8%) and cutting and piercing injury (n=70, 6.9%) were far less common for other-inflicted TBI. Firearms injuries comprised 14.1% (n=199) of all intentional TBIs. Of firearm-related TBI, more firearms were used for self-inflicted (59.8%) versus 40.2% for other-inflicted. Approximately 40% of all firearm injuries occurred for the age of 45 and over.

Injury Severity

Si-TBI had higher ISS scores and longer hospital stays than the other two TBI groups (Table 2.3). Overall, the median ISS showed that Si-TBI were more severely injured than

the other two TBI groups ($p < 0.001$). However, the median ISS of Si-TBI and unintentional TBI was similar (26 for Si-TBI and 25 for Oi-TBI); this difference doesn't seem to be clinically significant.

The mean LOS of Si-TBI and unintentional TBI was the same (median: 10 days). Oi-TBI had the lowest median LOS (6 days) among the TBI groups.

Table 2.3: Injury Severity by TBI groups

	Si-TBI (n=389)	Oi-TBI (n=1020)	Unintentional TBI (n=16211)	p-value
ISS (Median, IQR)	26 (25-35)	21 (17-26)	25 (17-30)	< 0.001
LOS (Median, IQR)	10 (1-31)	6 (3-14)	10 (5-21)	< 0.001

* Kruskal-Wallis test for ISS and LOS, IQR : Inter-quartile range

In-hospital death

At discharge, Unintentional TBI accounted for 16.6% (n=2698) of in-hospital death cases. Si-TBI had the greatest discharge mortality (n=184, 47.3%). As well, 125 (12.3%) cases of Oi-TBI did not survive to the point of at hospital discharge.

Temporal Characteristics

Incident time

Figure 2.3. shows incident time among the three TBI groups. Each group has different incidence peaks (for these groups) ($p < 0.001$). When divided into 3 hour times zone, Si-TBI occurred most often between 9:00-11:59 am. Oi-TBI occurred most frequently at night, particularly (especially) between midnight and 2:59 am. In contrast, unintentional TBI peaked during afternoon hours between 3:00-5:59 pm. When divided into night and day time, Si-TBI occurred more frequently during daytime, while Oi-TBI occurred more

frequently at night.

Figure 2.3. Incident time by TBI groups

Figure 2.4. Incident months by TBI groups

Incident months were also not equally distributed for each TBI group (Figure 2.4). Si-TBI peaked in May and August, while Oi-TBI peaked in August and September. Overall, the greatest number of injuries were in August.

Factors associated with Intentional TBIs

The major variables that showed significant differences between intentional and unintentional TBI groups were entered into the multiple regression model to test for associations with intentional TBIs (Table 2.4.1 ; Table 2.4.2).

Table 2.4.1: Multiple logistic regression results: modeling the probability of occurrence of intentional TBI (included in-hospital deaths)

Independent variables	Si-TBI vs. Unintentional TBI			Oi-TBI vs. Unintentional TBI		
	OR	95% CI	p-value	OR	95 % CI	p-value
Age	0.98	0.97 - 0.98	< 0.001	0.97	0.97 - 0.98	<0.001
Gender (male)	0.66	0.48 - 0.93	0.015	3.96	3.11 - 5.05	<0.001
Alcohol/drug abuse	2.02	1.30 - 3.15	0.002	1.45	1.14 - 1.83	0.002
Penetrating injury	152.98	93.99 - 248.97	< 0.001	41.11	26.64 - 63.44	<0.001
LOS	1.01	1.01 - 1.01	< 0.001	1.00	0.99 – 1.01	0.181
ISS	1.02	1.00 - 1.03	< 0.001	0.94	0.93 – 0.95	<0.001

Table 2.4.2: Multiple logistic regression results: modeling the probability of occurrence of intentional TBI (excluded in-hospital deaths)

Independent variables	Si-TBI vs. Unintentional TBI			Oi-TBI vs. Unintentional TBI		
	OR	95% CI	p-value	OR	95 % CI	p-value
Age	0.98	0.97 - 0.99	< 0.001	0.97	0.97 - 0.98	< 0.001
Gender (male)	0.70	0.53 - 0.91	0.009	3.67	2.92 - 4.60	< 0.001
Alcohol/drug abuse	1.70	1.17 - 2.50	0.007	1.43	1.14 - 1.80	0.002
Penetrating injury	196.68	132.34 - 292.29	< 0.001	59.03	39.67 - 87.84	< 0.001
LOS	1.00	1.00 - 1.01	0.032	1.00	0.99 - 1.00	0.434
ISS	1.03	1.02 - 1.04	< 0.001	0.94	0.94 - 0.95	< 0.001

* OR : Odds ratios, CI: confidence interval (upper-lower)

The results of the multivariate regression model based on significant variables from the bivariate analysis is displayed in Table 2.4.1. This model shows that Si-TBI was associated with younger age, female gender, having more alcohol/drug abuse history and penetrating injury. Si-TBI was also associated with higher ISS and shorter LOS. The likelihood of a Si-TBI occurring decreases by about 2.4 % for each increase in age

($p < 0.001$). Females were about 1.3 times more likely to incur a Si-TBI than unintentional TBI ($p = 0.015$). The probability of occurrence of Si-TBI was almost 2 times greater for alcohol/drug abuse history ($p = 0.002$) and 153 times greater for penetrating injury ($p < 0.001$).

For Oi-TBI, however, younger age, male gender, having more alcohol/drug abuse history, penetrating injury were independently associated. Oi-TBI was also associated with lower ISS. The likelihood of a Oi-TBI occurring decreases by about 3 % for each increase in age group. Males were about 4 times more likely to incur an Oi-TBI than unintentional TBI ($p < 0.001$). The probability of occurrence of Oi-TBI was almost 1.4 times greater for alcohol/drug abuse history ($p = 0.002$) and 41 times greater for penetrating injury ($p < 0.001$).

2.6. Discussion

This study provides information about the epidemiological patterns, mechanisms of injury and injury severity for intentional TBIs as compared with unintentional TBI in Ontario, using the CDS in a large publicly insured population admitted to trauma centres. Most previous studies focusing on intentional or violent TBI used hospital datasets for the population receiving rehabilitation. Using the CDS of OTR is a very useful approach to capture the magnitude and nature of intentional TBI province-wide. This study, however, was restricted to hospitalized TBIs with ISS > 12 from 11 lead trauma hospitals, therefore excluding less serious injuries. As well, suicides involving those of a chemical nature were not included in this dataset.

Males comprised a greater proportion than females of Oi-TBI, compared to Si-TBI and unintentional TBI. Younger age groups were more vulnerable for this intentional injury. Alcohol/drug abuse history also highly correlated for the intentional TBI group. These findings of pre-injury demographic characteristics were in concordance with previous reports (Harrison-Felix et al, 1998; Hanks et al, 2003; Gerhart et al, 2003). Regarding incident time, Si-TBI was more common during daytime and assault/homicide late at night. There are limited studies on incident time and month of head injury. However, the results of incident months were quite relevant to overall suicide and violence incidence in Ontario (Smartrisk, 2003). These peaks of each intentional injury groups need to be further studied.

Even though our rates of TBI in Canada are well below those of the US, The findings of this study are increasingly relevant to the Canadian population. It is also imperative to raise awareness regarding alcohol/drug abuse history in Si-TBI and Oi-TBI.

Violence may threaten the well-being of individuals, families and communities. Awareness of these devastating consequences and wider, more comprehensive information for public health in response to violence are needed. The initial step of this response to violence was to define and monitor the extent of the problem (WHO, 2002). Thus, this epidemiological study investigating intentional TBI is useful for prevention strategies, for post-acute care, and rehabilitation as well. In terms of relevance for rehabilitation, we believe it is important to be aware of mechanisms of injury involved in

the initial injury. Further research needs to find effective interventions to address these intentional TBIs.

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CHAPTER 3

Discharge against medical advice after traumatic brain injury: is intentional injury a predictor?

Kim, H., Colantonio, A., Bayley, M., Dawson, D. (2011). Discharge against medical advice after traumatic brain injury : is intentional injury a predictor ?
Journal of Trauma: Injury, Infection and Critical Care (in press).

3.1 Abstract

BACKGROUND: Discharges against medical advice (DAMA) have consistently been reported as causing adverse outcomes for both patients and service providers. However, little is known about the DAMA of patients with traumatic brain injury (TBI). The overall objective of this was to develop a risk profile of DAMA patients in the TBI population, to examine factors associated with DAMA occurrence, and to examine specifically whether injury intention (unintentional versus intentional) is a significant predictor of DAMA.

METHODS: A retrospective cohort study was conducted using hospital discharge data obtained from the Minimal Data Set (MDS) of the Ontario Trauma Registry (OTR) for the years of 1993/94 and 2000/01 on TBI patients 15-64 years of age. **RESULTS:** The MDS review yielded 15,684 cases of TBI with an average length of stay of 2.7 days. Of these, 446 (2.84%) had recorded DAMA events. When compared to people with unintentional TBI, DAMA was significantly associated with intentional injuries in those with self-inflicted TBI (adjusted odds ratio [aOR] = 1.97, 95% confidence interval [CI]: 1.36-2.84) and other-inflicted TBI (aOR=2.00, CI: 1.53-2.62). DAMA was also associated with younger age and a history of alcohol/drug abuse (aOR = 3.50, CI: 2.85-4.30). **CONCLUSION:** TBI patients who leave hospital against medical advice are a high-risk population. Early identification of these patients could allow implementation of better prevention and management strategies, thus improving health outcomes and

enhancing healthcare delivery.

Keywords: discharge against medical advice; traumatic brain injury ; intentionality

3.2. Introduction

Discharge against medical advice (DAMA), also known as ‘self-discharge’ or ‘signed out against medical advice’, have been reported in many settings of health care delivery (Ibrahim et al., 2007) and represents a public-health problem of considerable importance (Hwang et al., 2003). DAMA is defined as leaving hospital before the treating physician recommends discharge (Hwang et al., 2003; Alfandre, 2009). A report showed that 1% of all patients in Canada,—an estimated 20,000 in number—were discharged against medical advice annually (Hwang et al., 2003). This type of discharge situation has been reported to adversely affect health outcomes, such as worse psychiatric, medical, psychosocial functions, frequent readmission and higher mortality for patients (Hwang et al., 2003; Pennycook, Mcnaughton & Hogg, 1992; Gerbasi & Simon, 2003; Alfandre, 2009). DAMA can also frustrate clinicians in the provision of needed care (Duno et al., 2003). Therefore, DAMA is considered to be an undesirable hospital outcome for both medical professionals and patients and the number of DAMA was also suggested as a valid performance indicator of the health care delivery (Pennycook, Mcnaughton & Hogg, 1992). Several systematic reviews on DAMA are briefly described in the following section.

Five review studies on DAMA have been published since 1990. One review explored legal protection of DAMA documents (Devitt, Devitt & Dewan, 2000) and two were

about military experiences with DAMA (Jeffer, 1993a; Jeffer, 1993b). The remaining two studies critically reviewed DAMA issues in terms of prevalence, predictors, outcomes, and interventions (Brook et al., 2006; Alfandre, 2009). Brook et al. (2006) examined DAMA studies of psychiatric inpatients while Alfandre (2009) focused on medical patients who had not been admitted for psychiatric diseases (see Table 3.1).

Overall, the mean prevalence for DAMA was higher in psychiatric patients than in other medical patients (17% vs. 1-2%) (Brook et al., 2006; Alfandre, 2009). Common predictors were younger age, substance abuse problems, and prior DAMA. Male gender, lower socioeconomic status and lower self-esteem were associated with DAMA for non-psychiatric medical patients while these factors were not consistently found in studies of psychiatric patients. Having other types of psychiatric problems was found to be a predictor in Brook et al.'s study (2006); however, this was not found in Alfandre's review (2009). In both reviews, frequent readmissions and worse functional outcomes were consistently reported.

Table 3.1: A brief summary of systematic reviews of DAMA

	Alfandre (2009)	Brook et al. (2006)
Sources	PubMed and PsycINFO (1970-2008)	PubMed and PsycINFO (1955-2005)
Prevalence	Between 1 - 2%	Between 3 - 51% (mean: 17%)
Population	Medical patients, No. of studies = 26	Psychiatric patients, No. of studies = 61
Predictors	Younger age, Gender (male)	Younger age, Gender (mixed)
Personal	SES (Lower), African American (mixed) Substance abuse Medicaid or no insurance DAMA history Feeling better	SES (mixed), Non-Caucasian Substance use disorder Marital status (mixed) DAMA history Psychotic, depressive disorder Other psychopathologies Greater severity, length of illness Prior hospitalization Legal hearing history Behavioral factors*
Environmental	Sickness within the family Receipt of social assistance Lack of physician	Provider factors+ Temporal factors‡
Outcomes	Higher risk of readmission Higher cost due to readmission Higher risk of mortality	Re-hospitalized sooner and more Frequently Overused emergency care Worse outcomes of psychiatric, medical, psychosocial and socioeconomic functioning

*Behavioral factors: Antisocial, aggressive or disruptive behavior, suicide attempts, pessimistic attitude, treatment dissatisfaction, responsibility to family, desire to obtain substances

+ Provider factors: Failure on intake, threatening atmosphere, difficulties in doctor-patient relationship, inadequate unit staffing patterns

‡ Temporal factors: Initial critical therapeutic period, evening or night shifts, spring or summer months

DAMA studies have focused on a range of medical conditions including HIV (Chan et al., 2004), asthma (Baptist et al., 2007), pediatric emergencies (Reinke, 2008), inflammatory bowel disease (Kaplan et al., 2009), acute pulmonary embolisms (Aujesky et al., 2009), and stroke (Onukwugha & Weir, 2009), to name a few. One study found that head injury was the most frequent diagnosis associated with DAMA patients in emergency departments (Pennycook, Mcnaughton & Hogg, 1992). This is one of the first studies to examine the TBI population exclusively as most studies were done using psychiatric and the general medical populations.

Traumatic brain injury is consistently reported as a major cause of death and disability for young adults in North America. This type of injury, though it may be mild, can result in disabling conditions and premature death (O'Connor, Colantonio & Polatjko, 2005; Colantonio et al., 2008). TBI has also been associated with high average health care costs, averaging \$15,860 for falls and \$20,522 for motor vehicle crashes which were calculated by using the Projected International Classification of Clinical Services database during the year of 1997-1999 in United State(McGarry et al., 2002). Thus, "TBI is a public health concern that demands ongoing epidemiological study, increased efforts to prevent injuries from occurring, and research to advance medical options and therapeutic interventions" (IBIA, 2009).

One major variable profiled in most epidemiological TBI studies is injury intention; that is, the manner of injury wherein the injury is either unintentional or intentional. Many patients with intentional TBI have experienced psychological and emotional problems

prior to the injury and which may affect communication between patients and health professionals (Bogner et al., 2001). Intentional TBI occurs most frequently in those who are young and who have more alcohol/drug abuse problems. A recent study based on a large dataset reported that DAMA patients had more neurological disorders than regular discharge patients, and that having a neurological disorder was also associated with higher mortality within 30 days (Glasgow et al. 2010). Among the TBI population, patients with intentional TBI share common risk factors with psychiatric patients who are DAMA such as antisocial, aggressive or disruptive behaviors or suicide attempts (Brook et al., 2006).

According to a CIHI report on suicide attempts and self-inflicted injuries (CIHI, 2002), there was a higher proportion of DAMA among these patients (6%, n=1,317) compared to all other trauma patients (1%, n=1,629). Pages et al.'s study (Pages et al., 1998) on psychiatric patients revealed that hostility-aggression and suicide attempts were associated with DAMA when controlling for age, gender, and other key variables. Regarding outcomes of TBI, patients with intentional TBI have been found to have poor medical outcomes such as headaches, confusion, sensory and attentional disturbances (Gerhart et al., 2003); higher level of caregiver burden, decreased productivity (Hanks et al., 2003), and poor community integration (Gerhart et al., 2003 ; Hanks et al., 2003). A recent study (Kim et al., 2010) reported that the intentional TBI group had poorer recreation skills and family relationships compared to the unintentional TBI group.

Thus, patients with intentional injuries would potentially be at higher risk of leaving the

hospital against medical advice than those with unintentional injuries. However, a study on whether intentional injury is associated with DAMA among survivors of TBI has not yet been conducted.

3.3. Research objectives

The overall objective of this study was to develop a risk profile of people with TBI who leave hospital against medical advice, and to examine whether injury intention (unintentional versus intentional) was a significant predictor of DAMA. It was hypothesized that DAMA would be associated with younger age, male gender, a history of psychiatric disease, alcohol/drug abuse, and a shorter length of hospital stay. Intentional injuries were hypothesized to be a significant factor associated with DAMA, controlling for age, gender, alcohol/drug abuse history, and other potential confounders.

3.4. Methods

3.4.1. Study design: This is a retrospective cohort study using population based hospital discharge data of patients with a TBI diagnostic code.

3.4.2. Data source: The Ontario Trauma Registry's (OTR) Minimal Data Set (MDS) was utilized for this study. The OTR was developed to provide comprehensive, accurate and timely population based information about injury in the province of Ontario. This validated provincial database has been used to identify and to quantify TBI (Kim, Colantonio & Chipman, 2006). The MDS was developed to provide a scientific basis for injury prevention programs, to evaluate preventive measures and legislative changes, and to aid resource allocation decisions. The MDS includes demographic, clinical, and

managerial information on all patients admitted to acute care hospitals in the province of Ontario. This OTR MDS originally comes from the Discharge Abstract Database (DAD), which contains detailed records of all acute care hospital admissions from over 200 publicly funded hospitals in Ontario since 1963 (CIHI, 2007). Each record in the DAD contains a patients' health card number, age, gender, postal code, date of admission, date of discharge, most responsible diagnostic codes, and secondary and tertiary diagnostic codes.

3.4.3. Cases: Persons with TBI aged between 15-64 years who had an acute hospital admission in Ontario between the fiscal years of 1993-1994 and 2000-2001 were studied. TBI was defined by the International Classification of Diseases, 9th version, Clinical Modification (ICD-9-CM) codes 800-801, 803-804 and 850-854.

We excluded older individuals because they have more co-morbidities such as heart disease, diabetes and hip fractures compared to younger individuals, which can affect their discharge outcomes. Moreover, the percentage of TBI caused by violence in this older age group is extremely small compared to unintentional TBI.

3.5. Variables measured:

3.5.1. Pre-injury characteristics: Demographic

Gender and age were analyzed in descriptive and multivariate analyses. For the age, the MDS codes 5-year age intervals. We utilized ages 15-64.

Rural/urban residence: The MDS reports patients' residence codes using the Forward

Sortation Area (FSA); that is, the first 3 characters in the postal code of the patients' residence. Canada Post classifies postal codes as rural or urban, where a rural FSA code is recognized by the presence of "0" in the second character position (Canada Post, 2010).

3.5.2. Pre-injury characteristics: Clinical

Alcohol/drug abuse history: Patients in the MDS are assigned ICD-9-CM codes as follows: 291 for alcoholic psychoses, 292 for drug psychoses, 303 for alcohol dependence syndrome, 304 for drug dependence, and 305 for nondependent abuse of drugs. The term 'alcohol/drug abuse' is interchangeable with the term 'substance abuse,' which means the regular or frequent use of an illegal or harmful substance that causes problems in a person's life (Howard & Sippel, 2005).

History of other psychiatric conditions: For this category, we combined all the ICD-9-CM codes from 290 to 319 (Mental Disorders). Then, we excluded codes for alcohol/drug abuse used above.

3.5.3. Injury-related characteristics:

Intentional injury: Intentional injury was derived from the ICD-9-CM external cause of injury codes (E-Codes), self-inflicted injuries were defined by codes E950 and E959; homicide/assault injuries by codes E960 and E969, and E979; and unintentional injuries were categorized using codes E800 through to E949. Therefore, two major injury categories were created for analysis (intentional versus unintentional injuries). Within the intentional category, self-inflicted TBI (Si-TBI) and other-inflicted TBI (Oi-TBI)

categories were created.

Injury severity score (ISS): The ISS has been widely used as a standard measure to assess a person's overall injury level using scores from seven anatomical areas. The ISS is derived from the Abbreviated Injury Scale (AIS) to provide a numerical description of overall injury severity in persons who have sustained multiple injuries. This variable is readily available in the MDS.

Most Responsible Diagnosis: The one diagnosis or condition that can be described as being most responsible for the patient's hospital stay. This is an important clinical variable of the MDS to inform the major reason for hospital admission of each patient.

Length of stay (LOS): The total number of days spent in acute care in hospital as calculated from the date of admission to the date of discharge for those who discharge alive.

Seasons: This variable was derived from month of injury and was used for descriptive analyses. Spring was composed of the months March, April May, Summer was defined as the months June, July and August. Fall was based on September, October November and the rest of the months were collapsed in the Winter.

Year trends: Since our data were based on two different time points, we assessed the influence of more recent versus less recent admissions in the analysis.

The described pre-injury and injury-related variables were used in both descriptive and multivariate analyses as control variables.

3.5.4. Outcome:

DAMA: Discharge destinations coded in the MDS are: inpatient hospital care, long term

care facility, other facilities, home setting with support services, home setting without support services, signed out against medical advice, and in-hospital death. In this study, the first five destinations were categorized as regular discharge while the code for signed out against medical advice was categorized as DAMA, thus DAMA is a dichotomous variable derived from the discharge destinations available in the MDS. The cases of in-hospital death were excluded.

3.5.5. Data analysis:

Descriptive analyses were used to assess frequency distributions, means and medians. The Chi-square test for the categorical variables and the Kruskal-Wallis test for non-normal distribution were used to analyze differences between the two discharge status groups (regular discharge and DAMA). Multiple logistic regression analysis was also conducted to identify the factors associated with DAMA. Our analysis used logistic regression to model DAMA. The independent contribution of intentional injury was conducted controlling for relevant confounders such as age, gender, and alcohol/drug abuse history. All analyses were conducted using SPSS Version 17.0.

Ethics: This study was approved by the Office of Research Ethics at the University of Toronto (Protocol Reference # 23610).

3.6. Results

Pre-injury characteristics: demographic and clinical features

There were 446 (2.84%) DAMA cases out of the 15,684 TBI patients identified in the

study period. Thus, approximately 1 in 35 hospital discharges of TBI patients in Ontario were against medical advice. The prevalence of DAMA differed depending on gender, age group, and existence of an alcohol/drug abuse history (See Table 3.2). Male patients were more likely to be DAMA than female patients ($p=0.032$). Age distributions of the two discharge status groups were significantly different ($p < 0.001$). The group between 25-34 years had the highest proportion of DAMA; the peak occurring within these years. The prevalence of DAMA decreased with age, with the oldest group (55-64 years) having the lowest number of DAMA events. For patients with a history of alcohol/drug abuse, a higher proportion was observed in the DAMA group (40%). The proportion was 3.7 times higher than in the regular discharge group. There was no significant difference in DAMA rates between patients with or without a history of other psychiatric conditions. It was also noted that living in a rural or urban setting did not affect DAMA prevalence. The fourth column from Table 3.2 to Table 3.6 indicates the Rate of DAMA (%) which is the proportion of DAMA in the population of the row where the Rate is located. The p-value less than 0.05 was the significant level.

Table 3.2: Pre-injury demographic and clinical characteristics

Variables	Discharge Status		Rate (%)	p-value
	Regular (n, %)	DAMA (n, %)		
Gender				0.032
Male	10872 (71.3)	339 (76.0)	3.0	
Female	4366 (28.7)	107 (24.0)	2.4	
Age groups				< 0.001
15-24	4912 (32.2)	100 (22.4)	2.0	
25-34	3218 (21.1)	141 (31.6)	4.2	
35-44	2860 (18.8)	110 (24.7)	3.7	
45-54	2324 (15.3)	68 (15.2)	2.8	
55-64	1924 (12.6)	27 (6.1)	1.4	
Rural/Urban*				0.984
Urban	10455 (71.7)	299 (71.7)	2.8	
Rural	4135 (28.3)	118 (28.3)	2.8	
Alcohol/drug abuse				< 0.001
Yes	2251 (14.8)	179 (40.1)	7.4	
No	12987 (85.2)	267 (59.9)	2.0	
Other psychiatric conditions				
Yes	1104 (7.2)	34 (7.6)	3.0	0.761
No	14134 (92.8)	412 (92.4)	2.8	

Injury-related characteristics

Table 3.3 describes the injury-related clinical characteristics of the two discharge status groups. A significant association was found between discharge status and injury intention ($p < 0.001$). DAMA was more likely to occur if a patient had intentional injuries. The DAMA percentage was about 2.4 for unintentional causes of injury, 7.1 for other-inflicted causes, and 5.4 for self-inflicted causes; ratios of DAMA were about 1: 2.3: 3.0 in these groups respectively. This translates to 1 in 42 patients with unintentional TBI, 1 in 14 patients with Oi-TBI, and 1 in 18 patients with Si-TBI being DAMA. No significant differences between these groups were found in injury severity, which was measured by ISS ($p=0.782$).

Table 3.3: Injury-related characteristics: clinical features

	Discharge Status		Rate (%)	p-value
	Regular (n, %)	DAMA (n, %)		
Cause of injury				< 0.001
Unintentional	13582 (89.1)	332 (74.4)	2.4	
Other-inflicted	1027 (6.7)	78 (17.5)	7.1	
Self-inflicted	629 (4.1)	36 (8.1)	5.4	
ISS* (Mean, Median)	9.5 (9.0)	9.6 (9.0)		0.782
LOS (Mean, Median)	8.8 (3.0)	2.7 (1.0)		< 0.001

* ISS missing values n=2970, 18.9%,

Note. Chi-square test for cause of injury, Kruskal-Wallis test for ISS and LOS

In terms of LOS, DAMA patients stayed in hospitals for shorter periods of time than did others: median LOS of 1 day versus 3 days. ($p < 0.001$). As the distribution of LOS was highly skewed, we examined the prevalence of DAMA across the LOS. As can be seen in Table 3.4, the majority of DAMA cases left hospital within 24 hours (69.1%) double the number in comparison to patients who were not DAMA (35.7%). The DAMA rate on the first day was thus the highest (5.4%) among the four LOS groups, which means that 1 in 18 TBI patients left hospital AMA. Only 1.1% of TBI patients left hospital AMA in the group hospitalized for more than four days. Most intentional TBI patients left hospital against medical advice within 24 hours including 82% of patients with Oi-TBI and 72% of patients with Si-TBI.

Table 3.4: Categorized LOS groups

LOS (days)	Discharge Status		Rate (%)	p-value
	Regular (n, %)	DAMA (n, %)		
1	5434 (35.7)	311 (69.1)	5.4	< 0.001
2	1936 (12.7)	45 (10.1)	2.3	
3	1216 (8.0)	19 (4.3)	1.5	
≥ 4	6652 (43.7)	71 (16.9)	1.1	
Total	15238 (100.0)	446 (100.0)	3.1	

Table 3.5 illustrates the most responsible TBI diagnosis for admission into acute-care

hospitals. There was a significant association between the discharge status and the most responsible diagnosis. DAMA was less likely to occur if a person had a skull fracture, concussion, cerebral laceration, or cerebral hemorrhage. However, other types of intracranial injury and diagnoses other than head injury were highly related to DAMA prevalence. Table 3.6 describes the prevalence of DAMA by seasons. DAMA occurred most frequently in the autumn (3.5%) and least frequently in winter (2.4%).

Table 3.5: Most responsible diagnosis for TBI patients

ICD-9-CM Diagnosis	Discharge Status		Rate (%)	p-value
	Regular (n, %)	DAMA (n, %)		
Skull fracture	1999 (18.9)	44 (13.2)	2.2	< 0.001
Concussion	2443 (23.1)	65 (19.5)	2.6	
Cerebral laceration/contusion	633 (6.0)	18 (5.4)	2.8	
Cerebral hemorrhage	1471 (13.9)	19 (5.7)	1.3	
*Others	4010 (38.0)	188 (56.3)	4.5	
Total	10556 (100.0)	334(100.0)	3.1	

* Other injuries or diseases as the most responsible diagnosis for admission (n=4764, 30.6%), DAMA in this group: n=112, 25.1% of total DAMA.

Table 3.6: Injury–related characteristics: seasonal variations

	Discharge Status		Rate (%)	p-value
	Regular (n, %)	DAMA (n, %)		
Seasons				0.010
Spring	3339 (21.9)	105 (23.5)	3.0	
Summer	4490 (29.5)	116 (26.0)	2.5	
Autumn	3882 (25.5)	140 (31.4)	3.5	
Winter	3527 (23.1)	85 (19.1)	2.4	

*Missing value Rural/Urban n=1086, 6.9%

Through these bivariate analyses, we found that cause of injury, sex, age groups, alcohol/drug abuse history and LOS were significantly associated with DAMA

occurrence. These variables were entered into multivariate regression modeling.

Adjusted relationships between intentionality and DAMA

The results of the logistic multivariate regression model based on significant variables from the bivariate analysis are displayed in Table 3.7. The strongest association with DAMA among the entered independent variables was alcohol/drug abuse history. TBI patients with alcohol/drug abuse history were 3.5 times more likely to leave hospital without medical advice ($p < 0.001$, aOR = 3.5, CI: 2.85-4.30). The intentional TBI groups (Si-TBI and Oi-TBI) were also significantly associated with a higher risk of DAMA in comparison to the unintentional TBI group. TBI caused by assault or self-inflicted injury had about 2.0 times greater risks of being DAMA than unintentional TBI. Bivariate analyses showed that gender was significantly associated with DAMA, as shown noted in Table 3.2; however, in multivariate modeling, the gender effect was no longer significant ($p=0.80$, aOR=1.03, CI: 0.82 - 1.29).

Table 3.7: Risk factors for DAMA for TBI in acute care: multivariate logistic analysis

Independent variables	Regular discharge vs. DAMA		
	OR	95% CI	p-value
Unintentional (Ref.)	1.00	-	<0.001
Other-inflicted	2.00	1.53 - 2.62	<0.001
Self-inflicted	1.97	1.36 - 2.84	<0.001
Sex (male)	1.03	0.82 - 1.29	0.800
Age 55-64 (Ref.)	1.00	-	<0.001
Age 15-24	1.23	0.80 - 1.91	0.350
Age 25-34	2.43	1.59 - 3.72	<0.001
Age 35-44	2.22	1.44 - 3.41	<0.001
Age 45-54	1.92	1.22 - 3.02	0.005
Alcohol/drug abuse	3.50	2.85 - 4.30	<0.001
LOS	0.89	0.86 - 0.91	<0.001
Years	0.88	0.81 - 0.96	0.005
Constant	0.02		<0.001

Variable(s) entered in step 1: Cause of injury, Sex, Age groups, Alcohol/drug abuse, LOS,

Years.

The age groups within 25-54 years had a greater risk of DAMA than did the reference group and the oldest age group. Patients in the 25-35 years age group had a 2.4 times greater chance of being DAMA compared to patients in the reference group. The youngest age group (15-24 years), however, was not significantly associated with DAMA. Moreover, DAMA was associated with decreased LOS ($p<0.001$, $aOR=0.89$) and year trends ($p=0.005$, $aOR=0.88$) with more recent admission having less DAMA.

3.7. Discussion

This study, to our knowledge, is the first study that focuses on DAMA among TBI patients. This study found that the DAMA rate for TBI population was 2.84 %, which was higher than overall DAMA prevalence, estimated at 1% of all patients in Canada.

We also showed that injury intention (intentional injury versus unintentional injury) was an independent predictor of DAMA among survivors of TBI, controlling for previously established risk factors such as age, gender and a history of alcohol/drug abuse. The role of intentional injury in relation to DAMA also has not been previously studied. As a vulnerable population in acute care and rehabilitation care, patients with intentional injuries have been of interest in recent TBI studies (Gerhart, Mellick & Weintraub, 2003; Hanks et al., 2003).

A history of alcohol/drug (or substance) abuse has been frequently examined in DAMA studies and in outcome studies of TBI and found to be an independent factor of the DAMA and TBI outcomes. As a confounder in this study, a history of alcohol/drug abuse

was more strongly associated with DAMA than were the other factors, including injury intention. When a history of alcohol/drug abuse is reported, even though an admitted patient does not show any sign of immediate substance abuse at injury, the possibility of DAMA should be considered. Although there has been no thorough examination as to why a history of alcohol/drug abuse leads to DAMA, drug users' mistrust of medical care providers, their addictive behaviors, and their desire to get more drugs or alcohol have been suggested as causative factors (Alfandre, 2009; Saitz, 2003). Persons who abuse alcohol and drugs also had poorer outcomes in rehabilitation (Bogner et al., 2001). As indicated by the above result, pre-injury demographic characteristics often had a more important role in adverse outcomes than did injury etiology itself. Having a psychiatric condition other than alcohol/drug problems, contrary to other studies, was not found to be a predictor of DAMA in this study.

Previous studies have reported younger groups as having the highest DAMA prevalence. The age group in this study that was most at risk was the 25-34 years age group, falling within the age ranges most at risk in other studies as follows: 21-40 years (Ohanaka, 2003), 35-49 years (Moyse & Osmun, 2004), and 18-34 years (Kaplan et al., 2009). Our study also revealed that the youngest age group (15-24 years) had the lowest rate of DAMA occurrence, however this did not reach the level of statistical significance ($p=0.350$). Accompanied by their parents and/or financially dependent on them, this youngest age group would likely have a relatively lower DAMA rate. In the multivariate analysis, gender was not a significant predictor of DAMA occurrence: female patients left hospitals against medical advice as often as male patients did. Brook et al.'s systematic

review (2006) also reported that gender was not consistently found to be a predictor of DAMA. Injury severity as measured by ISS, which has not been previously studied in relation to DAMA was not a significant predictor.

Because of shorter hospital stays of only 2.8 days on average, with approximately 70% of DAMA occurring within 24 hours, preventive interventions for patients at risk of DAMA should be made immediately upon admission. This irregularly short LOS should not be considered by either payers or medical professionals as a favorable outcome due to cost savings.

Even though studies on geographical or temporal variables in relation to DAMA have the potential to inform prevention strategies, there is a dearth of literature on these variables. This study reveals that autumn is the peak season for DAMA; however, there are no clear reasons for this. It may be that autumn is related to seasonal affective episodes (Miller, 2005) resulting in poor cooperation with clinicians and poor cohesion to treatment protocols, which may be particularly relevant in a Canadian setting. We also suggest that autumn is the time to return to work or school after a summer vacation. This season of renewed challenges—job security, academic performance, or family care responsibilities—could contribute to the high rate of DAMA. A high prevalence in the spring and summer seasons was also reported for psychiatric patients (Dalrymple & Fata, 1993) though it was different than our findings. Other types of temporal factors explored in another study of DAMA were the day of the week (Wednesday), the time of day (nighttime), and weekends (lack of available medical professionals) (Ohanaka, 2003).

However, we did not have these variables available to us in our study.

This study used the OTR MDS, a large population-based dataset which collects patient information from all admissions in acute-care hospitals in a publicly insured province, so results are highly generalizable to Ontario. The sample size of this study (n=446) is the ninth largest among the 26 previous studies, where DAMA cases ranged from 20 to 176,101 as listed in Alfandre's systematic review (2009). Future research should examine other factors found to be associated with DAMA such as socioeconomic status, hospital environments, Glasgow Coma Scale scores and other mechanisms of injury (e.g. penetrating or blunt injury). Glasgow Coma Scale scores measuring brain injury severity were not consistently available in the MDS. However, overall injury severity, measured by ISS in this study, was not likely associated with DAMA.

There are a number of directions to go in future research including an ongoing monitoring through utilizing hospital datasets, qualitative studies and the study of DAMA in inpatient rehabilitation settings.

Several datasets, such as the OTR MDS and the National Trauma Registry (NTR), are readily available so monitoring DAMA incidence and identifying other factors in a timely and accurate manner is possible.

The reasons why people decide to go home have not been fully appreciated (Saitz, 2003). This is mostly because previous DAMA studies have been limited to numerical data from

a hospital discharge dataset. Thus a qualitative approach using narratives would be required to get better and more detailed information about patients' decisions to discharge against medical advice. Based on previous research, we expect that DAMA patients with TBI would suffer worse outcomes. The reduced length of stay may also be associated with discharge prior to recognition and treatment of complications of the injury. Further research would warrant examination of the consequences following DAMA.

Moreover, DAMA can also occur in rehabilitation settings; yet, there is little data published on this, which is important as a notable percentage TBI acute care patients receive post-acute care. A future DAMA study of TBI rehabilitation could also improve the quality of rehabilitation services and management, and possibly prevent the functional deterioration of DAMA patients. A longitudinal study on stroke patients (Onukwugha & Weir, 2009) reported that, among Caucasians, the risk of DAMA was higher for those in rehabilitation care than for those in acute care, while non-Caucasian patients in acute care were more likely to discharge AMA than their Caucasian counterparts. This finding needs to be explored in other rehabilitation settings.

This study based on secondary data analyses also has several limitations. Absence of GCS and CT information would be a limitation for examining the nature of the injury severity of this study population and examining GCS as a potential risk factor. The ISS is considered a better indication of injury severity than GCS scores and incorporates the GCS in its calculation. The ISS was similar in both groups (9.5 vs 9.6) but could not be included in multivariate analyses due to incomplete ISS scoring. There are some

statistical approaches to deal with missing data. Because of the large number of missing cases (n= 2,970, 18.9%) this study, however, did not apply these approaches for the ISS. In addition, we recognize that identified risk factors related to DAMA, such as socioeconomic status, race, and DAMA history, were not captured in the administrative data.

3.8. Conclusion

This study examined factors related to DAMA occurring in the TBI population, including intentional injury as a potential predictor of DAMA, by using a population-based dataset (OTR MDS). It was revealed that the DAMA rate in the TBI population was 2.8%, meaning that 1 in 35 patients admitted left hospital AMA. From multivariate modeling, younger age, intentional injuries, a history of alcohol/drug abuse and shorter LOS were associated with DAMA occurrence. These results could be used to develop better healthcare policy and management strategies that target this specific TBI population. This study also suggests that injury intention is an important variable to consider when modeling DAMA. Clinicians should be made aware that patients with intentional TBI appear to more likely to leave against advice and therefore need to be screened and assessed quickly to ensure they do not have any life-threatening complications of the brain injury.

This study also supports increased attention to this group of patients. In order to create a better system, which could be called ‘comprehensive’ and ‘client-centered’, a study targeting the causes and prevention of subsequent adverse outcomes in this vulnerable

population needs to be conducted in both acute and rehabilitation settings.

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CHAPTER 4

Rehabilitation Outcomes after Intentional Traumatic Brain Injury

Kim, H., Colantonio, A., Bayley, M., Dawson, D. (2011). Rehabilitation outcomes after intentional traumatic brain injury. *Archives of Physical Medicine and Rehabilitation* (in review)

4.1 Abstract

Objective: This study aimed to investigate functional changes and discharge destinations following inpatient rehabilitation for intentional traumatic brain injury (TBI) patients compared to unintentional TBI patients. **Design:** Prospective cohort study utilizing population based acute care and inpatient rehabilitation records; the Discharge Abstract Dataset (DAD) and the National Rehabilitation Reporting System (NRS) from the Canadian Institute for Health Information (CIHI). **Settings:** All rehabilitation hospitals and clinics in Ontario and other provinces in Canada. **Cases:** TBI patients receiving inpatient rehabilitation services during the fiscal years of 2001-2006. **Main Outcome Measures:** Functional Independence Measure (FIM): absolute FIM gains in motor and cognitive subscales, relative FIM gains in motor and cognitive subscales using Montebello Rehabilitation Factor Scores (MRFS) and discharge destinations (home versus others, home with service versus home without service) **Results:** People with intentional TBI had significantly lower motor FIM gain and cognitive MRFS in univariate analyses ($p=0.010$, $p=0.039$ respectively) at discharge. Intentional TBI was associated with lower cognitive MRFS only, while controlling for age, gender, alcohol/abuse history, and other demographic and clinical variables. Persons with intentional TBI were less likely to be discharged home, controlling for other relevant confounders. **Conclusions:** People with intentional TBI are a distinct population in the

rehabilitation setting in Canada. These findings suggest rehabilitation clinicians should focus on improving cognitive functions more than motor functions in this population. Different discharge destinations also suggests the need for more careful discharge planning.

4.2. Introduction

Traumatic brain injury (TBI) resulting from violence, such as by assault and self harm, is a major public health issue; a recent report by the Canadian Institute for Health Information (CIHI) indicates that the number of intentional TBIs is increasing among young adults (CIHI, 2006). Recently, Kim and Colantonio (2008) completed the first Canadian study on intentional TBI by using a population-based dataset. This study found that intentional TBI comprised 8.0% of TBI admissions to trauma centres; 27.6% of intentional TBIs were self-inflicted TBIs and the remaining 72.4% were inflicted by others. Younger age and a history of alcohol/drug abuse were factors independently associated with intentional TBI.

Most of the studies focusing on outcomes from intentional TBI have been conducted in the US where violence-related injuries are relatively more common. Some researchers reported more physical symptoms, more severe disability, shorter rehabilitation length of stay, higher levels of caregiver burden, and decreased community reintegration in individuals with intentional TBI receiving rehabilitation compared to those with unintentional traumatic brain injuries (Gerhart, Mellick, & Weintraub, 2003; Hanks et al., 2003; Gordon et al., 2006). Gordon et al. (2006) have advocated for more attention to this

vulnerable population, including in the post acute care phase. Despite these reportedly poor outcomes, there is a paucity of information regarding the outcomes of persons with TBI from intentional causes, particularly from a population based perspective.

4.2.1. Literature review on intentional TBI and outcomes

Two systematic reviews have investigated outcomes following intentional TBI: Butcher et al. (2007) conducted a systematic review on the prognostic value of cause of injury in relation to TBI outcomes while Willemse-van Son, Ribbers, Verhagen, and Stam (2007) completed a systematic review on prognostic factors for long term functioning and productivity following TBI.

Butcher et al. (2007) used individual patient data (n=8,708) from eight randomized clinical trials and three surveys in their study. The outcomes as assessed by Glasgow Outcome Scale (GOS) scores at 6 months, were found to be better for patients with assault injuries, road traffic accidents, or sports injuries than for the reference group of patients with injuries due to falls. However, when age factors were added to adjust the model, the association between cause of injury and GOS disappeared. The GOS is a widely used global outcome assessment, but has been criticized as being insensitive to subtle difference in functional outcomes. Performance-specific measurements, such as the FIM[®] Instrument (“FIM”) could provide richer information for comparative studies.

Searching the Pubmed and PsychInfo databases, Willemse-van Son et al. (2007) retrieved 35 articles from 14 different prospective cohort groups dating from 1995 to April 2005.

The authors concluded that older age, pre-injury unemployment, pre-injury substance abuse and more disability at rehabilitation discharge were major predictors of long-term functioning. They found mixed results from three studies examining TBIs from violent causes as a predictor of long-term disability and productivity; two studies found a relationship with negative outcomes while the third study did not.

In addition to these reviews, other studies were found that examined intentional injury in relation to outcomes. In a UK study, Wenden, Crawford, Wade, King, and Moss (1998) reported TBI caused by assault had worse outcomes at six months post injury when measured by the Rivermead Head Injury Follow Up Questionnaire. Jiang et al. (2007) studied 2254 violent head trauma cases in China from a population of 23,816 TBI patients reported from 11 hospitals representing 9.5% of the total cases. Most of these showed good recovery (85.7%). Hart, Bogner, Whyte, and Polansky(2003) studied blame attribution among accidental and violence-related TBI groups and found that blame of others, which is considered a sign of adverse psychological outcome, was strongest in patients with violence-related TBI. Esselman, Dikmen, Bell, and Temkin's (2004) study revealed that persons with violence-related TBI were more likely to be discharged to home than rehabilitation. Furthermore, some researchers reported higher levels of caregiver burden and decreased community reintegration in those receiving rehabilitation after intentional TBI compared to those with unintentional traumatic brain injury (Gerhart et al., 2003; Hanks et al., 2003)

Overall, the literature confirms that there are differential outcomes for persons with TBI

following injury from intentional causes, and this difference needs to be explored further in larger samples. To date, there are no peer-reviewed articles on comprehensive inpatient rehabilitation outcomes of patients with intentional TBI compared to patients with unintentional TBI in Canadian settings. Health care delivery systems in Canada are substantially different than those in the United States, where there is more differential access to care based on insurance status. Therefore, results from US studies may not be generalizable to a publicly insured population. Thus, research is warranted to better understand violence-related injury as a prognostic factor in the Canadian setting.

4.3. Research objectives and hypotheses

4.3.1 Objectives

The aims of the current study were threefold: a) to provide a demographic, clinical and functional profile of adults with intentional TBI who received in-hospital rehabilitation in Canada; b) to compare rehabilitation outcomes of persons with intentional TBI (absolute and relative functional changes, discharge destinations) with outcomes of persons with unintentional TBI; and c) to examine intentional injury as an independent potential predictor of rehabilitation outcomes (functional change, measured by absolute and relative FIM gains, and discharge destination) while controlling for relevant possibly confounding demographic and clinical factors .

4.3.2 Hypotheses

Hypothesis 1: Compared to adults with unintentional TBI, functional changes, such as absolute FIM gains and MRFS scores, would be less than those for adults with intentional TBI, controlling for relevant confounding factors.

Hypothesis 2: Compared to adults with unintentional TBI, adults with intentional TBI would more likely be discharged to other facilities than discharged to home

4.4 Methods

4.4.1 Study design: This study utilized a prospective cohort design and used data from two population based databases, the Discharge Abstract Dataset (DAD) and the National Rehabilitation Reporting System (NRS) covering the years 2001-2006. These two databases were linked by matching individual health card numbers by the Canadian Institute for Health Information (CIHI). The health card numbers were truncated to maintain data confidentiality.

4.4.1 Data sources

The NRS was developed to collect, process, and analyze data on adult inpatient rehabilitation services and to support management decision-making at the facility, regional, and provincial/territorial levels (CIHI, 2009). However, the NRS does not provide variables for etiology of injury, such as ICD E-codes. It is only possible to detect intentional injuries if the NRS is linked with other trauma databases such as CIHI's Discharge Abstract Database (DAD) using a unique identifier like the individuals health insurance number which was scrambled later on for confidentiality purposes. The DAD contains data on hospital discharges across Canada and contains variables such as initial injury severity and mechanism of injury. However, the two datasets were not perfectly merged: for the age group of 16-64 years there were 1945 cases identified. However of these, 81.6% (n=1,580) of the NRS data were merged. Therefore, 18.4% (n=362) of TBI

patients in the original dataset were not able to be linked with the data from acute care. This is in part because some patients (n=148) were directly referred from long-term facilities, nursing homes and physicians in private practice, so they would not have had an acute care record just prior to admission to inpatient rehabilitation. Consequently, we did not include these individuals as information on cause of injury was not available. We do not know why 214 cases referred from acute care were not included in the data. These data were merged by CIHI and as such we could not easily compare the merged and unmerged cases. For more information see Appendix C.

4.4.2 Cases: Persons with TBI aged between 16-64 years who received inpatient rehabilitation services in Ontario were studied. TBI was defined by the NRS's categorization of rehabilitation client groups (RCGs): RCG code 02.2 designates the Traumatic Brain Dysfunction group. We excluded individuals over 64 years because they have comorbidities such as heart disease, diabetes and hip fractures, compared to younger individuals, which might affect their discharge outcomes. Moreover, the proportion of intentional TBI in this older age group is extremely small (1.7%) compared to unintentional TBI (Kim & Colantonio, 2008).

4.4.3 Variables measured

The main independent variable was injury intention, derived from the cause of injury codes in the DAD. TBIs from intentional causes of injury, such as assault and self inflicted injury, formed one category of this dichotomous variable and all other causes formed the other category (unintentional injury). Additional variables were used as

control variables to assess the independent effect of intentional injury on outcomes of interest; we drew upon previous systematic reviews that identified key variables associated with TBI outcomes (Butcher et al., 2007; Willemse-van Son et al., 2007). We subdivided these control variables into demographic and clinical variables. These variables were also used to describe the study population.

Demographic characteristics: Gender (male or female), age (ordinal variable with 5-year age intervals), language other than English (English and others), vocational status, rural/urban residence, and living arrangement were examined.

Vocational status: NRS codes for employed full-time and employed part-time were designated as employed, while codes for unemployed and retired were designated as not working. Willemse-van Son et al. (2007) found that being employed at time of injury is associated with improved outcomes. People who were reported as retired were categorized as unemployed. We did not include older adults in our study over 64 and thus considered this too small group to be considered as separate category.

Rural/urban residence: Geographical variation was based on the NRS categorized by the residence of the patient coded as rural, urban and unknown. Rural/urban status affects discharge destination and health care utilization (Colantonio et al., 2008).

Living arrangement: Living status prior to admission was coded in the NRS as living with spouse, living with family, living with others, living alone and living in facilities. We dichotomized these variables into two categories to facilitate analyses: living with others

and living alone. We hypothesized that living with others would be a proxy for social support. Living situation is also known to affect discharge destination and post-discharge care (Tooth et al., 2001; Tooth et al., 2005).

Clinical characteristics: These included comorbidities prior to admission, alcohol/drug abuse history, days from injury to admission, and rehabilitation length of stay (LOS).

Comorbidities: During the years studied, the NRS recorded up to 10 comorbidities for each patient using ICD-9-CM codes. We calculated the number of comorbidities of each patient. The number of comorbidities has been associated with TBI outcomes (Colantonio et al., 2008).

Alcohol/drug abuse history: Alcohol/drug abuse was categorized exclusively from the comorbidity codes of the NRS. Alcohol/drug abuse history were frequently associated with TBI onset and outcome of TBI (Wagner et al., 2000; Bogner, et al 2001; Willemse-van Son et al., 2007)

Length of stay (LOS): We used actual rehabilitation LOS, which was calculated and recorded in the NRS dataset as the number of days between admission and discharge, excluding service interruption days. The service interruption days are recorded when the rehabilitation services are temporarily suspended because of patients' health status. These interruption days need to be excluded from LOS calculation to obtain more accurate days of receiving rehabilitation services (CIHI, 2008).

Injury to admission: We utilized time of injury to rehabilitation admission as a proxy for severity because this variable has been reported as having an association with poorer outcomes. This was operationalized as the time duration from the onset of TBI to rehabilitation admission. This parameter has been used in studies examining outcomes of treatment of patients with TBI (Heinemann et al 1995; Mammi et al., 2006)

Rehabilitation outcomes: FIM ratings (admission FIM, discharge FIM, absolute FIM gains, and MRFS scores) and discharge destinations (home versus facilities, home with care services versus home without care services) were examined with respect to these outcomes.

FIM[®] Instrument (“FIM”): Total FIM ratings as well as two separate FIM subscales: the Motor FIM subscale, consisting of 13 items, and the Cognitive FIM subscale, consisting of 5 items (Linacre et al., 1994; Heinemann et al., 1993). Granger et al. (1990) observed that the instrument’s ability to detect meaningful changes in levels of functioning during rehabilitation was high. Also, FIM has clinically appropriate validity and inter-rater agreement (Hamilton et al., 1994). Despite these findings, ceiling effects of FIM at rehabilitation discharge have been observed in the TBI population (Hall et al., 2001). About 49% and 84% of the sample achieved a high level of independence (Average FIM ratings of 6 or 7) by discharge and one year post injury respectively. In other words, the FIM is not sensitive to more subtle changes expected after discharge from acute inpatient rehabilitation. In order to overcome the ceiling effect, recent studies

have utilized the Montebello Rehabilitation Factor Scores (MRFS) (Drubach et al., 1994; Heruti et al., 1999; Zwecker et al., 2002; Denti, Agosti, & Franceschini, 2008).

For this study, two parameters were used: absolute FIM gains, and relative FIM gains, which were calculated using the MRFS. The absolute FIM gains reached during the rehabilitation stay was calculated as discharge FIM rating – admission FIM rating. For the relative FIM gains we used the Montebello Rehabilitation Factor Scores (MRFS): $\text{absolute FIM gain} / (\text{maximal FIM rating} - \text{admission FIM rating})$. For example, $\text{MRFS motor score} = \text{discharge motor FIM rating} - \text{admission motor FIM rating} / (91 - \text{admission motor FIM rating})$, and $\text{MRFS cognitive score} = \text{discharge cognitive FIM rating} - \text{admission cognitive FIM rating} / (35 - \text{admission cognitive FIM rating})$.

Discharge destinations: This variable was taken from the NRS variable ‘Living settings at discharge’. The variable is coded in the NRS as ‘home with services’, ‘home without services’, ‘residential care’, ‘assisted living’, ‘boarding house’, ‘shelter’, and ‘other/unknown places’. Going home instead of being transferred to facility care is considered a better functional outcome (Tooth et al., 2005). Thus, our study dichotomized the destinations into two categories: discharged to home versus discharged to other places (residential care, assisted living, boarding house, shelter, and other/unknown places); and ‘home with services’ and ‘home without services’.

4.4.4 Statistical analyses

Frequency distributions and univariate statistics were generated to provide descriptive

information about the study sample. Variables that were highly skewed such as rehabilitation length of stay and time to admission were transformed using logarithmic transformation.

To test our first hypothesis, we conducted univariate linear regression with all independent variables. Variables that had a p value of .2 or less were entered into a stepwise multivariate regression model to arrive at a final model. The contribution of intentional injury on modeling absolute FIM gain and MRFS scores controlling for relevant confounding variables therefore was assessed.

To test our second hypothesis, we used the same process as above only using logistic regression analyses for our dichotomous outcomes (discharged home/versus other; discharged with services versus without services). Post-hoc analyses were also conducted without self-inflicted TBI cases (n=16, 1% of the sample).

The goal of multivariate modeling was to identify the independent contribution of injury intention controlling for relevant confounding variables. Adjusted R^2 were also reported for multivariate analyses.

4.4.5 Ethics: This research study received ethics approval from the Research Ethics Board at the University of Toronto.

4.5 Results

Table 4.1 describes demographic and clinical characteristics of patients with intentional TBI hospitalized in rehabilitation settings compared to patients with unintentional TBI. There were 179 (11.3%) intentional TBI patients in the DAD-NRS linked dataset between 2001-2006 who were less than 65 years of age. Patients with intentional TBI were significantly younger and more likely to be male, unemployed, and living alone prior to admission. There were no significant differences in language use and location of residence prior to admission between the two groups. In terms of clinical characteristics, the proportion of patients with an alcohol/drug abuse history was significantly higher in the intentional TBI group ($p < 0.001$). Days from injury onset to admission were compared as a proxy for injury severity. Patients with intentional TBI were admitted into their rehabilitation settings significantly earlier than patients with unintentional TBI, suggesting that their injuries were less severe or complex. The length of stay was not significantly different between the two TBI groups. Most patients received informal support prior to admission; however this variable was not significantly different between the two TBI groups ($p = 0.302$).

Table 4.1: Demographic and clinical characteristics

	Unintentional TBI (n=1,401) N (%)	Intentional TBI (n=179) N (%)	p-value
Age groups 16 – 24	405 (28.9)	55 (30.7)	< 0.001
25 – 34	253 (18.1)	36 (20.1)	
35 – 44	268 (19.1)	51 (28.5)	
45 – 54	260 (18.6)	32 (17.9)	
55 – 64	215 (15.3)	5 (2.8)	
Gender (male)	1053 (75.2)	165 (92.2)	< 0.001
Language(English)	1318 (94.1)	172 (96.1)	0.529
Employed	909 (64.9)	81 (45.3)	< 0.001
Living alone	233 (16.6)	50 (27.9)	< 0.001
Rural residence	280 (20.0)	29 (16.2)	0.407
Alcohol/drug abuse	347 (24.8)	68 (38.0)	< 0.001
(Mean, SD)			
No. of comorbidities	3.4 (3)	3.0 (2)	0.206
Injury to admission(days)	56.8 (100.6)	50.4 (85.9)	< 0.001
Rehabilitation LOS	51.6 (59.8)	48.9 (96.0)	0.164

Table 4.2 describes the functional scores of the two TBI groups at rehabilitation admission and at discharge. Patients in the intentional TBI group had better motor function ($p < 0.001$) and similar levels of cognitive function on average ($p = 0.791$) upon admittance into a rehabilitation setting, compared to patients in the unintentional TBI group. This trend also continued for FIM ratings at discharge: patients with intentional TBI had better motor FIM ratings ($p < 0.001$) and similar cognitive FIM ratings ($p = 0.121$). Absolute motor FIM gains, however, were significantly higher for patients with unintentional TBI (21.1 vs. 17.0), but this absolute gain was not evident for cognitive function ($p = 0.29$). MRFS for total FIM gains and motor gains were not significantly different for the two groups; however, there were significant differences in cognitive MRFS scores.

Table 4.2: Functional scores at admission and discharge

Outcomes	Unintentional TBI (N=1401)		Intentional TBI (N=179)		p-value
	Median	Mean (SD)	Median	Mean (SD)	
Total FIM					
Admission	87	79.6 (30.2)	94	87.3(27.8)	0.001
Discharge	115	106.9 (22.0)	115	110.1(17.2)	0.294
FIM gain*	22	27.3 (23.2)	16	22.8(21.0)	0.011
Motor FIM					
Admission	65	59.5 (25.0)	75	66.8(22.9)	< 0.001
Discharge	88	80.5 (17.3)	90	83.8(14.3)	< 0.001
FIM gain*	16	21.1 (19.5)	12	17.0(17.4)	0.010
Cognitive FIM					
Admission	21	20.1 (7.6)	20	20.5(7.4)	0.791
Discharge	28	26.3 (6.4)	26	26.3(5.1)	0.121
FIM gain*	5	6.2 (5.6)	5	5.8(5.3)	0.290
MRFS Total	0.65	0.57(0.29)	0.60	0.55(0.27)	0.099
Motor	0.82	0.67(0.40)	0.84	0.68(0.44)	0.158
Cognitive	0.43	0.40(0.31)	0.38	0.36(0.28)	0.039

*FIM gains from admission and discharge within groups were also statistically significant ($p < 0.001$)

Overall, type of injury (unintentional TBI vs. intentional TBI) was related to the variations in discharge destinations (chi-square statistic=11.168, $df=3$, $p=0.01$). Most TBI patients, in both the unintentional and intentional groups, were discharged home (81.6% and 75.9%, respectively) (Table 4.3). Patients with intentional TBI, compared to patients with unintentional TBI, were more frequently discharged to other places rather than home (24% vs. 18.4%). However, when categorized into two groups, Home and Other locations, this was not statistically significant (chi-square statistic=3.327, $df=1$, $p=0.068$).

Moreover, for the home discharge variable, patients with intentional TBI were significantly more likely to be discharged home without services (chi-square statistic=8.131, $df=1$, $p=0.004$). The models that emerged from multivariate logistic regression analyses are presented in Table 4.5.

Table 4.3: Discharge destinations following TBI rehabilitation

Discharge destinations		Unintentional TBI (N=1401) N (%)	Intentional TBI (N=179) N (%)	p-value
Home	Home with services	419 (29.9)	33 (18.4)	0.011
	Home without services	725 (51.7)	103 (57.5)	
Other location	Facility care services	154 (11.0)	27 (15.1)	
	Others	103 (7.4)	16 (8.9)	

Table 4.4 indicates that intentional injury was only significantly related to the decreased cognitive MRFS, which means that intentional injury was an independent predictor for decreased relative cognitive function, controlling for other confounding variables. However, it was not a significant factor in absolute gains in motor or cognitive FIM and motor MRFS. Both absolutely and relatively, motor gains were related to younger age, alcohol and drug abuse history, and a longer rehabilitation LOS. With respect to both absolute cognitive FIM gain and MRFS, common predictors were having English as a first language, fewer days from injury to admission, longer rehabilitation length of stay, and lower cognitive FIM ratings. When MRFS was examined on its own younger age, being employed prior to admission, lower admission cognitive FIM ratings were independently associated with cognitive MRFS. The regression models in Table 4.4 explained the 55.1% of variance of motor FIM gain and 45.1% of cognitive FIM gain. However, the models for MRFS explained only 11.7% of the variance of motor MRFS and 11.7% of cognitive MRFS. Post-hoc analyses without self-inflicted TBI (N=16, 1% of total TBIs in this study) were also conducted ; the results from these analyses did not change the presented results in terms of the significant factors and the directions of the relationships.

Persons with unintentional TBI were more likely to be discharged home compared to persons with intentional TBI, controlling for several demographic, clinical and functional variables (Table 4.5). Younger age, being employed prior to admission, living with family or others, living in rural areas, and absence of a history of alcohol/drug abuse were independently associated with home discharge. Also, patients who achieved higher motor and cognitive functional scales at discharge and stayed in rehabilitation settings for less time were more likely to go back home rather than be discharged to other places. When further analyses were conducted on home discharge (home with service versus home without service), we found that intentional injury was not associated with this outcome; only younger age, living urban areas, shorter rehabilitation LOS and higher motor FIM ratings were independently associated with going home without services. Either going home or going home with services, gender, language, number of comorbidities and days from injury to admission were not significantly associated with injury cause. The regression models in Table 4.5 explained the 40.2% of variance of Home discharge and 15.7% of discharges home with services.

Table 4.4: Multiple linear regression (stepwise method, final model): factors related to absolute functional gains and relative functional gains (N=1,580)

Independent variables	FIM gain (motor)			FIM gain (cognitive)		
	B	Std. Error	p-value	B	Std. Error	p-value
Intentional injury		NS			NA	
Age group	-0.431	0.115	<0.001		NS	
Gender (male)		NS			NS	
Language		NS		1.434	0.447	0.001
Vocational status		NA			NA	
Living with others		NA			NA	
Living in urban area		NA			NA	
Alcohol/drug abuse	3.758	0.759	<0.001	0.843	0.067	<0.001
No. of comorbidities		NS			NS	
Injury to admission		NA		-2.164	0.130	<0.001
Rehabilitation LOS	1.738	0.447	<0.001	1.272	0.145	<0.001
Motor FIM(adm)	-0.567	0.017	<0.001		NS	
Cognitive FIM(adm)	0.206	0.055	<0.001	-0.410	0.015	<0.001
	MRFS (motor)			MRFS (cognitive)		
	B	Std. Error	p-value	B	Std. Error	p-value
Intentional injury		NA		-0.055	0.023	0.016
Age group	-0.011	0.003	0.001	-0.005	0.003	0.042
Gender (male)		NA			NS	
Language		NA		0.087	0.031	0.005
Vocational status	0.053	0.019	0.005	0.041	0.015	0.006
Living with others		NA			NS	
Living in urban area		NA			NA	
Alcohol/drug abuse	0.057	0.021	0.007		NS	
No. of comorbidities		NS			NS	
Injury to admission	-0.149	0.011	<0.001	-0.119	0.009	<0.001
Rehabilitation LOS	0.106	0.012	<0.001	0.069	0.010	<0.001
Motor FIM (adm)		NA			NS	
Cognitive FIM(adm)		NA		-0.004	0.001	<0.001

NA: Not applicable; a variable not entered into the multivariate model

NS: Not significant ; a variable entered into the multivariate model but not significant in the multivariate analyses

Table 4.5: Multiple logistic regression analyses (stepwise methods, final models): factors related to discharge destinations

Independent variables	Home vs. Other location (N=1,580)			Home with service vs. Home without service (N=1,280)		
	B	Std. Error	p-value	B	Std. Error	p-value
Intentional injury	-0.541	0.228	0.018	NS		
Age group	-0.125	0.029	<0.001	0.050	0.022	0.023
Gender		NA		NS		
Language		NA		NS		
Vocational status	0.496	0.161	0.002	NA		
Living with others	0.673	0.189	<0.001	NA		
Living in urban areas	-0.479	0.185	0.009	-0.423	0.133	0.001
Alcohol/drug abuse	-0.541	0.168	0.001	NS		
No. of comorbidities		NS		NS		
Injury to admission		NS		NS		
Rehabilitation LOS	-0.230	0.092	0.013	0.643	0.087	<0.001
FIM Motor (Dis)	0.047	0.005	<0.001	-0.040	0.007	<0.001
FIM Cognitive(Dis)	0.097	0.015	<0.001	NS		

NA: Not applicable; a variable not entered into the multivariate model

NS: Not significant ; a variable entered into the multivariate model but not significant in the multivariate analyses

4.6. Discussion

To our knowledge, this is the first study examining intentional TBI in the inpatient rehabilitation setting in Canada, or any other population based setting. This study showed a differential profile of patients injured by injury intention who access inpatient rehabilitation services. Persons with intentional TBI are more likely to be younger, male, unemployed, living alone, and have a history of alcohol/drug abuse. These patients had fewer comorbidities overall, and had earlier admission into rehabilitation, compared to patients with unintentional TBI. Intentional injury was not independently associated with rehabilitation outcomes, such as absolute functional changes. However, relative

functional changes in cognitive function were significantly poorer for the intentional TBI group, controlling for relevant confounders. It should be pointed out, however, that although it was significant, it represented a small actual difference in score between the 2 types of injury groups. The results from MRFS models are statistically meaningful; to be clinical meaningful, further studies with other comprehensive functional assessments would be required.

Injury intention was also an independent predictor of discharge destination for persons with intentional injury less likely to go home.

4.6.1. Discussion of study methods

This study utilized a population based dataset which is based on mandatory reporting in Ontario. These datasets are also subject to data quality management. Patients with intentional TBI admitted into rehabilitation settings comprised 11.3% of total TBI admissions captured in the DAD/NRS databases during the years 2001-2006, which was slightly more than those admitted into acute hospitals (10.2%) reported in a previous study (Kim & Colantonio, 2008). These patients did not appear disadvantaged regarding accessing inpatient rehabilitation. Esselman et al. (2004) also reported that there was no evidence of bias against persons with intentional TBI in accessing inpatient rehabilitation.

It should be noted that there are many ways in which to build statistical models. We chose a stepwise approach due to the fact that many of the variables were highly correlated, maintaining all the variables of interest that could be confounders results in

multicollinearity. As such, we decide to employ a data reduction technique such as stepwise regression to obtain a more stable model. When we did include all the variables of interest in the model and added intentional injury the results did not change our conclusions regarding the influence of intentional injury on outcomes.

4.6.2. Discussion of study results

Patients with intentional TBI in this study were unique in terms of their demographic and clinical characteristics. The results from the descriptive analysis showed that patients with intentional TBI were associated with younger age, male gender, unemployment/non-productivity, living alone, a history of alcohol/drug abuse, fewer medical comorbidities, and earlier admission into rehabilitation, compared to patients with unintentional TBI. These results support previous epidemiological studies (Novack et al., 2000; Gerhart et al., 2003; Hanks et al., 2003; Kim & Colantonio, 2008).

One of the noticeable findings in the demographic profile was the gender distribution in rehabilitation. The proportion of female patients with intentional TBI (7.8%) found in this study was significantly smaller than the 14% seen in a previous study that examined intentional TBI in acute care settings (Kim & Colantonio, 2008). This may be because female patients would have died more frequently during acute care; in-hospital fatality in acute care settings was higher for self-inflicted TBI, which was more likely to occur among females than males.(Kim and Colantonio, 2008). Male survivors from intentional injury would thus have greater needs for acute care services. It has also been shown that female patients with TBI due to intimate partner violence, a potential cause for

intentional TBI among female patients, are likely to avoid medical attention and try to leave hospital earlier than scheduled (Corrigan et al., 2003); the extent to which this is true in this patient population needs to be examined.

This study also examined intentional TBI as a potential predictor of functional changes and discharge destinations following inpatient rehabilitation. Absolute functional changes, either motor or cognitive, were not associated with intentional injury; however, relative functional changes in cognitive function were significantly lower for those with intentional injury. Specifically, this study found that patients with an intentional TBI did not have different rehabilitation outcomes in terms of motor or cognitive FIM ratings at discharge, despite having different demographic and clinical characteristics.

This result implies that patients with intentional TBI do not have worse functional outcomes than patients with an unintentional TBI. Our findings support previous studies on violence-related TBI (Harrison-Felix et al., 1998; Shopp et al., 2006). Patients with intentional TBI appear to equally benefit from rehabilitation as those with unintentional TBI. When examining relative functional gains however, these patients appear to benefit less in the cognitive domain compared to persons with unintentional injury. Reasons for this need to be examined.

This study, therefore, demonstrates the value of examining relative functional gains with respect to functional outcomes. Relative functional gains are not yet included as key indicators for the Hospital Reports in Canada (Cott et al., 2004) and other inpatient

rehabilitation reports utilizing the NRS.

Kim and Colantonio (2008) found that substance abuse was a predictor for intentional TBI. Unexpectedly, it was a significant factor associated with better functional gains. This finding contrasts with that of Bogner, Corrigan, Mysiw, Clinchot and Fugate's (2001) study, which stated that substance abuse had a stronger association with poorer long-term outcomes than intentional injury. A closer examination of this finding is warranted.

4.6.3. Study limitations

The NRS, like other databases, has data quality issues. The limitations of the data have been reported, such as missing health card numbers (CIHI, 2009), duplicate records (Ministry of Health and Long-Term Care [MOHLTC], 2005, as cited in MOHLTC, 2006), and data inaccuracies (Institute for Clinical Evaluative Sciences, 2005, as cited in MOHLTC, 2006). To ensure quality data, the NRS team regularly checks these issues and reports any concerns. CIHI also allows for corrections and updates to any previously submitted records at a later date; numbers reported for any period or point in time may change if/when a query is rerun at a later date (MOHLTC, 2005; as cited in MOHLTC, 2006).

4.6.4. Future studies/clinical implications

We found few peer-reviewed studies that used the NRS dataset. This is potentially a very valuable resource, as there are relatively few population based datasets focused on

inpatient rehabilitation internationally.

Since the relative functional gains are a potential indicator in reporting rehabilitation outcomes, these parameters should be incorporated in future research in order to enhance the quality of rehabilitation services. Currently, hospital reports focusing on inpatient rehabilitation in Canada are primarily based on absolute gains (Cott et al.,2004). Using relative functional gains, which take into account the amount of functional gain possible on the FIM scales, can provide valuable additional information.

This study focused on intentional injury as a predictor of outcome in patients who required inpatient rehabilitation. Thus, persons with mild TBI from violence related causes—that is, persons who did not require inpatient rehabilitation—were not included, and should be an area of further investigation. A focus on mild injury may include many more women, for instance. Many women experience mild brain injury from domestic violence (Jackson et al., 2002); however, they are not likely to be admitted. Women who are victims of domestic violence may have multiple and cumulative damage to the brain (Corrigan et al.,2003), and as such, domestic violence in relation to TBI should be considered an important public health issue. Epidemiological reports on the incidence and prevalence of this injury group should be published on a regular basis to assess trends over time in order to inform more focused prevention and treatment planning, as well as the evaluation of these strategies.

4.7. Conclusion

This study was designed to enhance research on intentional TBI within a Canadian context. Although intentional TBIs are not the most common type of injury, they pose unique challenges to front-line care in both acute and rehabilitation settings. A person who has been injured due to assault or suicidal attempt may need a different rehabilitation approach to ensure efficient recovery of cognitive functioning since they may be at greater risk for adverse rehabilitation outcomes. This research highlights the demographic and clinical characteristics of this group and associated rehabilitation outcomes, and can inform effective planning for resources and clinical practice.

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CHAPTER 5

DISCUSSION

This final chapter of the thesis focuses on the major contributions of this research regarding traumatic brain injuries due to violence-related mechanisms and its clinical and policy implications. A summary of the findings from chapters 2, 3 and 4 is provided as a background for that discussion.

5.1 Summary of findings

The main goals of this thesis were to examine the nature and extent of intentional TBI in comparison with unintentional TBI, and to determine if intentional injury was a significant factor in important outcomes measured in different stages of TBI care; the two stages of care referred to are the acute and rehabilitation stages. To fulfill these aims, three different databases were utilized; namely, the OTR (CDS and MDS datasets), and the DAD, which was linked with NRS data.

The first study (Chapter 2): This is the first study of intentional TBI from a Canadian population based perspective. This study provides information on the epidemiological patterns, the mechanisms of injury, and injury severity of intentional TBI compared with unintentional TBI in a large, publicly insured population admitted to trauma centers in Ontario. The results indicated that males sustained a greater proportion of TBI due to assaults than females. Younger age groups were more vulnerable to intentional injury. Also, the alcohol/drug abuse history variable was highly correlated with intentional TBI. These findings of pre-injury demographic characteristics were in concordance with

previous reports (Harrison-Felix et al., 1998; Hanks et al., 2003; Gerhart, Mellick, & Weintraub, 2003). Regarding time of incident occurrence, suicide was more common during daytime hours and assault/homicide was more common late at night. The initial step in responding to violence is to define and monitor the extent of the problem (WHO, 2002; Krug et al., 2004). Thus, this epidemiological study investigating intentional TBI is useful for prevention strategies, as it defines the characteristics of persons most at risk for intentional injury.

The second study (Chapter 3): This is the first study of discharges against medical advice (DAMA) in the TBI population. The results indicated that there were 446 (2.8%) DAMA cases out of the 15,684 TBI patients identified in the study periods. Thus, approximately 1 in 35 hospital discharges of TBI patients in Ontario were against medical advice. Male patients were more likely to DAMA than female patients ($p=0.032$) and the age group between 25-34 years had the highest proportion of DAMA. Through multivariate logistic analyses, this study found that TBI caused by assault was about 2.0 times more likely to result in DAMA than unintentional TBI. TBI resulting from self-inflicted injury was also about 2.0 times more likely to result in DAMA than unintentional TBI. History of alcohol/drug abuse was strongly associated with DAMA; this finding supports findings of previous studies.

The third study (Chapter 4): This is one of only a few studies examining rehabilitation outcomes after intentional TBI by using multivariate modeling, and the first study on this topic conducted in a Canadian population. The results indicated that patients with

intentional TBI were admitted into rehabilitation with better motor function and similar cognitive function compared to patients with unintentional TBI. This trend also continued for FIM ratings at discharge: better Motor FIM ratings and similar Cognitive FIM ratings from patients with intentional TBI. Absolute Motor FIM gains, however, were significantly higher for unintentional TBI patients, but this absolute gain was not evident for cognitive functions. MRFS for total FIM gains and motor FIM gains were not significantly different for the two groups; however, there were small but significant differences in cognitive MRFS.

In multivariate models, intentional injury became a significant predictor for decreased relative cognitive function, controlling for other confounding variables; it was not a factor in absolute gains in Motor or Cognitive FIM. We found that all absolute and relative functional gains were related to younger age, employment status prior to admission, shorter duration of time between injury and admission, and a longer rehabilitation LOS. This study also reported discharge destination following rehabilitation; persons with unintentional TBI were more likely to be discharged home compared to persons with intentional TBI, controlling for several demographic, clinical and functional variables.

5.1.1. Major contributions

This thesis contributes to the field of acute trauma care and neurotrauma rehabilitation, and extends the current understanding of the epidemiology and rehabilitation treatment following TBI. Each study in this thesis provides a unique contribution that could

influence the advancement of health care research and delivery in the acute and post-acute stages for people with intentional TBI. Overall, the first two studies in this thesis utilized population based datasets based on people residing in Ontario and the third study in Ontario and some other provinces. Thus, the results derived from these studies are highly relevant and generalizable to the population in Ontario.

The first study (Chapter 2) presented a risk profile and risk factors of intentional TBI. This epidemiological study was the first to separate the intentional TBI population into two injury groups—self-inflicted TBI and other-inflicted TBI—and to provide vital risk information on each group. For the DAMA study (Chapter 3), we first assumed intentional injury was a potential risk factor for DAMA in the TBI population; this proved to be a significant factor predicting the occurrence of DAMA. Lastly, in the third study (Chapter 4), alternative parameters of rehabilitation outcomes—relative functional gains—were examined. This study also discussed these relative functional gains as the potential indicator for future program evaluation or hospital reports.

Throughout this thesis, we consistently examined a specific cause of injury: intentional injury. This is of concern from public health perspective. Because the objectives of this thesis are not limited to medical concerns, but apply to social issues as well, the results could also impact research or practices in other fields related to violence prevention and intervention for the victims of violence.

5.2. Methodological issues

5.2.1. Definitions of key words/operationalization of measures

Intentional TBI: Throughout the three studies in this thesis, the term ‘intentional TBI’ was commonly used and was selected and categorized by E-codes of the ICD-9-CM, which includes causes related to assault or self-harm (Appendix A). Previous studies focusing on violence-related or intentional TBI, which utilized free-standing hospital data or registries such as Traumatic Brain Injury Model System(TBIMS) in the United States, also used the E-codes to create a variable for intentional injuries.

DAMA: Discharge against medical advice (DAMA) is defined as leaving hospital before the treating clinician recommends discharge and/or as self-discharge or signing out against medical advice. This variable is recorded as one of the ‘discharge dispositions’ in the MDS of the OTR (Appendix B).

Functional outcomes: The functional outcome ‘rehabilitation program’ was measured by the FIM (Chapter 3). However, indicators from the FIM are presented in various ways. This study adopted Montebello Rehabilitation Factor Scores (MRFS), which indicate relative functional changes, in addition to absolute FIM ratings (total, motor, and cognitive FIM ratings). This study addressed the reasons to include MRFS scores and found meaningful results from these relatively new indicators. The MRFS was also considered to be an indicator of resource utilization in health care delivery.

5.2.2. Strengths of the study

This thesis utilized large population-based datasets that collect patient information from all admissions into acute-care hospitals (the MDS OTR, Chapter 3), 11 trauma hospitals for more severe cases (the CDS OTR, Chapter 2) and all rehabilitation hospitals or clinics (the NRS and DAD, Chapter 4) in a publicly insured province; thus, results are highly generalizable to the population in Ontario. All of these datasets are stored and maintained by CIHI. The fact that this data is population-based is the most significant difference between this study and previous studies conducted for people with intentional TBI. Most previous studies used either individual hospital databases with small sample sizes or non-population based datasets, such as the TBIMS.

5.2.2. Limitations of the study

One limitation across the three studies is a lack of variables of interest concerning personal, clinical and environment characteristics of the individual cases. Socioeconomic status, ethnicity and level of education data were not available in the datasets used (OTR, NRS, DAD). Previous studies have shown that these variables influence the occurrence of DAMA and intentional TBI. For instance, francophone and First Nations populations in Canada have been shown to have higher rates of intentional injury (Clarke et al., 2008). We were not able to capture these cultural differences, however.

Initial injury severity data, such as Injury Severity Scores (ISS), were also not included (Chapter 4) or were only partially recorded (Chapter 3) in our studies. Moreover, the CDS of the OTR (Chapter 2) contains records of hospitalized TBI patients with ISS over

12 only; consequently, less severe cases were not included in this study. The patients included in the CDS were transferred to one of the 11 major trauma centres in Ontario; thus, one could consider these cases as representative of moderate/severe TBI occurring in the province. It should be noted that fatal injuries occurring prior to admission were not captured in this data but it is not known how many of these cases may have been missed.

The NRS, like other databases, has data quality issues. The limitations of the data have been reported, such as a few missing health card numbers (Canadian Institute for Health Information [CIHI], 2009), duplicate records (Ministry of Health and Long-Term Care [MOHLTC], 2005, as cited in MOHLTC, 2006), and data inaccuracies (Institute for Clinical Evaluative Sciences, 2005, as cited in MOHLTC, 2006). To ensure quality data, the NRS team regularly checks these issues and reports any concerns. CIHI also allows for corrections and updates at a later date to any previously submitted records; numbers reported for any period or point in time may change if/when a query is rerun at a later date (MOHLTC, 2005; as cited in MOHLTC, 2006).

The number of TBIs due to suicidal injuries reported was small (Chapter 4); these cases needed to be incorporated into the intentional TBI groups as previous studies have done. Thus our findings are likely most relevant to other inflicted TBI due to mechanisms such as assault. It should be noted that mechanisms of injury are not included in the NRS and as such it was necessary to link NRS records with acute care records (DAD) to obtain this information. This merge of records resulted in losing some cases from either the DAD or

NRS. Based on our research, we recommend that the NRS include acute care data such as acute care diagnosis, severity and mechanism of injury, so merging with the DAD may not be necessary in the future.

In terms of the years of data production, the CDS OTR and the MDS OTR data in this study are becoming dated; on-going research on occurrence of intentional TBI and DAMA should follow with recent available data to see if there are any changing trends.

5.3. Study implications

5.3.1. Implications for clinical practice

It is evident from the first study (Chapter 2) that more prevention initiatives are needed to decrease overall intentional injury in younger aged individuals, and to decrease firearm-related intentional TBI. As well, it is imperative to raise awareness of alcohol/drug abuse in patients with intentional TBI. The seasonal peaks for specific types of intentional TBI may have implications for planning of preventive interventions.

The findings from the DAMA study (Chapter 3) are suitable for professionals working in emergency departments or acute care. These medical professionals need to be aware of DAMA, and specifically of DAMA in relation to intentional TBI patients. Approximately 1 in 10 TBIs are from intentional causes, and intentional TBI patients are more likely to leave hospitals against medical advice, compared to unintentional TBI patients. Closer attention needs to be paid to this population, with careful monitoring on the first and second days of a hospital stay in particular.

The third study (Chapter 4) is highly relevant for rehabilitation professionals. From the point of intake of a patient with TBI, clinicians need to be aware of the cause of injury; namely, whether injury was caused by unintentional or intentional mechanisms. Rehabilitation professionals should combine traditional rehabilitation approaches for functional recovery, which are not likely to be provided in in-patient rehabilitation. For patients with intentional TBI, more attention should be paid to the recovery of cognitive function.

5.3.2. Implications for rehabilitation policy

Rates of TBI and violence-related injury in Canada are well below those in the U.S. Thus, the findings of this thesis are more relevant to the Canadian population. Canadian perspectives on intentional TBI should include an awareness of the sizable number of intentional TBI cases in both acute care and in rehabilitation programs. Epidemiological studies on this vulnerable population need to be monitored on a regular basis to help promote preventive efforts. Rehabilitation services for the TBI population need to be more carefully geared toward people with intentional TBI.

The first study in this thesis proposes injury prevention strategies for, epidemiological features of, and risk factors causing, intentional TBI. This study suggests that rehabilitation professionals need to be aware that approximately 1 in 10 TBI patients are likely to have (a) violence-related injury, and therefore (b) different pre-injury demographic characteristics. Both of these factors affect rehabilitation outcomes, such as

functional changes and discharge destinations. Consequently, close attention to each patient's cause of injury prior to the provision of rehabilitation services is needed.

Via these studies, we also found that a history of alcohol/drug abuse frequently accompanied intentional injury, not only as a risk factor for sustaining intentional TBI but also as the major predictor of an increased likelihood of discharge against medical advice. Alcohol and drug abuse pre-injury has been considered a predominant risk factor for TBI occurrence, and also for alcohol abuse one year after TBI (Kolakowsky-Hayer et al., 1999; Sherer et al., 1999; MacMillan et al., 2002; Horner et al., 2005). Moreover, it was suggested that additional interventions, including substance abuse treatment and longer-term follow-up, would be required for this population (Bombardier et al., 2003; Horner et al., 2005).

Efficacy of inpatient rehabilitation programs should also be examined in relation to relative gains in functional recovery resulting from the programs provided to patients.

5.3.3. Future research

An epidemiological study with recent data is required to capture more recent epidemiological features. Future studies could include the temporal variations of onset of injury. Studies of the time of day, and day of the week and month of the occurrence of intentional injury could provide helpful information for the design of more targeted prevention strategies.

Strategies for the prevention of DAMA, targeted to patients with TBI or intentional injury, should be designed and implemented. Considering the reasons for DAMA, qualitative research could provide more comprehensive information; the reasons for DAMA could be better defined if qualitative methods were combined. DAMA cases can also occur in rehabilitation settings, thus DAMA studies on patients in rehabilitation need to be conducted. The NRS has a parameter named 'Person withdrew against professional advice' in the Reason for Discharge variable, which could be explored further.

Relative functional gains are not yet important indicators for the Hospital Report (Cott et al., 2003) in Canada. In order to enhance the quality of rehabilitation services, these parameters need to be consistently incorporated in future research.

For the study of rehabilitation outcomes, more research on long-term outcomes of intentional TBI is recommended. This includes a focus on both self inflicted and other inflicted TBI more specifically. Intentional injury could also influence psychosocial functioning and vocational functioning in community settings. More outcomes, such as depression, post-traumatic stress disorders, interpersonal relationships, family roles, and return to work would be of interest in future studies.

Intentional TBI can be found among soldiers, workers, health care providers and among vulnerable populations such as homeless persons, inmates, prostitutes, and the elderly. The intentional TBI population has more pre-injury socio-economic and psychosocial problems, compared to people who sustain unintentional injuries. Thus, close

observation of and research directed at this population is required. Appropriate intervention programs based on future studies should also be developed.

5.4. Conclusion

This study was designed to discover information on intentional TBI for which we have limited Canadian data. Although intentional TBIs are not the most common types of injury, they pose unique challenges to front-line care, both acute and rehabilitation care. A person who has been injured due to assault or suicidal attempt may need more individualized care as they may be at greater risk for adverse rehabilitation outcomes. This research highlights the demographic and clinical characteristics of this group in relation to rehabilitation outcomes, and informs effective use of resources and professional practice.

Appendix A: E-Codes categories for the OTR (CIHI, 2002)

The following lists the E Code categories used for the OTR and the DAD reporting purposes, based on the OTR trauma definition. 'Incident' and 'unintentional' have been substituted for the terms 'accidents' and 'accidental' used in the ICD definitions.

E Code Category		Definition
Motor Vehicle/Traffic Accident (MVA)	E800-E807	Railway incidents
	E810-E819	Motor vehicle traffic incidents
	E820-E825	Motor vehicle non-traffic incidents
	E826	Pedal cycles
	E827-E829	Other road vehicle incidents
	E830-E838	Water transport incidents
	E840-E845	Air and space transport incidents
	E846-E848	Vehicle incidents not elsewhere classifiable
Falls	E880-E888	Unintentional falls
Other	E890-E899	Incidents caused by fire and flame
	E900-E902, E906-E909	Incidents due to natural and environmental factors
	E910 & E913	Incidents caused by drowning and suffocation
	E914-E915	Foreign bodies (excluding choking)
	E916-E928	Other incidents
Intentional (self-inflicted)	E953-E958	Suicide and self-inflicted injury (excluding poisoning)
Intentional (assault)	E960-E961, E963-E968	Homicide and injury purposely inflicted by other persons
Others	E970-E976, E978	Legal intervention
	E983-E988	Injury undetermined whether unintentionally or purposely inflicted
	E990-E998	Injury resulting from operations of war

APPENDIX B. Discharge outcomes from the MDS OTR (CIHI, 2002)

Variable name: discharge dispositions

Variable codes

01: transfer to home without services

02: transfer to home with services

03: transfer to facilities (acute rehabilitation, other hospitals)

04: signed out against medical advice

05: dead

06: cadaver

07: still birth

This study (Chapter 3) was categorized into two groups: Regular discharge group (01, 02, 03) and DAMA group (04). Dead (05), cadaver (06) and still birth (07) were excluded in this study.

APPENDIX C. Comparison of the referral sources between merged NRS and original NRS (year of 2001-2006, age less than 65)

A total of 263 (13.4%) patients in the original NRS dataset were from other referral sources; these patients' records might lack the acute hospital data. Of the cases that were in the merged NRS with acute care data, 92.8% came directly from acute care settings, which was higher than those in the original unmerged NRS dataset (86.6%). This difference was statistically significant (chi-square test for inpatient units vs. others within the two datasets, chi-square statistic=53.325, df=1, $p < 0.0001$).

When the NRS data file was merged with acute care data, the merged data file captured 81.6% of the original NRS dataset. Therefore, 18.4% (n=362) of TBI patients in the original NRS data set were not included in the merged data file.

Possible explanations for this loss of data are as follows:

1. Not all patients were transferred from acute inpatient units: 86.6% of TBI patients came from acute units, according to a current data analysis. Therefore, 13.4% (n=263) of patients were admitted from other places, for instance from rehabilitation units, long term care facilities, or home care agencies. As such, these patients would not have had an acute care episode just prior to being admitted to inpatient rehabilitation, and therefore would not have been captured in the DAD, which provides mechanism of injury data. Of the cases that were in the merged data file, 92.8% came directly from acute care settings; this quantity of cases was significantly higher than the number of cases in the original, unmerged NRS data file (chi-square statistic=53.3, df=1, $p < 0.0001$).
2. A very small percentage of cases in the NRS (0.2%) may have been missing a health

card number, which is a critical variable needed to perform data linkage (CIHI, 2009). The only identifier for data linkage was the individual health card number.

3. There are duplicate records in the NRS. Because the NRS is ‘admission based’, and because CIHI allows for corrections and updates to any previously submitted records at a later date, numbers reported for any period may change if/when a query is rerun at a later date (MOHLTC, 2005, as cited in MOHLTC, 2006). There is a possibility that if an individual had more than one admission to the NRS, we may have only captured one prior acute care episode, most likely preceding the first NRS admission rather than prior to a subsequent NRS admission.
4. The NRS was voluntarily reported up to 2002. MOHLTC (2006) reported that caution should be exercised regarding data quality, as the NRS is still relatively new. Using data prior to October 2002 is discouraged. The Institute for Clinical and Evaluative Sciences (ICES) also mentioned that the NRS is a new program so there may be data inaccuracies (ICES, 2005, as cited in MOHLTC, 2006).

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