Traumatic Brain Injury in Older Adults: A Descriptive and Etiologic Analysis

by

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AUTHORS DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

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DEDICATION

To William R. Carson (1931-2013).

For giving your grandchildren all that they needed to be successful and happy.

ABSTRACT

A two-part study was undertaken to determine the characteristics and incidence of older adults who sustained a traumatic brain injury (TBI) while in Ontario home care from 2003 to 2013, and to determine the association between depression and sustaining a TBI. Both parts used data from the Ontario Association of Community Care Access Center's database. Data were retrieved for all service users 65 years or older who had home care between 2003 and 2013; these data are based on the Resident Assessment Instrument-Home Care. The variables used in the analyses included: TBI, depression, demographics, neurological conditions and history of falling. For the descriptive component, comparisons of characteristics were made between service users who did and did not sustain a TBI using odds ratios (OR). The ten-year trend of annual cumulative incidence and standardized incidence rates were assessed using regression. For the etiologic component, incident TBI cases were matched to four controls by age, sex and date of assessment. Crude OR's were determined for the association between depression and TBI. Multivariable conditional logistic regression was used to adjust for potential confounders and identify effect modifiers. Multivariable estimates were stratified by history of falling. A total of 554,313 service users were included, of which 5215 (0.9%) had a TBI and 39,048 (7.0%) had depression. Characteristics associated with TBI were: male sex (OR: 1.54, 95% CI: 1.45, 1.62), aboriginal origin (OR: 1.98; 95% CI: 1.57, 2.50), increasing age (OR: 1.22, 95% CI: 1.09, 1.35 for 70-74; up to OR: 2.31, 95% CI: 2.05, 2.59 for >90; referent group 65-69), being widowed (OR: 1.59, 95% CI: 1.41, 1.80), having a history of one or more falls (OR: 2.31, 95% CI: 2.19, 2.44), the use of antidepressants (OR: 1.49, 95% CI: 1.40, 1.59) and the presence of depression (OR: 1.57, 95% CI: 1.43, 1.71), dementia (OR: 1.65, 95% CI: 1.54, 1.76), hemiplegia (OR: 4.34, 95% CI: 3.88, 4.85), multiple sclerosis (OR: 3.19, 95% CI: 2.49, 4.08) and parkinsonism (OR: 1.22, 95%

CI: 1.07, 1.38). Incidence was significantly higher than previously reported figures in the general population. There was a decrease in the annual cumulative incidence over the ten-year period. Female standardized rates decreased significantly ($p<0.05$) in a linear fashion while male and overall decreased in a non-linear fashion. The crude OR for the association between depression and TBI was 1.54 (95% CI: 1.43, 1.64). Stratified analyses indicated that the association was significantly different for those with a history of falling (OR: 1.45, 95% CI: 1.22, 1.73) and those without a history of falling (OR: 1.19, 95% CI: 0.99, 1.42). Multivariable analysis suggested that there were three significant effect modifiers for the exposure: history of falling, level of education and Alzheimer's. As the level of education increased, the association between depression and TBI became smaller (OR: 1.88, 95% CI: 1.30, 2.70 for 8^{th} grade or less compared to OR: 1.11, 95% CI: 0.78, 1.65 for graduate degree). Service users with a TBI had greater odds of having a history of falling (OR: 1.45, 95% CI: 1.22, 1.73) and being diagnosed with Alzheimer's Disease (OR: 1.18, 95% CI: 1.05, 1.32). Longitudinal studies are needed to confirm this finding, as our study was cross-sectional in nature, and to investigate the association between other chronic conditions and TBI.

Table of Contents

LIST OF TABLES

1. INTRODUCTION

Traumatic brain injury (TBI) represents a common and costly problem for the health care system and society. Increasing age, female sex, non-white race, and the presence of certain medical conditions are known risk factors for TBI in the older adult population aged 65 years and above (1, 2). Consequently, as the Canadian population ages, there may be an increasing burden of TBI on the health care system. Yet, few population-based estimates of the current incidence of TBI in the older adult population exist.

Home care is a relatively new development in caring for older adults (3). There has been substantial investment in home care at the provincial level due to its cost-effectiveness compared to long-term care, and for the ability to help older adults live independently in the community (3). Investigating TBI in this subset of the home care population will help understand the care needs with regards to TBI so appropriate supports can be implemented or improved.

A retrospective cohort study was used to describe the demographic characteristics and determine the annual cumulative incidence of those who sustained a TBI in an older adult home care population of Ontario from 2003 to 2013. Additionally, the association between depression and TBI in the older adult population was assessed using a nested matched case control study design. Depression is known to be associated with an increased risk of falling, and falls are correlated with TBI. Yet, no one has assessed the direct effect of depression on TBI. Understanding this association will help target interventions for primary prevention of TBI in groups that are most at risk.

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2. OBJECTIVES

(1) To describe the characteristics of older adults (aged 65 years or older) who sustain a TBI while using home care in Ontario.

(2) To determine the annual cumulative incidence and assess the 10-year trend of TBI incidence in older adults using home care in Ontario.

(3) To determine the association between depression and TBI in older adults using home care in Ontario.

3. BACKGROUND & RATIONALE

3.1 TBI in Older Adults

Traumatic brain injury (TBI) is the most common cause of death and disability in adolescents and older adults (1, 2). Although all ages experience TBI, youth and adolescents along with older adults aged 65 and above have the highest incidence of TBI hospitalization (3). TBI can result in a variety of long term cognitive, physical, behavioral, and emotional consequences, and consequently TBI is one of the most disabling injuries (3). In addition to disability, TBI in the older adult population can lead to an increased risk of other health conditions including epilepsy, depression and potentially Alzheimer's disease (4-6). It has been estimated that over 10 million TBI's occur annually in the general population and that over 57 million people have been hospitalized with one or more TBIs during their lifetime (2). Estimates of both the direct and indirect costs have shown that TBI is the most frequent, common, and costly cause of injury in the US and Canada (7). Older adults aged 65 and above account for over 70% of the estimated $20 billion in yearly direct and indirect TBI related costs in Canada (7, 8). Falls and motor vehicle collisions are the leading causes of death and disability from TBI in the older adult population (1); yet, little is known regarding factors associated with incident TBI cases.

TBI can be graded as mild, moderate, or severe on the basis of symptoms, including consciousness, eye movements, awareness, etc. These are commonly captured in the Glasgow coma scale (GCS) score (9). Mild traumatic brain injury (GCS 13-15) accounts for 70-75% of all TBI's, and in most cases there is full neurological recovery within three months to a year (1, 10, 11). In moderate TBI (GCS 9-13) the patient is dazed and lethargic (1) and in severe TBI (GCS 3-8) the patient is in a comatose state and unable to open his or her eyes or follow basic

functional commands (1). Patients with severe TBI often have a significant risk of hypotension and brain swelling and if the injury is not treated appropriately then it can result in death (1).

Because only hospitalized cases are commonly captured when determining incidence of TBI in older adults, the true number of persons sustaining a TBI is likely much higher than the reported hospitalization figures. In the United States, the age-adjusted hospitalization rate for TBI in the general population is 60.6 per 100,000 population; however, for older adults aged 65 and above this rate increases to 155.9 per 100,000 population (8, 11). Longitudinal trends of TBI incidence in the older adult population have been largely under studied. However, studies focusing on the general US population have shown a small overall decrease in the incidence of TBI leading to hospitalization (12). The decrease in incidence is most likely due to alterations in hospital admission policies, enhanced intracranial imaging, and improvements in acute trauma care (12). Comparing data from 1980-1981 with 1994-1995 in the United States, hospitalized TBIs decreased 51% in the general population (12). Severe TBI increased during this time period from 10% to 19%, while both mild (61%) and moderate (19%) TBIs decreased (12). However, in the older adult population, the incidence of all cases of TBI only decreased 9% during that time period (12). Older adults have the highest rates of TBI hospitalization (155.9 per 100,000 population) (8, 11) and death (30-80%) (8) yet, the incidence of TBI in the general older adult population is largely unknown.

Risk factors for sustaining a TBI in the older adult population include non-white race, female sex, and the presence of one or more chronic diseases (3, 8). Studies have shown that prior to sustaining a TBI, 73% of older adults versus 23% of younger adults had a medical condition before the injury occurred (8). This higher prevalence of comorbid disease among older adults suggests that the presence of disease may play a significant role in the occurrence,

outcome, and prognosis of TBI. Research has shown that neurological diseases associated with dementia or mild cognitive impairment (e.g., Alzheimer's disease or other etiologies) (6, 13) along with depression are risk factors for TBI (14). Studies of TBI risk factors have mostly taken place in the United States using hospitalization-based studies and no studies appear to have examined risk factors in the general Canadian population.

3.2 Impact of Depression

Depression is a prevalent mental health condition and is a major public health concern. The accumulation of a long life of depressive events can put older adults at a particularly high risk of depression (15). Older adults with depression can experience feelings of sadness, anxiety, helplessness, irritability or restlessness along with sleeping problems, digestive problems, general aches and thoughts of suicide (16). Older adults have some of the highest rates of depression in Canada and depression has a significant effect on their quality of life and wellbeing (17). Community based studies in the United States have found that a diagnosis of depression is present in 1.8% to 8.9% of older adults (18-22). However, the prevalence of depression in acute and long-term care settings is even higher, ranging between 20% and 40% (23, 24). Persons with depression are at a significantly greater risk for suicide, overall mortality and other adverse health events (15, 25) . Older adults in particular have the highest rates of suicide compared to other age groups, representing approximately 17% of all suicides (25). The overall mortality rate associated with depression among older adults aged 65 and above has been shown to be 16% (19). As the Canadian population ages, the prevalence of depression in older adults is hypothesized to increase based on population estimates (20).

Depression can be complicated to diagnose in the older adult population. Older adults may experience personal loss such as the death of a spouse, making it difficult to separate normal grief from clinical depression (26). The prevalence of poor physical health in older adults can also mask mood symptoms, making it harder to differentiate between a medical illness and a psychological illness (26). Older adults with a medical illness are twice as likely to develop depression compared to those without a medical illness (27). In addition, depression can interfere with treatment compliance, medical recovery and lead to disability (28, 29). Understanding the role of depression as a risk factor for falling and consequently TBI has the ability to impact the day-to-day lives of older adults.

3.3 Association Between Depression and Falling

It is important to understand the relationship between depression and falling so that it is possible to examine the effect of depression on TBI. Research has shown that falling is associated with over 75% of TBI's in the older adult population aged 65 and above (12). Existing research on the association between depression and falling is limited. Although there are some studies that have looked at the association between depression and falling, these studies have mostly taken place in a hospital setting and have focused on patients with specific ailments such as knee problems or spinal injuries (30). The majority of studies focus on the development of depression after an injury or medical condition, as opposed to whether or not depression is a risk factor for the injury or condition itself. There have been few studies formally examining the association between depression and falling in a community dwelling older adult population with various illnesses and medical conditions.

Biderman and colleagues (2002) conducted a study of older adults aged 60 and above in Israel to determine whether there was a common set of factors that could predict an increased risk of both depression and falling (31). They used a cohort study design with a one-year follow up of 283 persons from a mixed socioeconomic population that were recruited from a primary care clinic (31). At follow up, 12% of the sample reported frequent falls and 25.5% screened positive for depressive symptoms. Five risk factors were successful at discriminating between fallers and non-fallers (86% discrimination) and those with and without depressive symptoms (76% discrimination): self rated health, impaired ADL, poor cognitive status, two or more clinic visits in the past month and slow walking speed (31). For each factor added, there was an increased risk of falling and showing depressive symptoms. Although these results show common risk factors between depression and falling, the study objective was not to determine the association between falling and depression. Additionally, the study examined participants in a clinical setting as opposed to a community dwelling setting.

Tinetti and colleagues (1998) conducted a prospective cohort study of 336 older adults aged 75 and above living in the community to determine the risk factors for falling (32). After undergoing detailed mental and physical evaluations, participants were followed up bi-monthly for one year to identify falls and their circumstances (32). The study found that six factors were directly associated with risk of falling: sedative use, cognitive impairment, disability of the lower extremities, palmomental reflex, abnormalities of balance and gait and foot problems. The risk of falling increased linearly with the number of risk factors present, from 8% with no risk factors to 78% with four or more risk factors (32). For depression in particular, they found that the relative risk of falling was 70% greater among elderly people with depression than elderly without depression (32). The main limitation of this study was the inclusion criteria of being aged 75 or

above. Because of this inclusion criterion the study missed capturing older adults between the ages of 65 and 75, which are at a high risk for falling.

Whooley and colleagues (1999) conducted a prospective study of elderly Caucasian women aged 65 and above who were recruited from population-based listings in the United States to determine whether depression leads to increased risk of bone fracture (33). The study found that women with depression were more likely to experience falls than women without depression (70% versus 59%) (33). The age adjusted hazard ratio (HR) for this association was 1.6 (95% CI: 1.3, 1.9) and this association persisted after adjusting for various confounding variables that included age, marital status, history of vertebral fracture, history of stroke, history of myocardial infarction, hypertension, COPD, diabetes, arthritis, weight gain, physical activity level, smoking, alcohol consumption, supplement use and hypotension (HR: 1.6; 95% CI: 1.3, 1.9). Women with depression were also more likely to have non-vertebral (HR: 1.4, 95% CI: 1.2, 1.7) and vertebral fractures (HR: 2.1, 95% CI: 1.4, 3.2) (33). Unfortunately this study only looked at Caucasian women aged 65 and above, so consequently the study results are not generalizable to the male older adult population.

Graafmans and colleagues (1996) conducted a prospective cohort study of 354 older adults aged 70 and above who were living in homes or apartments for the elderly in Amsterdam to determine the risk factors and profiles of those who fall (34). During a 28-week period, 251 falls were reported by 126 subjects (36%) and recurrent falls were reported by 57 subjects (16%) (34). The Geriatric Depression Scale was used to measure depression and they found that 23% of participants were depressed (34). Persons with depression were not more likely to fall (OR: 1.6, 95% CI: 0.9, 2.8) but were more likely to have a recurrent fall (OR: 2.2, 95% CI: 1.1, 4.3). The authors did not adjust for potential confounding factors such as age, marital status or other

medical conditions. Consequently, this association is suggestive only and does not demonstrate a true causal association. This study did not have a large sample size and failed to capture the elderly between the ages of 65 and 70.

Robinson and colleagues (35) conducted a small cross sectional study of 40 persons with idiopathic Parkinson's disease to determine the risk factors associated with falling in this population. They found that among fallers, 71% had been diagnosed with depression compared to 19% among non-fallers (35). This study had a very small sample size and only looked at falling in persons with Parkinson's disease and so the results would not be generalizable to the entire population. The study used a cross sectional design so the results cannot be interpreted as causal.

Based on the described research the presence of depression is likely a risk factor for falling. However, the studies described have small sample sizes and focus on persons who are hospitalized and/or have specific ailments. This study will address the literature gap by focusing on the general older adult population who are accessing home care using a large sample size.

3.4 Antidepressants and Falling

A review of the literature indicates that although there are substantial studies looking at post-TBI depression symptomology, there is little existing research looking into depression as a risk factor for sustaining a TBI. Demographic characteristics such as level of education, sex and marital status have not been shown to be predictive of depression and the associated side effects of depression in the older adult population (36). However, medications used to treat the symptoms of depression can have side effects that may increase the risk of falling and subsequently sustaining a TBI (37).

Common side effects of the popular selective serotonin reuptake inhibitors (SSRIs) that are used to treat geriatric depression include nausea, insomnia, dry mouth, excessive sweating and sexual dysfunction (37). SSRIs are generally considered one of the more safe treatments for depression among the elderly, however approximately 10% of patients taking SSRIs develop hyponatremia (abnormally low levels of sodium in the blood) due to inappropriate secretion of antidiuretic hormone (37). Low levels of sodium can cause fatigue, malaise and delirium, and combined with the use of other diuretics these symptoms can increase significantly (37). These symptoms can lead to falling, which in turn can increase the risk of sustaining a TBI (38).

A study completed by Arfken and colleagues (38) investigated the association between SSRIs and falling among older nursing home residents. All older adults above the age of 60 and who were residents of the nursing home during the year 1995 were eligible for inclusion in the study. The total sample size of both persons who fell (n=190) and persons who did not fall (n=272) was 462 (38). The study found that older adults using SSRIs were significantly more likely to fall compared to older adults not taking antidepressants (p=0.003) and were significantly more likely to have an injurious fall (p=0.03) (38). Even after controlling for demographics and the use of other medications, the association between SSRI use and falling remained significant (p=0.007) (38).

A similar study completed by Ruthazer and Lipsitz investigated the association between antidepressant use and falling in older adults aged 65 years and older (39). All residents of a long-term care setting were prospectively followed for a one-month period to watch for the occurrence of falls. They found that residents of the long-term care facility that were female and taking antidepressants had an increased risk of falling (OR: 1.84, 95% CI: 0.91, 3.69), even after controlling for confounders (demographics, medication use, functional status and history of

falling) (39). They did not find an increased risk of falling among men who were taking antidepressants (antidepressant use was not significant at the bivariate level for males so was not examined in the multivariable model), however the sample size of males (n=147) was substantially lower than females (n=488) (39).

Tricyclic antidepressants are another medication commonly used to treat depression in the geriatric population (37). They have a number of side effects that include, but are not limited to postural hypotension, cardiac abnormalities, anticholinergic effects and the symptoms commonly associated with SSRI use (37). Postural hypotension in particular has been shown to increase the risk of falling, which can lead to fractures and potentially sustaining a TBI (40). In addition, tricyclic antidepressants have been shown to worsen certain medical conditions among the elderly such as dementia and Parkinson's disease (37).

A systematic review and meta-analysis completed by Leipzig and colleagues examined English language articles from 1966 to 1996 to critically evaluate evidence of the association between psychotropic drugs and falls in the older adult population (41). A total of 40 studies were included based on their eligibility criteria. They found that the association between any antidepressant use (mainly tricyclic antidepressants) and falling had an odds ratio of 1.51 (95% CI: 1.14, 2.00). The study found that the odds ratio for only tricyclic antidepressant use was 1.48 (95% CI: 1.23, 1.77) (41). The authors acknowledged that the data included in the meta-analysis is solely from observational studies with no adjusted estimates controlling for known confounders (41). Consequently, the meta-analysis may not have been an appropriate study to complete given the lack of etiologic studies.

A prospective cohort study completed by Ensrud and colleagues (42) over a one-year period looked at central nervous active medications (e.g., antidepressants, benzodiazepines,

anticonvulsants and narcotics) and the risk of falls among elderly women using a large sample size of 8127 women aged 65 or older. The study found that the odds ratio for the association between antidepressant use and falling was 1.54 (95% CI: 1.14, 2.07) (42). They found that there was no evidence to suggest that women who were using SSRIs (OR: 3.45, 95% CI: 1.89, 6.30) were less likely to experience frequent falls compared to those using tricyclic antidepressants (OR: 1.28, 95% CI: 0.90, 1.84) (42). Unfortunately this study only examined women and did not control for potential confounders.

A study completed by Thapa and colleagues (43) looked at antidepressant use and the risk of falling among nursing home residents using a sample size of 2428 women from Tennessee, United States. After controlling for a variety of confounding factors (admission date, demographic characteristics, functional status and other medication use) they found that the adjusted rate ratio for SSRIs and falling was 1.2 (95% CI: 1.0, 1.4) and for tricyclic antidepressants was 1.8 (95% CI: 1.6, 2.0; 43). The rates of injurious falls (falls that caused fractures, sprains, dislocations, lacerations or head injuries with altered consciousness) among those using SSRIs was 1.7 (95% CI: 1.2, 2.5) and for tricyclic antidepressant was 1.3 (95% CI: 0.9, 1.9), after adjusting for confounding factors (43). The study also found that the rate ratios for SSRIs and tricyclic antidepressants increased significantly as the dosages increased. The rate ratios for SSRIs increased to 1.9 (95% CI: 1.7, 2.2) for dosages of 20mg or more per day and the rate ratios for tricyclic antidepressants increased to 2.4 (95% CI: 2.1, 2.8) for dosages of 50mg or more per day (43).

Antidepressant medications have been shown to be associated with an increased risk of falling in the older adult population and may be linked to an increased risk of TBI as well.

Existing literature suggests depression, and its consequences, may increase the risk of falling, which in turn may increase the risk of TBI.

3.5 Contribution of this Thesis

A review of the literature indicates that there are no studies that have specifically examined the direct association between depression and sustaining a TBI in the community dwelling older adult population. Based on the studies outlined above it is probable that depression is associated with falling. However, the studies described did not address the association between depression and falling using a longitudinal study accounting for potential confounders, in a large community dwelling population aged 65 and above. This thesis research will fill the literature gap in order to inform clinical decision making in regards to preventing falls and TBI in older adults aged 65 and above with depression.

3.6 Thesis Format

This thesis is written in the format of two distinct journal articles that will be submitted for publication following thesis completion. The first article will be descriptive (Objective 1 & 2) and the second article will be etiologic (Objective 3). The first article titled "Characteristics and Incidence of Traumatic Brain Injury in Older Adults of Ontario from 2003-2013" will be submitted for publication to the journal Brain Injury and is formatted to their specific guidelines. The second article titled "The Association between Depression and Traumatic Brain Injury in Older Adults: A Nested Case Control Study" will be submitted for publication to the American Journal of Epidemiology and is formatted to their specific guidelines.

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4. HYPOTHESES

We hypothesize that the risk of sustaining a TBI will be higher in older age groups, females and non-white races. We hypothesize that the annual cumulative incidence of TBI in the older adult home care population will be greater than the reported figure for the age-adjusted hospitalization rate: 155.9 per 100,000 population (1, 2). We hypothesize that the 10-year trend of TBI incidence in older adults using home care in Ontario will decrease. We hypothesize that TBI will be associated with the presence of depression. We hypothesize that the association between TBI and depression will be larger for those with a history of falling than for those without a history of falling.

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5. CHARACTERISTICS AND INCIDENCE OF TRAUMATIC BRAIN INJURY IN OLDER ADULTS OF ONTARIO FROM 2003-2013

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5.1 ABSTRACT

OBJECTIVES: To describe the characteristics of and determine the annual cumulative incidence of traumatic brain injury (TBI) in the older adult (i.e., 65 years or more) home care population of Ontario from 2003 to 2013.

HYPOTHESES: The incidence of TBI will be highest in males, non-white races and in increasing age groups. The annual cumulative incidence will be greater than reported figures (155.9 per 100,000 population) and the incidence trend will decrease over time.

METHODS: A cross-sectional analysis of longitudinal data from the Ontario Association of Community Care Access Centers was conducted. TBI, demographic variables, depression, neurological conditions, and history of falling were measured from the validated Resident Assessment Instrument-Home Care. Comparisons were made between characteristics of service users who did and did not sustain a TBI using odds ratios and associated confidence intervals. The ten-year trend of annual cumulative incidence and standardized incidence rates were assessed using regression.

RESULTS: A total of 554,313 service users were included, of which 5215 (0.9%) sustained a TBI. Characteristics associated with TBI were: male sex (OR: 1.54, 95% CI: 1.45, 1.62), aboriginal origin (OR: 1.98; 95% CI: 1.57, 2.50), increasing age (OR: 1.22, 95% CI: 1.09, 1.35 for 70-74 years; up to OR: 2.31, 95% CI: 2.05, 2.59 for >90; referent group 65-69), being widowed (OR: 1.59, 95% CI: 1.41, 1.80), having one or more falls (OR: 2.31, 95% CI: 2.19, 2.44), the use of antidepressants (OR: 1.49, 95% CI: 1.40, 1.59) and the presence of depression (OR: 1.57, 95% CI: 1.43, 1.71), dementia (OR: 1.65, 95% CI: 1.54, 1.76), hemiplegia (OR: 4.34, 95% CI: 3.88, 4.85), multiple sclerosis (OR: 3.19, 95% CI: 2.49, 4.08) or parkinsonism (OR: 1.22, 95% CI: 1.07, 1.38). Incidence was significantly higher than previously reported figures.

There was no change in the annual cumulative incidence over the ten-year period ($p = 0.13$). Standardized rates decreased significantly among women ($p = 0.04$), but did not among men ($p = 0.41$).

CONCLUSIONS: Certain demographic characteristics, neurological diseases, the use of antidepressants and a history of falling are associated with TBI. The incidence of TBI in the older adult home care population of Ontario is higher than previous literature estimates and the incidence is not decreasing over time. A longitudinal analysis examining the characteristics associated with TBI should be conducted to assess causality.

5.2 INTRODUCTION

Traumatic brain injury (TBI) is a significant cause of disability and death in the adolescent and older adult population [1, 2]. Sustaining a TBI is not limited to a certain age group, however youth below the age of 21 and older adults aged 65 and above have the highest incidence of TBI hospitalizations [3]. Symptoms of TBI include a variety of physical, cognitive, emotional and behavioral consequences. TBI can also increase the risk of other adverse conditions such as epilepsy, depression and potentially Alzheimer's disease [4-6]. Because of the risk of disability and adverse health events, TBI is considered one of the most serious injuries among older adults. The yearly costs of TBI in Canada, both direct and indirect, have been estimated at over $20 billion [7]. An estimated 70% of this cost is due to older adults aged 65 years and above [7, 8].

The characteristics of persons who sustain a TBI have been studied considerably using hospital-based studies. Hospital based studies in the US have shown that demographic risk factors for sustaining a TBI in the older adult population include non-white race, female sex, the presence of certain conditions like depression and Alzheimer's disease [4, 7] and the use of antidepressants [4]. Studies of demographic risk factors for TBI have mostly taken place in the United States using hospitalization-based studies; it appears no studies have examined potential risk factors in the general Canadian population. There has been a substantial shift to support independence at home through the use of home care in Canada [9] and it is important to understand the risk factors for TBI in this population.

It is estimated that over 10 million TBI's occur annually across the globe and that over 57 million people have been hospitalized with a TBI during their lifetime [2]. For comparison, the annual cumulative incidence of TBI is greater than that of spinal cord injury, multiple sclerosis,

HIV/AIDS and breast cancer combined [10]. Because only hospitalized cases are commonly captured when determining TBI incidence, the true annual cumulative incidence rate of TBI is most likely much higher than the reported figures in Canada and the United States [10]. In the United States, the age-adjusted hospitalization rate for TBI in the general population is 60.6 per 100,000 population. However, for older adults aged 65 and above this rate increases to 155.9 per 100,000 population [7, 11]. Although longitudinal trends of TBI have been largely under studied in the general population, US studies have shown a small overall decrease in the annual incidence of TBI leading to hospitalizations [12]. Comparisons between the years 1980-1981 and 1994-1995 show that the annual incidence of TBI leading to hospitalizations decreased 9% in older adults aged 65 years and older [12]. Older adults have the highest rates of TBI hospitalization and death; yet, the incidence of TBI and associated risk factors in the general older adult population are largely understudied.

The objectives of this study were to 1) describe the characteristics of older adults sustaining a TBI while using home care in Ontario, Canada and 2) determine the annual cumulative incidence and assess the 10-year trend of TBI incidence in older adults using home care in Ontario.

It is hypothesized that TBI will be associated with older age, male sex, and non-white race. It is further hypothesized that the annual cumulative incidence of TBI in the older adult home care population will be greater than the reported figure for the age-adjusted hospitalization rate of 155.9 per 100,000 population. It is also expected that the 10-year trend of TBI incidence in older adults using home care in Ontario will decrease over time.

5.3 METHODS

5.3.1 Data Source

The data source used for this research was the Ontario Association of Community Care Access Centers (OACCAC) home care database. The OACCAC home care database includes longitudinal assessments of all individuals in Ontario, Canada, expected to be in home care service for 60 or more days (i.e., long stay clients) [13]. Any person, regardless of income, who is eligible can receive publicly funded home care [14]. Service users are assessed every 6-months for the duration of their service, or when there is a significant change in status (which includes sustaining a TBI) [15]. However, the period of time between assessments may be longer.

5.3.2 Assessment Instrument

Analyses are based on the RAI-HC assessment system, which is used as part of regular practice in Ontario's home care sector. The RAI-HC was developed by the InterRAI collaborative network as a means of examining issues in older adults related to functioning and quality of life [15]. The RAI-HC supports evidence-informed clinical decision-making, and can help health professionals in the planning, implementation, and monitoring of care [15].

The RAI-HC has a variety of items, which fall under the domains of identifying information, demographic items, assessment information, cognitive patterns, communication/hearing patterns, mood and behavior patterns, social functioning, physical functioning, disease diagnosis, medications and more [15]. Many of the items on the RAI-HC are organized into scales and clinical assessment protocols (e.g., Depression Rating Scale) to help interpret the meaning of the items. The items included in the RAI-HC have been shown to be valid and reliable by numerous national and international studies [16-19]. The RAI-HC

assessment is administered by trained assessors (nurses or social workers), who use all sources of information available to complete all sections of the instrument [15].

5.3.3 Study Design

Characteristics of those who sustained a TBI between 2003-2013 were captured using the RAI-HC. Characteristics of those who sustained a TBI were compared to those who did not sustain a TBI (controls). Controls were service users who did not sustain a TBI from 2003-2013. Control characteristics were measured at the time of initial assessment while case characteristics were measured at the time of TBI. A retrospective cohort study was used to determine the annual cumulative incidence and describe demographic characteristics of older adults sustaining a TBI while using home care in Ontario. Individuals were eligible for inclusion in the study if they were aged 65 years or older and were administered home care between 2003 and 2013. The annual cumulative incidence of TBI from 2003-2013 was determined using the yearly number of incident TBI cases from the OACCAC home care database as the numerator, and the yearly number of service users who were administered home care as the denominator. If someone had more than one TBI over the time period, only the first occurrence would count as a TBI for the respective year it occurred. Annual cumulative incidence was used to assess TBI trends over a 10-year period. We calculated standardized rates using the 2003 base population as the standard and then used these rates to compare the incidence over the 10-year period. Ethical review was not required to conduct this study due to the use of anonymized secondary data [22].

5.3.4 Study Measures

Traumatic brain injury: The primary outcome for this study was incident cases of TBI. The definition of TBI as stated in the RAI-HC user manual is "damage to the brain as a result of physical injury to the head" [Page 212; 13]. Incident TBI cases were identified from the disease diagnoses section of the RAI-HC form. Cases were considered incident because nurses or social workers completing the RAI-HC were instructed not to include past TBI, which ensures that only incident cases were captured. There are two ways to capture TBI: the "Head Trauma" item and text entries. A diagnosis of "Head trauma" was used to capture cases of TBI [13]. TBI is indicated as present on a person's RAI-HC assessment if the doctor has indicated it affects a person's status, requires treatment, or symptom management. TBI is also indicated as present if the disease is monitored by a home care professional or led to a hospitalization in the 90 days prior to the RAI-HC assessment (or since last assessment if less than 90 days) [13]. On the RAI-HC assessment, TBI is coded as either not present (blank check box), (1) present- not subject to focused treatment or monitoring by home care professional, or (2) present- monitored or treated by home care professional [13]. For this study we recoded TBI as present if either (1) or (2) was indicated on the RAI-HC assessment. In addition to capturing TBI using the "Head trauma" item, the text entries section was also used to capture TBI. This section allows health care workers to input text that describes the diagnoses of interest. Using this section will help capture more instances of TBI, as health care workers would not always indicate TBI as present under the diagnoses of "head trauma." Any text diagnoses in this section that referred to head trauma, concussion, closed head injury, head injury or acquired brain injury was used to capture cases of TBI (Appendix B).

This method of capturing TBI from the RAI-HC has been validated by Foebel and colleagues [20]. Foebel and colleagues compared the RAI-HC measure of TBI with linked data

from the National Ambulatory Care Reporting System (NACRS) and the Canadian Institute for Health Information (CIHI) to determine the validity of the measure of specific items on the RAI-HC. The RAI-HC had a sensitivity of 0.23, a specificity of 0.99, a positive predictive value of 0.22 and a kappa statistic of 0.22 compared to CIHI and NACRS data [21]. The low sensitivity of the TBI outcome measure may be due to the vague nature of how TBI is captured (using the "head trauma" item), making assessors less likely to record a TBI. This outcome measure is the most appropriate due to the lack of proper case definition and measurement tool for capturing TBI in community dwelling older adults.

Demographic variables: Demographics were measured at the time of TBI for cases and from the initial assessment date for controls. Demographic characteristics of those who sustained a TBI in the older adult home care population over the 10-year period were described and compared to those who did not sustain a TBI over the 10-year period. Demographic characteristics included: sex, age, aboriginal origin, marital status and highest level of education completed [13].

Depression: Depression was measured at the time of TBI for cases and from the initial assessment date for the controls. Depression was assessed individually using the Depression Rating Scale (DRS; 23), based on the mood and behavior patterns section of the RAI-HC. An indicator can be coded as either not present (leaving the check box blank), (1) exhibited in 1-2 of the last three days, or (2) exhibited on each of the last 3 days [13]. A service user was considered depressed if they had a score greater than or equal to 3 out of 14 on the DRS. Depression in the residents past was not captured, only depression that was present at the time of assessment and had an impact on the service users status, required treatment or active monitoring [13].

Burrows and colleagues (2000) compared the RAI-HC depression scale described above with the Cornell Scale for Depression and the Hamilton Depression Rating Scale [23]. They found that a cut-point score of 3 or greater on the RAI-HC depression scale maximized sensitivity (0.78 for Cornell and 0.94 for Hamilton) with minimum loss of specificity (0.77 for Cornell and 0.72 for Hamilton) when tested against cut-offs for mild to moderate depression [23].

Antidepressants: Antidepressant use was measured as a potential confounder and effect modifier using the RAI-HC (22). Antidepressant use was captured as a categorical variable, under the receipt of psychotropic medication heading. Antidepressant use is captured as present if antidepressants were taken in the last 7 days or since last assessment. Antidepressant use was captured at the time of TBI for cases and from the assessment date nearest to the index data (time of matched case's TBI) for controls.

Neurological diseases: Neurological diseases were measured at the time of TBI for cases and from the initial assessment date for controls. A service user was considered as having a neurological disease if it was indicated as present at the time of assessment. Neurological diseases were reported using the list of disease diagnoses and included: Alzheimer's disease, dementia other than Alzheimer's disease, hemiplegia/hemiparesis, multiple sclerosis and parkinsonism [13]. Neurological diseases were ascertained as present similarly to TBI [13]. Foebel and colleagues [20] found that the validity of items related to diagnoses of Alzheimer's disease and other dementia (sensitivity of 0.76; specificity of 0.89; PPV of 0.53; kappa statistic of 0.55), parkinsonism (sensitivity of 0.83; specificity of 0.98; PPV of 0.59; kappa statistic of 0.68), and multiple sclerosis (sensitivity of 0.90; specificity of 1.00; PPV of 0.77; kappa statistic of 0.83) was acceptable.

History of falling: History of falling was measured at the time of TBI for cases and from the initial assessment date for the controls. History of falling was captured as an ordinal variable, under the heading of falls frequency [13]. Falls frequency is reported as the number of times fallen in the last 90 days (or since the last assessment if less than 90 days), coded as "0" for none, or "9" if nine or more falls [13]. For the purposes of this study history of falling was categorized as no falls or one or more falls.

5.3.5 Data Analysis

Univariate descriptive analyses were conducted on all variables to check for errors and outliers, examine distributions and to examine responses for each of the variables. Counts and proportions were determined for all variables and means and standard deviations were reported for continuous variables.

To achieve the first objective, the characteristics of service users who sustained a TBI were described using univariate statistics. Means and standard deviations were used to examine continuous variables and proportions were used to describe categorical variables. Odds ratios and 95% confidence intervals were calculated for each characteristic to compare home care service users who did and did not sustain a TBI.

To achieve the second objective, the annual number of incident cases of TBI that occurred each year from 2003-2013 in eligible service users were divided by the eligible service users who were administered the RAI-HC assessment during that year. A sensitivity analysis was conducted on the overall annual cumulative incidence of TBI using the sensitivity of 0.23 based on previous work [20] to determine what the true incidence would be using a measure with high sensitivity. The sensitivity of 0.23 indicated that there would be 77% more cases of TBI should a

measure with 100% sensitivity be used. Thus, 77% more cases were added to each annual cumulative incidence rate in order to determine the true incidence. Age-and sex-standardized annual cumulative incidence rates were calculated with 95% confidence intervals (standardized to the 2003 base population). Linear regression was used to determine if there was a significant change in standardized annual cumulative incidence rates over the 10-year period. All data were analyzed using SAS software, version 9.4 [23].

5.4 RESULTS

The total sample size for this study was 554,313 service users, of which 5215 (0.9%) had sustained a TBI while in Ontario home care from 2003 to 2013. There were no differences between TBIs that were captured using the "head trauma" item (n = 4188) and the other text diagnoses section (n = 1027) of the RAI-HC. Service users without TBI had similar characteristics to all service users (Table 1). Service users with TBI had a more equal sex distribution, a greater prevalence of depression and antidepressant use, dementia and hemiplegia and had more service users with a history of falling. Males and females with TBI were similar on most characteristics; however, males were more likely married, while females were more likely widowed. Females with TBI also had a higher prevalence of depression and a lower prevalence of hemiplegia compared to males with TBI.

Table 1. Univariate descriptive characteristics of all service users, service users without TBI, service users with TBI, and the OR comparing service users with and without TBI in the older adult home care population of Ontario from 2003 to 2013.

Variable	All service users	Service users without TBI	Service users with TBI	Odds Ratio (95% CI)
N	554,313	549,098	5215	
TBI				
Yes	5215 (0.9)			
No	549,098 (99.1)			
Sex				
Male	202,536 (36.5)	200,094 (36.4)	2442 (46.8)	1.54 (1.45, 1.62)
Female	351,745 (63.5)	348, 972 (63.6)	2773 (53.2)	1.0
Aboriginal origin				
Yes	3973 (0.7)	3900 (0.7)	73 (1.4)	1.98 (1.57, 2.50)
No	550,308 (99.3)	545,167 (99.3)	5141 (98.6)	1.0
Missing	32	31	1	
Age				
65-69	44,531 (8.0)	43,896 (8.0)	635 (12.2)	1.0
70-74	65,964 (11.9)	65,189 (11.9)	775 (14.9)	1.22 (1.09, 1.35)
75-79	102,669 (18.5)	101,609 (18.5)	1060 (20.3)	1.47 (1.33, 1.63)
80-84	139,201 (25.1)	137,949 (25.1)	1252 (24.0)	1.88 (1.71, 2.08)
85-89	122,555 (22.1)	121,557 (22.1)	998 (19.1)	1.40 (1.28, 1.55)
>90	79,393 (14.3)	78,898 (14.4)	495 (9.5)	2.31 (2.05, 2.59)
Mean (SD)	81.9 (7.6)	81.9 (7.6)	80.2 (7.7)	
Education level				
8^{th} grade or less	133,701 (24.1)	132,442 (24.1)	1259 (24.1)	1.0
9^{th} – 12^{th} grade	176,938 (31.4)	175,281 (31.9)	1657 (31.8)	1.01 (0.93, 1.08)
Post-secondary	106,736 (19.3)	105,488 (19.2)	1248 (23.9)	0.80 (0.74, 0.87)
Graduate degree	12,107 (2.2)	11,945 (2.2)	162 (3.1)	0.70 (0.59, 0.83)
Unknown	124,786 (22.5)	123,895 (22.6)	888 (17.1)	1.33 (1.22, 1.45)
Missing	48	47	1	
Marital status				
Never married	24,268 (4.4)	23,978 (4.4)	290 (5.6)	1.0
Married	221,704 (40.0)	219,317 (40.0)	2387 (45.8)	1.11 (0.98, 1.26)

Separated	33,806 (6.1)	33,335 (6.1)	471 (9.0)	0.86 (0.74, 0.99)
Other	4687 (0.8)	4651 (0.8)	36 (0.6)	1.56 (1.10, 2.21)
Missing	31	31		
Depression				
Yes	39,048 (7.0)	38,497 (7.0)	551 (10.6)	1.57 (1.43, 1.71)
No	515,265 (93.0)	510,601 (93.0)	4664 (89.4)	1.0
Antidepressant use				
Yes	112,836 (20.4)	111,401 (20.3)	1435 (27.5)	1.49 (1.40, 1.59)
No	441,447 (79.6)	437,697 (79.7)	3780 (72.5)	1.0
Alzheimer's				
Yes	45,840 (8.3)	45,401 (8.3)	439 (8.4)	1.02 (0.92, 1.13)
No	508,473 (91.7)	503,697 (91.7)	4776 (91.6)	1.0
Dementia				
Yes	83,431 (15.1)	82,257 (15.0)	1174 (22.5)	1.65 (1.54, 1.76)
No	470,882 (84.9)	466,841 (85.0)	4041 (77.5)	1.0
Hemiplegia				
Yes	9168 (1.7)	8827 (1.6)	341 (6.5)	4.34 (3.88, 4.85)
No	545,145 (98.3)	546,931 (99.6)	4874 (93.5)	1.0
Multiple sclerosis				
Yes	2232 (0.4)	2167 (0.4)	65 (1.3)	3.19 (2.49, 4.08)
No	552,081 (99.6)	546,931 (99.6)	5150 (98.7)	1.0
Parkinsonism				
Yes	22,456 (4.1)	22,202 (4.0)	254 (4.9)	1.22 (1.07, 1.38)
No	531,857 (95.9)	526,896 (96.0)	4961 (95.1)	1.0
Falls frequency				
No falls	159,194 (64.8)	356,871 (65.0)	2323 (44.5)	1.0
One or more falls	195,075 (35.2)	192,183 (35.0)	2892 (55.5)	2.31 (2.19, 2.44)
Missing	44	44		
Mean (SD)	0.72 (1.44)	0.71 (1.43)	1.34 (1.97)	

The annual cumulative incidence of TBI from 2003 to 2013 along with associated confidence intervals are shown in Table 2. Linear regression indicated that there was no significant change in the annual cumulative incidence of TBI over the ten-year period (p = The sensitivity analysis of the annual cumulative incidence rates showed significantly high incidence rates than the unadjusted analysis.

Table 2. Annual cumulative incidence and sensitivity analysis of annual cumulative incide TBI in the older adult home care population of Ontario from 2003 to 2013.

Year	Numerator	Denominator	Incidence per 100,000 (95% CI)	Sensitivity analysis of inci per 100,000 (95% CI
2003	576	45077	1278 (1174, 1382)	2262 (2169, 2355)
2004	628	61210	1026 (946, 1106)	1816 (1733, 1899)
2005	445	48515	917 (832, 1002)	1623 (1544, 1702)
2006	386	41955	920 (829, 1011)	1628 (1549, 1707)
2007	313	38246	818 (728, 908)	1448 (1373, 1523)
2008	275	36028	763 (673, 853)	1351 (1279, 1423)
2009	223	30889	722 (628, 816)	1278 (1208, 1348)
2010	206	26081	790 (683, 897)	1398 (1325, 1471)
2011	1110	108948	1019 (959, 1079)	1804 (1721, 1887)
2012	404	46061	877 (792, 962)	1552 (1480, 1624)
2013	649	71303	910 (840, 980)	1611 (1532, 1690)

Age- and sex-standardized annual cumulative incidence rates and associated confid intervals were calculated using the 2003 population as the standard and are shown in Table Linear regression indicates female age-standardized incidence rates decreased significantly the 10-year period (p = 0.04). Male and overall age- and sex-standardized incidence rates decreased in a non-linear fashion.

Table 3. Age- and sex- standardized annual cumulative incidence rates of TBI in the older home care population of Ontario from 2003 to 2013.

Year	Sex-specific age-standardized annual cumulative incidence rates		Age- and sex-standardized cumulative incidence ra
	Male (95% CI)	Female (95% CI)	Overall (95%CI)
2003	1823 (1600, 2046)	1044 (920, 1168)	1278 (1174, 1382)
2004	1327 (1104, 1491)	872 (784, 960)	1003 (896, 1110)
2005	1147 (983, 1311)	779 (691, 867)	903 (779, 1027)
2006	1126 (962, 1290)	778 (671, 885)	905 (781, 1029)

2007	944 (792, 1096)	725 (618, 832)	805 (681, 929)
2008	873 (721, 1025)	681 (574, 788)	747 (623, 871)
2009	806 (654, 958)	675 (551, 799)	723 (599, 847)
2010	1024 (924, 1124)	608 (484, 732)	792 (640, 944)
2011	1461 (1337, 1585)	822 (760, 884)	1031 (969, 1093)
2012	1273 (1109, 1437)	648 (560, 736)	869 (745, 993)
2013	1215 (1091, 1339)	767 (679, 855)	929 (841, 1017)

5.5 DISCUSSION

A positive association between male sex, aboriginal origin, increasing age, being widowed, having depression, using antidepressants, one or more falls, the presence of dementia, hemiplegia, multiple sclerosis and parkinsonism and the likelihood of sustaining a TBI in the older adult home care population of Ontario was found. The annual cumulative incidence of TBI was significantly higher than reported figures in the literature and there was no change in the annual cumulative incidence over the 10-year period. The sensitivity analysis indicated that the true annual cumulative incidence rates are likely much higher then the incidence rates we determined due to the low sensitivity of the TBI outcome measure. Male age-standardized and overall sex- and age-standardized incidence rates did not change significantly over the 10-year period, however female age-standardized rates decreased significantly.

The results indicated that there was a distinctly large sample size for all service users and service users who sustained a TBI during the year 2011, which was an unexpected finding. There are a variety of factors that may have played a part in increasing the number of service users receiving home care during the year 2011. During the fiscal year of 2009/2010 spending on home care was $1.9 billion and during the fiscal year 2010/2011 spending increased to $2.1 billion [9]. This 10.5% increase in spending may have allowed more persons across the province of Ontario to receive home care. Overall, home care across the province of Ontario had received a 56% increase in funding from the fiscal years 2003/2004 to 2010/2011 [9]. Another factor that

may have led to an increase in service users is the Ontario Aging at Home Strategy, a $1.1 billion dollar funding package granted to the Community Care Access Centers across Ontario who implement and organize home care [24]. This funding package was spread over four years from 2008 to 2012, however a report in 2010 by the Auditor General of Ontario found that funds were used sparingly in the first two years. A greater percentage of the funds were used from 2010-2011 and this may have increased the number of service users in home care [9].

Demographic characteristics are known to be associated with the recovery time following a TBI [25]; however, there is limited research on how certain demographics may be risk factors for TBI. Research in the United States and abroad has shown that males are approximately two times more likely to experience a TBI compared to females [2, 3]. This study found similar results; however, the association was not as strong. This could be due to differences between study populations or other external factors.

Research in the US has shown that aboriginals are no more likely to sustain a TBI (p = 0.002) than Caucasians [26]. However, a Canadian study examining older adults found that persons of aboriginal origin are more likely to sustain a TBI [27], which corroborate our findings. Numerous studies have found that increasing age among the older adult population is a risk factor for sustaining a TBI [2, 3, 7, 9, 10, 11] and the present study confirms literature findings. The association between education level and TBI has not been thoroughly investigated; however, a US study found that persons with some college education had a slightly lower incidence of TBI hospitalization [28]. Other research has shown that persons with a higher level of education are less likely to sustain injuries and develop health conditions in general [29-31]. The present study found that a higher education level is negatively associated with sustaining a TBI, which agrees with the literature. Studies have examined the effects of TBI on marital status

following injury and found that sustaining a TBI increases the risk of divorce or separation [32, 33]. However, the present study is the first to investigate the association between marital status and sustaining a TBI. The finding that being widowed is associated with a higher risk of TBI is worth investigating in future studies. The association between falling and sustaining a TBI has been studied extensively and falling is regarded as a major risk factor for TBI [2, 3, 9, 10, 34]. The present study corroborates with existing evidence suggesting that falling is associated with TBI [34]. Interestingly, we found that neurological conditions like hemiplegia, multiple sclerosis and dementia were associated with an increased risk of sustaining a TBI. Research has not investigated these neurological conditions as potential risk factors for TBI and future studies should incorporate the findings into their study designs.

Depression following brain injury has been studied [35], however no studies have examined depression as a potential risk factor for TBI in older adults. The present study is the first to formally examine the association between depression, antidepressant use and sustaining a TBI. The present study found a substantial association, which may be due to the use of antidepressants to treat depression among older adults, which leads to an increased risk of falling and consequently sustaining a TBI [36-39]. The results should be interpreted carefully, as the present study is cross sectional in nature without controlling for potential confounding factors.

Incidence rates of TBI in older adults vary significantly in the literature depending on the case definition and population under study [40]. However, there have been no studies formally examining TBI incidence in the older adult population of Canada. United States figures for the older adult population aged 65 years or older indicate that the age-adjusted incidence rate for hospitalized TBIs is 155.9 per 100,000 population [7, 10]. This study found significantly higher rates during the ten-year period in Canada. This is most likely due to the fact that this study was

based on a home care population, who are a closely monitored group, while the US study used hospitalized cases of TBI, which are known to be susceptible to under reporting [7]. The sensitivity of the TBI item on the RAI-HC is also low and the sensitivity analysis of the incidence rates indicates that the results in this study are most likely an under-estimation of the true incidence. A best evidence synthesis completed by the WHO collaborating center task force on mild traumatic brain injury (MTBI) found that the incidence of MTBI in hospital treated older adults is between 100-300 per 100,000 population [40]. This study also indicated that the true population based incidence is most likely higher than 600 persons per 100,000 population [40]. Although the present study found that the incidence rates were significantly higher than 600 per 100,000 population, the results corroborate existing literature as the present study included all severities of TBI in the case definition, which could help to explain the higher incidence rates.

Trends of TBI incidence have been examined in a variety of populations across the world and results have been largely mixed. A major US study found that overall hospitalizations for TBI declined 51% from 1980 through 1995 for all ages [41]. However, the decline in incidence was least among those aged 65 years or older with a decrease of 9% [41]. The literature suggests that a decrease in the incidence of TBI could be due to a number of factors including a change in hospital admission policies, improved safety and preventative programs and increased survivability after TBI [42]. A study of TBI incidence rates in Sweden from 1987 to 2000 found an increase in TBI rates for both males and females [43]. A study of the general population in Ontario, Canada, found that TBI hospitalization rates were unchanged from the year 1992 to 2001 among those aged 66 years or older [9]. The results of this study concur with the most pertinent study in the Ontario, Canada, region [9] that incidence rates of TBI remain largely unchanged between the years 2003 and 2013. This study also found that male age-standardized

rates were significantly higher than female rates, which is similar to numerous recent studies in the United States [3, 10].

The main strengths of this study include the use of longitudinal and recently collected data, the large sample size, the population-based nature of the data, the use of a validated instrument and the ability to assess a number of variables and their associations with TBI. A major limitation of this study is the inability to distinguish between the severities of TBI in the outcome. The RAI-HC amalgamates all severities of TBI under one diagnosis even though the incidence of each severity of TBI varies [1-3]. This heterogeneous outcome measure may mask associations between the varying severities of TBI and the service user characteristics. A further limitation of this study is the low sensitivity of TBI measurement using the RAI-HC assessment [10]. Based on the sensitivity analysis of the annual cumulative incidence of TBI, the unadjusted incidence rates are likely underestimates of the true incidence and should be interpreted cautiously. The case definition of TBI has not been firmly established which makes it difficult to accurately measure TBI status. A universal case definition for the varying severities of TBI needs to be established so population-based measures can be developed for the home-care setting. We were not able to control for cause of TBI and history of TBI as potential confounders, which is a limitation.

TBI is an important injury due to its significant burden on healthcare spending and its short and long-term impact on individuals. This descriptive study has identified new associations between a variety of intrinsic characteristics and TBI, so that future studies can examine these characteristics in more detail. This study has also provided valuable estimates regarding the incidence and impact of TBI on the general Canadian home care population, where previous estimates did not exist. Future research should examine the incidence of TBI in other institutions,

such as long-term care and mental health facilities and in aboriginal and military populations so that preventative measures can be implemented in populations suffering from this disabling injury.

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6. THE ASSOCIATION BETWEEN DEPRESSION AND TRAUMATIC BRAIN INJURY IN OLDER ADULTS: A NESTED MATCHED CASE CONTROL STUDY

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6.1 ABSTRACT

OBJECTIVES: To determine the association between depression and traumatic brain injury (TBI) in the older adult home care population of Ontario, Canada from 2003 to 2013.

METHODS: A nested matched case control study was conducted to determine the association between depression and TBI. Data from the Ontario Association of Community Care Access Center's database were retrieved for all service users 65 years or older who received home care between 2003 and 2013; these data are based on the Resident Assessment Instrument-Home Care. The variables used in the analyses included: TBI, depression, demographics, neurological conditions and history of falling. Incident cases of TBI were matched to four controls by sex, age and date of assessment. Crude odds ratios for the association between depression and TBI were determined. Multivariable conditional logistic regression analysis was used to adjust for potential confounders and identify effect modifiers. Estimates of association were stratified by a history of falling. **RESULTS:** A total of 554,313 service users were included, of which 5215 (0.9%) had sustained a TBI and 39,048 (7.0%) had depression. The crude odds ratio (OR) for the association between depression and TBI was 1.54 (95% CI: 1.43, 1.64). Multivariable analysis suggested that there were three significant effect modifiers: history of falling, level of education and Alzheimer's. As the level of education increased, the association between depression and TBI became smaller (OR: 1.88, 95% CI: 1.30, 2.70 for 8^{th} grade or less compared to OR: 1.11, 95% CI: 0.78, 1.65 for graduate degree). Service users with a TBI had greater odds of having a history of falling (OR: 1.45, 95% CI: 1.22, 1.73) and being diagnosed with Alzheimer's Disease (OR: 1.18, 95% CI: 1.05, 1.32). **CONCLUSIONS:** Results indicate that depression is associated with sustaining a TBI using a nested matched case-control design. This study has uncovered a potential association between depression and TBI and laid the groundwork for future studies.

6.2 INTRODUCTION

Traumatic brain injury (TBI) is one of the most common causes of injury in youth and older adults (1, 2). All ages are affected by TBI; however, youth (i.e., under 21 years) and older adults (i.e., 65 years or older) have the highest incidences of TBI leading to hospitalization (3). Sustaining a TBI can have a number of long-term consequences that can affect an individual's emotional (e.g., depression; see 1, 2), physical (e.g., epilepsy and Alzheimer's disease; see 4-6) and behavioral well-being (e.g., memory problems; see 1, 2). The risk of developing health conditions makes sustaining a TBI one of the most disabling conditions. The incidence of TBI in older adults aged 65 and above has been estimated at 155.9 per 100,000 population (7) and costs over $20 billion yearly in direct and indirect costs (7, 8). Falls and motor vehicle collisions are the main cause of TBI in older adults (1); however, little is known regarding the risk factors associated with incident TBI cases.

Research has shown that older adults are 40% more likely to have a medical condition prior to sustaining a TBI compared to younger adults (8, 10). It is possible that the presence of a medical condition may play a role in the occurrence of TBI. Any illness or chronic conditions associated with cognitive impairment or dementia (e.g., Alzheimer's disease or other etiologies) are hypothesized risk factors for TBI (6, 11). Research concerning the association between medical conditions and TBI has largely taken place in the US using hospitalization-based studies.

Depression is a prevalent medical condition, especially in the older adult population. The accumulation of a long life of depressive events can put older adults at a particularly high risk of depression (12). An estimated 8.9% of older adults have depression (13) and depression is associated with a 16% mortality rate in older adults (14). As the North American population ages, it is hypothesized that the prevalence of depression is going to increase (15, 16).

Many studies have investigated the development of depression following a TBI (13-15); however, depression has not been investigated as a risk factor for sustaining a TBI in the older adult population.

Medications used to treat depression have side effects that may increase the likelihood of falling and consequently sustaining a TBI (17). Selective serotonin reuptake inhibitors (SSRIs) and tricyclic antidepressants are commonly used to treat geriatric depression. Approximately 10% of patients taking SSRIs develop hyponatremia (abnormally low levels of sodium in the blood), which can lead to an increased risk of falling (Odds ratio (OR): 1.84; 95% CI: 0.91, 3.69) (18, 19). A systematic review of 40 studies by Leipzig and colleagues (1999) found that tricyclic antidepressant use was associated with an increased risk of falling (OR: 1.48; 95% CI: 1.23, 1.77) (20). A study completed by Ensrud and colleagues (2002) also found that antidepressant use in general was associated with an increased risk of falling (OR: 1.54; 95% CI: 1.14, 2.07) (21). Use of these medications along with other comorbid medical conditions may increase the risk of TBI in depressed older adults.

Research shows that antidepressants are associated with an increased risk of falling; however, the relationship between depression and sustaining a TBI in the older adult population has not been fully investigated. The objective of this study is to determine the association between TBI and depression in older adults using home care in Ontario from 2003 to 2013. This study will also assess the modifying effects of having a history of falling, because it is known that falling is the main cause of TBI (1).

It is hypothesized that TBI will be positively associated with the presence of depression in the older adult population. It is further hypothesized that the magnitude of effect will be greater for those with a history of falling than for those without.

6.3 METHODS

6.3.1 Data Source

The data source used for this study was the Ontario Association of Community Care Access Centers (OACCAC) home care database. The OACCAC database contains longitudinal assessments of service users expected to be in Ontario home care for 60 or more days (22). Community Care Access Centers (CCAC) administer home care in Ontario and determine the eligibility for long-term care (23). Eligible persons living in the province of Ontario are entitled to home care, regardless of income (23). The CCAC eligibility criteria for home care include: the person must be insured under the Ontario Health Insurance Plan; the person must need at least one professional service in the home (e.g., nursing, physiotherapy or occupational therapy); the setting where the service is delivered must be appropriate in terms of safety, space, and privacy; the person can only access the services that are available within the persons CCAC catchment area (i.e., in some areas, not all services may be available within the area); and it must be shown that the provision of service is goal-oriented (23). Service users are assessed every 6-months for the duration of their service, or when there is a significant change in status (which includes sustaining a TBI) (23). However, the period of time between assessments may be longer.

6.3.2 Assessment Instrument

Analyses are based on the RAI-HC assessment system, which is used regularly in home-based health care settings. The RAI-HC was developed by the InterRAI collaborative network as a means of examining issues in older adults related to functioning and quality of life (23). Items in the RAI-HC have been validated by a variety of international studies (24-28). The RAI-HC assessment is administered by trained assessors (nurses or social workers), who use all sources of

information available (e.g., family interviews and chart reviews) to complete all sections of the instrument. The RAI-HC has a variety of items, which fall under the domains of identifying information, demographic items, assessment information, cognitive patterns, communication/hearing patterns, mood and behavior patterns, physical functioning, disease diagnosis and more (23). Many of the items on the RAI-HC are organized into scales and clinical assessment protocols (e.g., Depression Rating Scale) to help interpret the meaning of the items.

6.3.3 Study Design

A nested matched case control study was used to determine the association between depression and sustaining a TBI in older adults using home care in Ontario. Individuals were eligible for inclusion in this study if they were aged 65 years or older and were administered home care between 2003 and 2013. Cases were selected from the cohort where follow-up began at the time of initial assessment and ended at the time of first TBI, discharge from home care, relocation outside of Ontario, death, or the end of the assessment period in 2013. All persons included in the study had and initial/admission assessment and at least one reassessment. Each case was randomly matched to four controls (individuals without a TBI at the time of the case's TBI) by date of cohort entry (+/- 3 months of admission to home care), age (+/- 1 year), and sex to control for potential confounding factors, including time at risk. Matching was used because age and sex are known to be associated with sustaining a TBI (1-3) and controlling for time at risk is always prudent when conducting a matched case control study (29). Goldstein and Zhang (2009) have shown that using four controls per case minimizes the amount of efficiency lost when performing a nested case control study compared to a full cohort study analysis (29).

Ethical review was not required to conduct this study due to the use of anonymized data collected as part of regular practice used for secondary analysis (30).

6.3.4 Study Measures

Traumatic brain injury: The primary outcome for the study was incident cases of TBI. There are two ways to capture TBI: the "Head Trauma" item and text entries (22). The definition of Head Trauma" as stated in the RAI-HC user manual is "damage to the brain as a result of physical injury to the head" (22). TBI is indicated as present on a service users' RAI-HC if the doctor has indicated it affects the service users' status, requires treatment, or symptom management. TBI is also indicated as present if the disease is monitored by a home care professional or led to a hospitalization in the 90 days prior to the RAI-HC (or since last assessment if less than 90 days) (22). Cases were considered incident because nurses or social workers completing the RAI-HC were instructed not to include past TBI, which ensures that only incident cases were captured. If a service user had more than one TBI (either during a year period of during the whole ten year period from 2003-2013), then only the first TBI was counted as a case and subsequently matched to four controls for the analysis. On the RAI-HC, TBI is coded as either not present (leaving the check box blank), (1) present- not subject to focused treatment or monitoring by home care professional, or (2) present- monitored or treated by home care professional (22). For this study, we recoded TBI as present if either (1) or (2) were indicated on the RAI-HC. In addition to capturing TBI using the "Head trauma" item, the text entries section was used to capture TBI. This section allows health care workers to input text that describes the diagnoses. Any text diagnosis in this section that refers to head trauma, concussion, closed head injury, head injury or acquired brain injury were also used to capture cases of TBI

(Appendix B). This method of capturing TBI from RAI-HC data has been validated by Foebel and colleagues (31). They compared the incidence (or number) of TBI from RAI-HC data to TBI incidence from the Canadian Institute for Health Information (CIHI), and the National Ambulatory Care Reporting System (NACRS), which captures inpatient hospital and emergency departments records, to determine reliability and validity. They found the RAI-HC assessment to have a sensitivity of 0.23, a specificity of 0.99, a positive predictive value of 0.22 and a kappa statistic of 0.22 when comparing the RAI-HC measure of TBI to CIHI and NACRS data (31). The low sensitivity of the TBI measure may be due to the vague nature of the "head trauma" definition of TBI, making assessors less likely to record the diagnosis. Foebel and colleagues indicate that administrative databases like CIHI and NACRS consistently under-report medical conditions such as TBI, which suggests that these databases may not have been appropriate gold standards to assess the reliability and validity of the RAI-HC measure of TBI.

Depression: Depression was measured from the RAI-HC assessment conducted at the time of TBI for cases, and from the assessment nearest to the index date (time of matched case's TBI) for the controls. Depression was assessed using seven items from the mood, anxiety, and behaviours section of the RAI-HC. The seven items used to measure depression were: a feeling of sadness or being depressed, persistent anger with self/others, expressions of what appear to be unrealistic fears, repetitive health complaints, repetitive anxious complaints/concerns, sad/pained/worried facial expressions and recurrent crying/tearfulness. An item can be coded as either not present (leaving the check box blank), (1) exhibited in 1-2 of the last three days, or (2) exhibited on each of the last 3 days (22). A service user was considered depressed if they had a score greater than or equal to 3 out of 14 on the seven-item scale (32). Past depression was not captured. We included depression present at the time of assessment with an impact on the service

users' status, requiring treatment or active monitoring (22). Burrows and colleagues compared the RAI-HC depression scale with the Cornell Scale for Depression and the Hamilton Depression Rating Scale (32). They found that a cut-point score of 3 or greater on the RAI-HC depression scale maximized sensitivity (0.78 for Cornell and 0.94 for Hamilton) with minimum loss of specificity (0.77 for Cornell and 0.72 for Hamilton) when tested against cut-offs for mild to moderate depression (32).

Antidepressants: Antidepressants use was measured as a potential confounder and effect modifier using the RAI-HC (22). Antidepressant use was captured as a categorical variable, under the receipt of psychotropic medication heading. Antidepressant use is captured as present if antidepressants were taken in the last 7 days (or since last assessment). For cases, antidepressant use was captured at the time of TBI and for controls from the assessment date nearest to the index data (time of matched case's TBI).

Demographics: Demographic characteristics were obtained from the RAI-HC and included sex, age, aboriginal origin and highest level of education completed (22). For cases, demographics were measured at the time of TBI and for controls from the assessment nearest to the index date (time of matched case's TBI).

History of falling: History of falling was measured as a potential confounder and effect modifier using the RAI-HC. History of falling was captured as a categorical variable, under the heading of fall frequency (22). Fall frequency is reported as the number of times fallen in the last 90 days (or since the last assessment if less than 90 days). On the RAI-HC fall frequency is coded as "0" for none, or "9" if more than nine falls (22). For this study, history of falling was re-coded as one or more falls or no falls. For cases, history of falling was measured at the time of TBI and for controls from the assessment nearest to the index date (time of matched case's TBI).

Neurological diseases: Neurological diseases were measured as potential confounders and effect modifiers using the RAI-HC. Neurological diseases were assessed as potential effect modifiers because their presence may influence the association between depression and TBI. A service user was considered as having a neurological disease if a neurological disease is indicated as present on the RAI-HC. Neurological disease was reported using the list of disease diagnoses and included: Alzheimer's disease, dementia other than Alzheimer's disease and Parkinsonism (22). Neurological diseases were ascertained as present similarly to depression. Foebel and colleagues found that the validity and reliability of the Alzheimer's disease and other dementia (sensitivity of 0.76; specificity of 0.89; PPV of 0.53; kappa statistic of 0.55) and parkinsonism (sensitivity of 0.83; specificity of 0.98; PPV of 0.59; kappa statistic of 0.68) items were acceptable (31). For cases, neurological diseases were measured at the time of TBI and for controls from the assessment nearest to the index date (time of matched case's TBI).

6.3.5 Data Analysis

Univariate descriptive analyses were conducted on all variables to check for errors and outliers, examine distributions, and to examine responses for each of the variables. Counts and proportions were determined for all variables and means and standard deviations were reported for continuous variables.

A crude bivariate association between depression and TBI was determined using a contingency table and odds ratio with 95% confidence interval. A sensitivity analysis of the crude unmatched association between depression and TBI was conducted using the validity results published by Foebel and colleagues (32) assuming non-differential misclassification in the TBI outcome measure. The sensitivity of 0.23 from Foebel and colleagues (23) indicates that

for the true association between depression and TBI there will be 77% more cases. Thus, 77% more cases were added to both the exposed and unexposed case group and the true measure of association was then calculated and compared to our unadjusted measure. Results were stratified by history of falling and effects were estimated with the Cochran-Mantel-Haenszel odds ratio. Multivariable analysis was conducted using conditional logistic regression modeling to estimate the odds ratio and 95% confidence interval for the association between TBI and depression. A three step modeling process was used (34). First, the modifying effects of history of falling, antidepressant use, Alzheimer's disease, dementia and Parkinsonism on the association between TBI and depression were tested. Effect modifiers were considered statistically significant if the p-value of the interaction term was less then or equal to 0.05 (Appendix D). Potential confounders as identified from the literature were included in the gold standard (GS) model (34): sex, aboriginal origin, age, marital status, falls frequency, antidepressant use, Alzheimer's disease, dementia and parkinsonism. Second, the potential confounding factors were evaluated by methodically determining different subsets of potential confounders that gave comparable estimates of effect as the GS model (i.e., within 10% of the GS model) (34). The final model was selected based on which subset model was closest to the GS model (34). If more than two models gave similar estimates compared to the GS model, then the subset with the fewest variables along with acceptable precision was selected as the final, adjusted parsimonious model. All data were analyzed using SAS software, version 9.4 (35)

6.4 RESULTS

The total sample size for this study was 554,313 service users, of which 5215 (0.9%) had sustained a TBI (Table 4). Of the 5215 cases of TBI, 4188 were captured using the "head

trauma" item and 1027 were captured using the text entries section of the RAI-HC. The selected controls were found to be representative of service users without TBI, however a greater percentage of the controls were male compared to service users without TBI (Table 4).

Table 4. Univariate descriptive analyses of the characteristics of service users without TBI, matched controls (matched on age (+/- 1 year), sex, and date of admission (+/- 3 months) to home care) and TBI cases in the older adult home care population of Ontario from 2003 to 2013.

Variable	Service users without TBI	Matched Controls	TBI Cases
N	549,098	20,823	5215
Sex			
Male	200,094 (36.4)	9741 (46.8)	2442 (46.8)
Female	348, 972 (63.6)	11,082 (53.2)	2773 (53.2)
Aboriginal origin			
Yes	3900 (0.7)	134 (0.6)	73 (1.4)
No	545,167 (99.3)	20,689 (99.4)	5141 (98.6)
Missing	31		1
Age			
65-69	43,896 (8.0)	2505 (12.0)	635 (12.2)
70-74	65,189 (11.9)	3084 (14.8)	775 (14.9)
75-79	101,609 (18.5)	4146 (19.9)	1060 (20.3)
80-84	137,949 (25.1)	5175 (24.9)	1252 (24.0)
85-89	121,557 (22.1)	3900 (18.7)	998 (19.1)
>90	78,898 (14.4)	2013 (9.7)	495 (9.5)
Mean (SD)	81.9 (7.6)	80.2 (7.7)	80.2 (7.7)
Education level			
8^{th} grade or less	132,442 (24.1)	5466 (26.3)	1259 (24.1)
9^{th} – 12^{th} grade	175,281 (31.9)	7624 (36.6)	1657 (31.8)
Post-secondary	105,488 (19.2)	3854 (18.5)	1248 (23.9)
Graduate degree	11,945 (2.2)	468 (2.3)	162 (3.1)
Unknown	123,895 (22.6)	3409 (16.4)	888 (17.1)
Missing	47	2	1
Depression			
Yes	38,497 (7.0)	1435 (6.9)	551 (10.6)
No	510,601 (93.0)	19,388 (93.1)	4664 (89.4)
Antidepressant use			
Yes	111,401 (20.3)	5091 (24.5)	1435 (27.5)
No	437,697 (79.7)	15,732 (75.6)	3780 (72.5)
Falls frequency			
No falls	356,871 (65.0)	14,115 (67.8)	2323 (44.5)
One or more falls	192,183 (35.0)	6708 (32.2)	2892 (55.5)
Missing	44	3	
Mean (SD)	0.7 (1.4)	0.7 (1.4)	1.34 (1.97)
Alzheimer's			
Yes	45,401 (8.3)	1950 (9.4)	439 (8.4)

No	503,697 (91.7)	18,873 (90.6)	4776 (91.6)
Dementia			
Yes	82,257 (15.0)	2914 (14.0)	1174 (22.5)
No	466,841 (85.0)	17,909 (86.0)	4041 (77.5)
Parkinsonism			
Yes	22,202 (4.0)	962 (4.6)	254 (4.9)
No	526,896 (96.0)	19,861 (95.4)	4961 (95.1)

A total of 5209 of the original 5215 cases could be matched to four controls. All 5215 cases were included in the regression analyses. Some controls were matched to more than one case and the total matched case control sample size was 26,038. Table 5 shows the number of matched controls with depression for cases with and without depression. The odds ratio of the crude association between TBI and depression was 1.54 (95% CI: 1.43, 1.64).

Table 5. Exposure amongst matched sets (matched on age, sex, and date of admission to home care) showing number of cases and matched controls with a history of depression in the older adult home care population of Ontario from 2003 to 2013 (N=5215 matched pairs).

Cases with depression	Number of controls with depression					Total number of sets
	0	1	2	3	4	
Yes	377	149	25	0	0	551
No	3432	1172	52	3	5	4664

A sensitivity analysis was conducted on the outcome measure of TBI using the sensitivity of 0.23 as determined by Foebel and colleagues (30). The sensitivity analysis of the full non-matched case control data indicated that the true OR was 1.77 (95% CI: 1.66, 1.85), which suggests our matched results are a conservative estimate.

Multivariable analysis was conducted using conditional logistic regression modeling to estimate adjusted odds ratios and 95% confidence intervals for the association between depression and TBI. Analyses suggested that education level ($p < 0.0001$), history of falling ($p < 0.0001$) and Alzheimer's disease ($p < 0.0001$) were significantly associated with sustaining a TBI. Furthermore, effect modification and confounding were assessed (Table 6). Three significant effect modifiers for the exposure were found: history of falling, level of education and

Alzheimer's (Appendix D). As the level of education increased, the association between depression and TBI became smaller. Service users with a TBI had greater odds of having a history of falling (OR: 1.45, 95% CI: 1.22, 1.73) and being diagnosed with Alzheimer's Disease (OR: 1.18, 95% CI: 1.05, 1.32).

Table 6. Adjusted effect modification assessment between depression and TBI in the older adult home care population of Ontario from 2003 to 2013.

Exposure	Odds Ratio	95% Confidence Interval
Education level[a]		
8th grade or less	1.88	1.30, 2.70
9th – 12th grade	1.31	1.00, 1.72
Post-secondary	1.20	0.81, 1.78
Graduate degree	1.11	0.78, 1.65
Unknown	1.08	0.76, 1.55
Falling[b]		
No falls	1.19	0.99, 1.42
One or more falls	1.45	1.22, 1.73
Alzheimer's[c]		
Yes	1.56	0.63, 3.86
No	1.18	1.05, 1.32

[a]Model adjusted for history of falling and Alzheimer's disease.
[b]Model adjusted for education level and Alzheimer's disease.
[c]Model adjusted for education level and falling.

6.5 DISCUSSION

The crude analysis found a positive association between depression and TBI (OR: 1.54, 95% CI: 1.43, 1.64) and after controlling for confounders there were three significant effect modifiers: history of falling, level of education and Alzheimer's disease. As the level of education increased the association between depression and TBI decreased (OR: 1.88, 95% CI: 1.30, 2.70 for 8th grade or less compared to OR: 1.11, 95% CI: 0.78, 1.65 for graduate degree). Service users with a TBI had greater odds of having a history of falling (OR: 1.45, 95% CI: 1.22, 1.73) and being diagnosed with Alzheimer's disease (OR: 1.18, 95% CI: 1.05, 1.32). Given the low sensitivity of the TBI outcome measure, all ORs are likely underestimates of the true

association between depression and TBI. Service users with a history of falling had a stronger association between depression and TBI (OR: 1.45, 95% CI: 1.22, 1.73) than did those without a history of falling (OR: 1.19, 95% CI: 0.99, 1.42).

Depression following TBI has been investigated extensively and found to occur more frequently in persons who suffered a TBI (36-38), however depression has not been specifically investigated as a potential risk factor for sustaining a TBI using validated measures. A number of factors could explain why the observed association was not larger. Service users who are depressed may not be receiving treatment, which would decrease their likelihood of falling as various studies have indicated that depression medications increase the likelihood of falling (18-21). Depression could also be undetected or undiagnosed. Depression also leads to a more sedentary lifestyle in older adults and this may decrease the likelihood of falling and sustaining a TBI (39). Nondifferential misclassification of the TBI outcome measure would also bias the OR towards the null hypothesis.

Research has shown that persons with a higher level of education are less likely to experience a brain injury (40) and the results of this study confirm this. Falling is the cause of over 80% of all TBIs in the older adult population (1-3, 7, 41) and having a history of falling has been shown to be associated with sustaining a TBI (3, 7). The results did show that the association between depression and TBI was modified by having a history of falling. Alzheimer's disease following brain injury has been investigated; however, Alzheimer's disease prior to TBI has not been fully investigated (6, 11). The results add to the literature by showing that those with Alzheimer's disease and depression are more likely to sustain a TBI compared to those with depression.

The results of the sensitivity analysis indicate that the study findings are likely an underestimation of the true association between depression and TBI. This was expected due to the low sensitivity in the TBI outcome measure. An accurate case definition and operational measure of TBI need to be developed to improve the accuracy of etiologic associations between various conditions and TBI.

The main strengths of this study were the use of population-based data, a large sample size, the ability to match on important confounding factors and the ability to control for a number of variables. The limitations of this study were the use of a low sensitivity instrument to capture TBI, the amalgamation of all severities of TBI under one diagnosis, the inability to examine the cause of TBI and history of TBI as potential confounders, the inability to examine recurrent TBIs (using Poisson regression) due to the small numbers of multiple TBIs, and the inability to establish causality by using a cross-sectional analysis. The sensitivity was poor for the TBI outcome measure; however, because the misclassification is considered nondifferential in nature the estimate is biased towards the null. This indicates that the study estimate is conservative. This study is the first to examine the association between depression and TBI, so a nested matched case control study design is appropriate.

The impact of TBI is widespread and is a major public health concern among older adults. This etiologic study has investigated a major mental health condition among older adults and its association with sustaining a TBI. The findings are important, as this is the first study investigating the direct association between depression and TBI and serves as a hypothesis generating study for more focused studies in the future. The results suggest that depression is associated with TBI; however, the results cannot be interpreted as causal due to the cross sectional nature of the study analysis. Longitudinal studies should be conducted in the future to

ensure the temporal relationship between depression and TBI. With an aging population, more research is needed into the association between various chronic conditions and TBI.

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7. DISCUSSION

7.1 Overview

This thesis was conducted in two major parts in order to 1) assess the characteristics and annual cumulative incidence of TBI (descriptive) and 2) determine the direct association between depression and sustaining a TBI (etiologic) in older adults using home care in Ontario from 2003 to 2013.

Hypotheses associated with the descriptive component were that 1) the risk of sustaining a TBI would be higher in older age groups, males and non-white races; 2) the annual cumulative incidence of TBI would be greater than the reported figure for age-adjusted hospitalization rate of 155.9 per 100,000 population; and 3) the 10-year trend of TBI incidence would decrease. Hypotheses associated with the etiologic component were that 1) the presence of depression would be associated with sustaining a TBI; and 2) a history of falling would increase the likelihood of sustaining a TBI.

The OACCAC database was chosen to complete this study as it allowed retrospective access to a large, population based dataset of the general older adult population of Ontario for a recent and long period of time. Using the RAI-HC allowed a variety of measured variables to be tested as confounders, it had been validated by numerous studies, and it contained a measure of depression and TBI.

TBI is a damaging condition among youth and older adults alike. Incidence rates have been largely understudied in the general population and few studies have tried to establish the relationship between various chronic diseases and the occurrence of TBI. The goals for these studies were to provide some valuable estimates of how prevalent the disease was among the general older adult population of Canada and to conduct a hypothesis generating etiologic study

for the relationship between depression and TBI. Future researchers could use this information to implement primary preventative measures to reduce the incidence of TBI and for higher-level etiologic studies to determine causal relationships between other chronic conditions, depression and TBI.

7.2 Main Findings

The descriptive study found that of the total sample size of 554,313 service users, 5215 (0.9%) had reported a TBI. Of all service users, two thirds were female, most were not of aboriginal origin, half had a high school education or less, most were either married or widowed and the mean age was 81.9 years old (SD: 7.6). The prevalence of depression, Alzheimer's Disease, hemiplegia, multiple sclerosis and parkinsonism was below 10% and for dementia was approximately 15% in all service users. Two thirds of all service users had no history of falling and the mean number of falls per service user was 0.72 (SD: 1.44). Service users who had not sustained a TBI had similar characteristics to all service users as a whole. Service users who had a TBI had similar characteristics to all service users and service users without TBI. However, they had a more equal sex distribution, a greater prevalence of depression, dementia, hemiplegia and had more service users with a history of one or more falls (mean number of falls per person: 1.34, SD: 1.97). Females and males with TBI overall had similar characteristics; however, males were more likely to be married while females were more likely to be widowed. Females with TBI also had a higher prevalence of depression and a lower prevalence of hemiplegia compared to males with TBI.

The descriptive study found that the main characteristics associated with sustaining a TBI were: male sex (OR: 1.54, 95% CI: 1.45, 1.62), aboriginal origin (OR: 1.98; 95% CI: 1.57, 2.50),

increasing age (OR: 1.22, 95% CI: 1.09, 1.35 for 70-74; up to OR: 2.31, 95% CI: 2.05, 2.59 for >90; referent group 65-69), being widowed (OR: 1.59, 95% CI: 1.41, 1.80), having one or more falls (OR: 2.31, 95% CI: 2.19, 2.44), antidepressant use (OR: 1.49, 95% CI: 1.40, 1.59) and the presence of depression (OR: 1.57, 95% CI: 1.43, 1.71), dementia (OR: 1.65, 95% CI: 1.54, 1.76), hemiplegia (OR: 4.34, 95% CI: 3.88, 4.85), multiple sclerosis (OR: 3.19, 95% CI: 2.49, 4.08) and parkinsonism (OR: 1.22, 95% CI: 1.07, 1.38). Incidence rates in the older adult home care population were significantly higher than previously reported figures and annual cumulative incidence rates decreased over the ten-year period. A sensitivity analysis of the annual cumulative incidence rates indicated that the incidence rates are likely an underestimation of the true incidence rates. In addition, female age-standardized rates decreased significantly in a linear fashion ($p<0.05$) while overall and male rates decreased in a non-linear fashion.

The etiologic study found that the crude OR between depression and TBI was 1.54 (95% CI: 1.43, 1.64) and the OR from the sensitivity analysis indicated that this was likely an underestimation of the true association. The sensitivity analysis of the full non-matched data indicated that the true OR was 1.77 (95% CI: 1.66, 1.85). Multivariable analysis indicated that depression was significantly associated with TBI even after controlling for confounding factors (OR: 1.24, 95% CI: 1.12, 1.38). Stratified analysis indicated that the association between depression and TBI was significantly different for service users with a history of falling (OR: 1.45, 95% CI: 1.22, 1.73) and those without a history of falling (OR: 1.19, 95% CI: 0.99, 1.42). There were three important confounders for the adjusted most parsimonious multivariable model: education level, history of falling and Alzheimer's Disease. There were also three effect modifiers for the adjusted most parsimonious multivariable model: education level, history of falling and Alzheimer's disease. Effect modification analyses indicated that as the level of

education increased the OR decreased and service users with depression were more likely to sustain a TBI compared to service users with depression and Alzheimer's disease.

7.3 Descriptive Component

7.3.1 Service User Characteristics

Characteristics of persons who sustained a TBI have mostly been studied using hospitalization-based studies from the United States. A CDC study that took place in the United States from 1995 to 2001 found that males had significantly higher rates of TBI in all age groups (1, 2). This study found similar results as males not only had higher OR's (OR: 1.54, 95% CI: 1.45, 1.62) compared to females (OR: 1.0, referent category), they also had higher age-standardized incidence rates throughout all ten years of the study. The CDC study did find that males were twice as likely to sustain a TBI, while the current study only found half that chance. Although prognostic studies have largely found that sex is not significant in predicting outcome following a TBI (3), the descriptive study confirmed the results of risk factor studies that male sex is associated with an increased risk of sustaining TBI.

Aboriginal origin has been largely understudied as a risk factor for sustaining a TBI (4). A study comparing TBI rates in Saskatchewan aboriginals to non-aboriginal persons found that aboriginals were more likely to sustain a TBI compared to non-aboriginals ($p<0.05$) (4). Studies have found that aboriginals across all age groups are more likely to experience trauma and injuries in general compared to the non-aboriginal population (4, 5). The results agree with these studies, as aboriginals were approximately two times more likely to sustain a TBI compared to the non-aboriginal population. Further longitudinal studies are certainly warranted to understand the characteristics, risk factors and incidence of TBI in the Canadian aboriginal population.

Similar to previous research (1, 2, 6, 7), this study found that as age increases past the age of 65 the risk of sustaining a TBI increases. The descriptive study found what was expected, that increasing age is certainly associated with sustaining a TBI. However, the age group of 85-89 years old had a decreased association (OR: 1.40, 95% CI: 1.28, 1.55) compared to the younger age group of 80-84 years old (OR: 1.88, 95% CI: 1.71, 2.08). It was expected that the OR's would increase steadily for each age group; however, the 85-89 years old age group did not fit with this expectation. It is unclear why this occurred in the study; however, this subgroup may have more comorbidities or mobility issues that would decrease their likelihood of falling. The association between old age and sustaining a TBI has been investigated in the literature and future studies could be used to confirm this finding in other populations.

The association between education level and sustaining a TBI has not been thoroughly investigated (8). However, studies investigating other injuries and diseases in the older adult population have found that an increased education level is associated with a lower incidence and risk of injury and disease (9-11). The descriptive study showed a weak association between education level and TBI, with an increased level of education associated with a lower risk of sustaining a TBI. The results agree with the literature that a higher level of education is generally associated with a lower risk of injury or disease.

Research has shown that there is an association between TBI and change in marital status following injury (12, 13); however, literature on the relationship between marital status and sustaining a TBI is sparse. The results add to the literature by showing that persons who are widowed may be more likely to sustain a TBI (OR: 1.59, 95% CI: 1.41, 1.80) while persons who are separated may be less likely to sustain a TBI (OR: 0.86, 95% CI: 0.74, 0.99) compared to persons who are never married (OR: 1, referent category). These findings are interesting because

both persons who are widowed and separated may be on their own with no significant other to help take care of them. Further studies should investigate the true association between marital status and TBI using a longitudinal study.

Depression following TBI has been investigated extensively (14), however this study is the first to formally examined depression and its association with sustaining a TBI. The association crude between depression and TBI was significant (OR: 1.54, 95% CI: 1.43, 1.64), as we would have expected based on the literature review. The use of antidepressants has been shown to increase the risk of falling, the main cause of TBI in older adults, so it makes sense that depression and antidepressant use is directly associated with sustaining a TBI. The descriptive study showed that depression is not a rare condition in the older adult home care population of Ontario (prevalence of 7.0%) and consequently, should be further investigated as a potential risk factor for TBI using a longitudinal study.

The descriptive study is the first to find that dementia, hemiplegia, multiple sclerosis and parkinsonism are associated with sustaining a TBI. This is interesting, as these diseases are more likely to occur in persons who have sustained a TBI in the past (15, 16). The results cannot be interpreted as causal, due to the cross sectional study design; however, the results were able to generate hypotheses about which diseases may contribute to the risk for sustaining a TBI.

Falls are known to be the main risk factor for sustaining a TBI in the older adult population (1, 2, 6, 7) and this study found that older adults with a history of falling were more likely to sustain a TBI. Understanding the relationship between falling and brain injury is necessary to try and prevent future occurrences of TBI.

The characteristics of service users who sustained a TBI were typical of what you would expect in a cohort of older adults with TBI (1, 2, 6, 7). However, there were some interesting

associations (e.g., the associations between dementia, hemiplegia, multiple sclerosis, parkinsonism and TBI) that will certainly provide hypotheses for future studies and the results can serve as a comparison group for future studies.

7.3.2 Annual Cumulative Incidence

The literature on the annual cumulative incidence of TBI varies considerably depending on the case definition of TBI and the population being studied. The case definition of TBI in the current study was quite broad and the population was typical of a group of older adults in Canada who require home care support. A large number of cases were captured due to these two factors.

An unexpected finding from the results was the large sample size for all service users and service users with TBI in the year 2011, which led to a substantial increase in incidence compared to the year 2010. National and particularly provincial spending may have played a role in the increase in older adult home care users during the year 2011. Home care is regulated through the CCAC's across Ontario and these CCAC's depend primarily on provincial funding to operate (17). CCAC's then in turn establish contracts with various service provides to provide home care to eligible persons across Ontario, who would ordinarily receive no care or be admitted to long term care establishments or hospitals (17). From the year 2010 to 2011 home care funding increased by 10.5% across the province of Ontario, from $1.9 billion to $2.1 billion (17). This is a substantial funding increase and allowed the province of Ontario to increase its enrollment in home care from 600,000 to 637,000 persons (17, 18). Governmental spending on home care has increased significantly during the past fifteen years in general. Between the years 2003/2004 and 2010/2011 spending increased over 50% (18). Increases in governmental spending may have contributed to the increased home care enrollment and incidence increased

during the year 2011 compared to prior years. In addition, home care enrollment and incidence may have increased due to a large funding package that was granted to CCAC's across the province. Over a period of four years from 2008 to 2012 the Government of Ontario invested $1.1 billion into the provincial home care program through the Aging at Home Strategy (18). This Ontario Aging at Home Strategy was purposefully implemented by the government of Ontario to specifically provide seniors (aged 65 years and older) with the care they need to live independently at home while staying healthy (18). Because this funding package was targeted specifically at seniors, it is likely that this is one of the main reasons why enrollment increased from the year 2011 and onward. In addition, during the first two years (2009-2010 fiscal years) of the funding from the Aging at Home Strategy, funds were spent sparingly compared to the last two years (2010-2011 fiscal years) (18). In the descriptive study we saw the large jump in enrollment during the year 2011, which was likely due to the increased provincial spending on home care.

Studies have examined the incidence of TBI in older adults and this study agrees with the findings that male cumulative incidence rates are generally greater then female rates (19, 20, 21). However, the descriptive study still had significantly higher overall incidence rates. This is most likely due to this study capturing TBI in the general population as opposed to the hospitalized population where incidence is thought to be under-reported.

The WHO collaborating center task force on mild traumatic brain injury (MTBI) found that the incidence of MTBI in hospital related studies is between 100-300 per 100,000 population (22). Although this study determined only the incidence of MTBI, not TBI in general, the study predicted that the true population based incidence of MTBI is likely greater than 600 per 100,000 population (22). Because the study amalgamated all severities of TBI under one diagnosis and

approximately 70% of all TBIs are mild (1, 22), it is likely that the WHO study would have predicted the true incidence of all TBIs to be greater than 800 per 100,000 population. The overall and sex specific incidence rates were significantly higher then the predicted figures for MTBI and overall TBI incidence.

The study results found that incidence rates among older adults in Ontario home care were significantly higher than reported figures in the literature. This may be due to an increase of TBI cases in Ontario or a change in hospital admission policies. The RAI-HC measure of TBI has a low sensitivity (0.23) so it is likely that the estimates are an underestimation of the true incidence (see Table 3). Further studies should utilize validated measures with acceptable sensitivity to more accurately measure the incidence of TBI.

7.3.3 Trend of TBI Incidence

Trends of TBI incidence have been studied in a variety of populations and the results have been mixed. A US study determined incidence rates of TBI-associated hospitalizations between the years 1980 and 1995 using ICD-9-CM diagnostic codes (23). The study found that although the incidence of TBI decreased over 50% overall, the decrease among older adults aged 65 and above was only 9% (23). The authors indicate that there are two main reasons why the incidence of TBI decreased significantly from 1980 to 1995. First, injury prevention measures, especially those influencing motor vehicles, increased substantially during the study period (24). Second, from 1980 to 1994 the overall rate of hospitalization across the country for all causes decreased 29% (25, 26). This decrease in the overall rate of hospitalization suggests that there was a change in hospital admission practices, most likely due to a shift from more inpatient services to more outpatient services (27). This study found an overall decrease in annual

cumulative incidence using linear regression and if you compare the rates from 2003 and 2013 there was a 28.8% decrease.

A Swedish study completed in 2003 investigated the incidence of TBI from 1987 to 2000 using national-level hospital admissions data (28). TBI diagnosis was captured using ICD-9 codes from 1987 to 1996 and from 1997 onwards was based on ICD-10 codes. The study found an increase in annual cumulative incidence for both males and females aged 65 years old and above (28). The authors had hypothesized that the incidence of TBI in older adults would decrease due to a number of new preventative strategies implemented in Sweden in the early 1990's. The descriptive results disagree with the results found by the study completed in Sweden, as we found a decrease in the overall and sex specific annual cumulative incidence rates.

A study completed in the Ontario, Canada, region from 1992 to 2002 found that hospitalization rates of TBI were unchanged among older adults (29). Specifically, female incidence rates in the 66 to 75 (66.1 to 62.4 per 100,000 population), 76 to 85 (156.4 to 148.7 per 100,000 population) and 86 years and older (66.1 to 62.4 per 100,000 population) age groups did not decrease significantly from 1992 to 2002. There was also no change in the male incidence rates in the 66 to 75 (98.8 to 94 per 100,000 population), 76 to 85 (191.2 to 184.8 per 100,000 population) and 86 years and older (369.8 to 333.6 per 100,000 population) age groups. Interestingly, the study also found that the mean age of all TBI-hospitalized patients increased from 24 to 41 years old (29). This study was remarkably similar to the study that we conducted; however, they used hospitalization data from an earlier time period. The descriptive study results were different as we found a significant decrease in annual cumulative incidence rates over the 10-year period.

This study found different results to various studies completed in the US, Sweden and Canada regarding the trend of TBI incidence. The trend of TBI incidence has remained unchanged across numerous countries due to lack of proper preventative measures, changes in admission policies and other potential factors that have yet to be examined. More research is necessary to understand which preventative measures are most effective in reducing the incidence of TBI in both Canada and abroad.

7.3.4 Practical Applications

The descriptive results provide the groundwork for future, more focused studies. The association between various characteristics and TBI indicates that many of the characteristics examined in this study may be risk factors for sustaining a TBI. In particular, future studies should investigate the role of neurological conditions in sustaining a TBI. Although the study was cross-sectional in nature, some associations were strong and significant (i.e., hemiplegia and multiple sclerosis) so it is quite possible that these neurological conditions may be risk factors for sustaining a TBI. Hopefully this study will be used for generating hypotheses in future, more advanced studies concerning the etiology of TBI.

7.4 Etiologic Component

7.4.1 Depression and TBI

The direct association between depression and sustaining a TBI in older adults has not been examined using a longitudinal study with validated measures. Although depression following TBI has been investigated extensively (30-32), this study is the first to examine depression as a potential risk factor for TBI. The finding that depression is associated with TBI

after controlling for potential confounders is important because it can be used to inform policy for primary preventative measures to reduce the occurrence of TBI in home care settings across Ontario and potentially across Canada. This study has generated hypotheses for more advanced studies to determine the proper causation between depression and TBI in older adults.

The hypothesis was that depression would be significantly associated with TBI. Although this hypothesis was confirmed, the strength of association between depression and TBI was low after adjusting for confounding factors. A number of factors could explain this finding. Service users with depression may not be getting treatment. If a service user is not getting treatment for depression, it is unlikely they are taking antidepressants like SSRI's or tricyclic antidepressants. Antidepressants like SSRI's and tricyclic antidepressant are the most common antidepressants used among older adults (33-35). They have been shown to increase the risk of falling among older adults (33-39) due to their ability to cause postural hypotension (39). If a service user is not taking antidepressants then their risk of falling and sustaining a TBI is most likely lower than if they were undergoing treatment. Future studies should continue to investigate the effect of antidepressant medications on the relationship between depression and TBI.

Depression leads to a more sedentary lifestyle in older adults and this may decrease the risk of falling and sustaining a TBI (40-42). A Spanish study of community dwelling older adults from the ages 60 to 98 years old found that depression was associated with decreased physical activity (41). A prospective, two-year European study of 11 countries found that older adults with depression were less likely to engage in regular physical activity (42). Falling is the main mechanism of TBI in older adults and if service users in the study were not physically mobile and able to independently move, then it is unlikely that they would experience a fall and subsequent TBI.

Nondifferential misclassification of the outcome measure is likely another reason why the association between depression and TBI was not stronger. Nondifferential misclassification of a dichotomous outcome measure biases the association towards the null hypothesis, in this case towards an OR of 1.0 (48). We have no reason to suspect that differential misclassification was present as opposed to nondifferential misclassification. Based on the assumption of nondifferential misclassification and the results of the sensitivity analysis (see page 56) it is clear that nondifferential misclassification was a likely reason why the association between depression and TBI was lower then expected.

The sensitivity analysis indicated that the estimate was likely an underestimation of the true association. This was expected based on the very low sensitivity of the RAI-HC measure of TBI. Unfortunately this was the only available measure of TBI on the RAI-HC so it was not possible to get a better estimate of the true occurrence of TBI in older adult home care population of Ontario. It is difficult to suggest a way that would be able to better measure TBI in the home care population of Ontario. As there is no universally accepted case definition of TBI, it remains challenging to crease a simple, valid measure of TBI. Ideally once a case definition of TBI is established a measure would be created that would be able to properly estimate TBI in the general older adult population. It is crucial that researchers begin trying to establish and use a case definition of TBI so incidence estimates and etiologic factors can be investigated and compared across populations.

The etiologic study found three significant effect modifiers between the association of depression and TBI: education level, history of falling and Alzheimer's disease. Socioeconomic characteristics like education level and their association with injury in general have been investigated extensively (43). However, a review of the literature indicated that the association

between education level and TBI has not been fully investigated. A US study found that older adults with some college education level were less likely to sustaining a MTBI (8). No studies have examined the modifying effects of education level between the association of depression and TBI. Based on the literature and the descriptive results, it makes sense older adults with more education are less likely to sustain a TBI. Nonetheless the study adds to the literature by showing that future studies should take into account education level when investigating the etiology of TBI in older adults.

The finding that history of falling is an effect modifier between the association of depression and TBI was not surprising. Research has shown that falling is the cause of over 80% of TBIs in older adults (1, 2, 6, 7, 22, 44) and that persons with a history of falling are more likely to fall again (1, 21). The study confirms the results of past studies that older adult with a history of falling are more likely to sustain a TBI. Future studies should take into account history of falling when conducting multivariable analyses of the association between chronic conditions and TBI.

The association between Alzheimer's disease and TBI has not been investigated and researchers have indicated it should be (16). The study suggests that Alzheimer's disease may play a modifying effect between depression and TBI. Research has shown that depression moderately increased the risk of Alzheimer's disease and other dementias in older adults and that depression occurs frequently in persons with Alzheimer's disease (45). There is clearly a relationship between depression and Alzheimer's disease, and the combination of both diseases may place older adults at an increased risk for sustaining a TBI.

7.4.2 Internal Validity

When interpreting the results of an epidemiologic study it is crucial to assess whether estimates are valid and reliable. Interpreting the validity of a study is important because there are often a number of alternate factors that could explain the association between the exposure and outcome. In the case of this study, the potential threats to internal validity were chance, bias (misclassification, selection bias, recall bias and overmatching bias), confounding, choice of case group and sensitivity. Although effect modification is not a threat to internal validity, it will also be discussed.

Calculating p-values and confidence intervals assesses the degree of chance in a study (46). For the present study, findings were considered significant if p-values were less than or equal to 0.05. This means that the chance of obtaining the result in question would have less than or equal to 5% chance of occurring due to chance alone. For the etiologic association between depression and TBI, after controlling for history of falling, education level and Alzheimer's disease, the p-value was less than 0.0001. This means that there was less than a 0.01% chance that the findings were due to chance alone. This p-value is also significantly lower than the interpreted significance level of 0.05. The OR between depression and TBI was 1.24 with confidence intervals from 1.12 to 1.38 after adjusting for confounders. Because confidence intervals are based on sample size and standard error, the confidence intervals were precise around the OR estimate. Because no studies have examined the association between depression and TBI it is not possible to compare the result to expected literature results. However, the precise confidence intervals indicate that there is likely an association between depression and sustaining a TBI in older adults after controlling for confounding factors.

Bias should always be considered when conducting an epidemiologic study. Bias is defined as a systematic error that leads to an incorrect association between exposure and

outcome (47). Because the study was conducted using a nested matched case control study design, the following types of bias will be discussed: misclassification bias, selection bias, recall bias and overmatching bias. Confounding, the choice of case group and effect modification will also be discussed.

Misclassification bias can occur when the means for obtaining data about the study participants are inadequate so that as a result some of the information collected regarding exposure and/or outcome is incorrect (48). In differential misclassification, the rate of misclassification is different between study groups (48). In non-differential misclassification, the rate of misclassification is not different between study groups (48). Although it was not possible to statistically assess misclassification during out study, we have no reason to believe that the misclassification was differential. If misclassification was present it was most likely non-differential because both cases and controls were exposed to the same measures to determine the status of depression, TBI and the various confounders and effect modifiers. Although the sensitivity of the outcome measure was low (discussed below), the misclassification of TBI would not be related to the exposure status. The low sensitivity of the outcome measure is simply a problem inherent in the data collection measures on the RAI-HC and is not due to exposure status in any way. There is no evidence to suggest that the study was subject to differential misclassification; however, it is very probable that nondifferential misclassification biased the findings towards the null (see page 56).

The biggest threat to the study was the low sensitivity of the TBI outcome measure. Sensitivity is defined as the ability of a measure to identify correctly persons who have the condition of interest (48). The sensitivity of the TBI outcome measure was only 0.23, which means that we only captured 23% of the true TBI cases. The association we found between

depression and TBI was most likely an underestimation, which was expected with such a high nondifferential measurement error. The poor sensitivity would have also underestimated the incidence of TBI. We also conducted a sensitivity analysis of annual cumulative incidence of TBI (see Table 3) to account for the misclassification in the TBI outcome measure. The results of this sensitivity analysis showed how much the incidence rates were likely an underestimate of the true incidence. Unfortunately there was no way we could use another measure or improve the sensitivity to strengthen the study. More research is necessary to develop a universal definition of TBI, construct a valid measure for the older adult population, and then incorporate this measure into the RAI-HC.

Selection bias is defined as a distortion that results from procedures used to select cases and controls, or exposed and nonexposed, and from factors that influence study participation (48). Selection bias was minimized in this study as both cases and controls were not selected based on their exposure to depression. Because the study utilized a secondary data source where the RAI-HC was administered to all persons included, it was not possible for persons to be included in home care without undergoing a RAI-HC assessment. This means that there were no external factors that could influence study participation, because service users undergoing home care treatment had to be assessed using the RAI-HC. Administering the RAI-HC is necessary to properly determine a persons needs, care goals and overall wellbeing (49). Thus, selection bias is not a reasonable explanation for the association found between depression and TBI.

Recall bias is defined as enhanced recall of exposure or outcome status in cases compared to controls or vice versa (48). Healthcare professionals administering and collecting data for the RAI-HC are instructed that disease status is not to be reported as present if an episode occurred several years ago unless it is current being controlled with medications, diet, being regularly

monitored to prevent occurrence or other means (49). This is done to ensure that only diseases and conditions currently affecting the service user are captured. In terms of TBI-status, the RAI-HC is commonly administered if there is a significant change in a service user's status (which includes sustaining a TBI) (49). The relative prevalence of memory affecting neurological conditions (parkinsonism, Alzheimer's disease and dementia) among service users with and without TBI may have influenced the ability to recall certain events related to depression and other variables. Approximately 5% of service users with TBI had Parkinson's, 8% had Alzheimer's disease and 22% had dementia. Service users without TBI had similar rates to service users with TBI; however, the prevalence of dementia among service users without TBI was substantially lower (15%) than those with TBI. This may cause service users with TBI to be less likely to remember exposure related events. Although this was unlikely to have a significant effect on the study results, it is important to acknowledge the possibility. It is also possible that persons suffering from dementia would use a proxy to answer any medical questions, however it was not possible to evaluate the use of a proxy based on the RAI-HC.

Overmatching bias is defined as matching on variables that are not considered risk factors for the disease (48). Because we were using a large secondary database it was possible to match on a variety of proven risk factors in order to control for confounding. The study matched each case to four controls. Each case to four controls because research has shown that using more than four controls does not increase the amount of efficiency gained when performing a nested case control study versus a full cohort study (48). The literature review indicated that males are approximately two times more likely to sustain a TBI compared to females (1, 2, 6, 7), so we matched on sex. The literature review also indicates that as age increases older adults are more likely to sustaining a TBI (1, 2, 6, 7). For this reason we matched each case to controls based on

age (+/- 1 year). In addition, we wanted to control for time at risk by matching based on date of cohort entry (+/- 3 months, admission to home care). We did not match on any other variables because we wanted to examine certain variables as potential confounders and effect modifiers (i.e., neurological conditions). It is unlikely that there was significant overmatching bias present in the study, as we only matched on proven risk factors for sustaining a TBI.

Confounding is defined as any variable in a statistical model that is associated directly or inversely with both the exposure and outcome (48). During statistical analyses it is easy to derive a causal inference between two variables; however, the relationship may not be causal and could be confounded by other variables. In order to properly control for confounding in this study, we conducted crude bivariate associations between all potential confounders (identified based on the literature review) and the outcome of TBI (Appendix C). If the crude bivariate associations were statistically significant ($p \leq 0.05$), then the confounder was included in the initial model. In addition, matching was used to control for sex, age and time at risk.

The choice of case group may have had an effect on the association between depression and TBI. As previously mentioned, the RAI-HC amalgamates all severities of TBI under one diagnosis. Ideally we would want a homogenous outcome measure; however, that was not possible using the OACCAC database and the RAI-HC. The cases did not all have the same severity of TBI, as estimates have indicated that approximately 70-75% of TBI cases are mild, 20-25% are moderate and 5-10% are severe in older adults (3, 10, 11). The effect of depression may vary depending on the severity of TBI; however, the study is still able to show the amalgamated effect of depression on TBI in general.

Effect modification is not a systematic bias, it a phenomena that should be investigated and described (48). Effect modification occurs when the incidence of disease in the presence of

two or more risk factors differs from the incidence rate expected to result from their individual effects (48). The effect can either increase the associated risk or decrease the associated risk (48). Suspected effect modifiers were assessed by generating interaction variables (e.g. depression * aboriginal origin) and then conducting bivariate assessments with TBI. Effect modifiers were considered statistically significant if the p-value of the interaction term was less than or equal to 0.05 (Appendix C). Effect modification was described in the study by looking at various strata of each specific confirmed effect modifier to understand the effect on the exposure and outcome. This allowed us to uncover some interesting relationships between exposure and outcome and to generate new hypotheses for future longitudinal studies, such as testing the modifying effects of Alzheimer's disease and education level on the relationship between various chronic conditions and sustaining a TBI.

7.4.3 External Validity

External validity is known as the generalizability of a study. A study that has a high degree of generalizability is able to generalize its result beyond the study population itself (48). The first and most important criterion for an externally valid study is having an internally valid study methodology. Except for the limitation of low sensitivity, the study was internally valid. Utilizing validated measures, case control matching and measuring a variety of known confounders and effect modifiers allowed the study to be internally valid.

As this study only investigated the association between depression and TBI in older community dwelling adults using home care, the results are not generalizable to younger adults or other age groups. Older adults are known to have significantly more chronic conditions (1, 2, 6, 7) and rates of depression (51-62) compared to other age groups. This increased prevalence of

chronic conditions and depression among older adults minimizes the generalizability of the results.

The OACCAC database collects home care data from all CCAC's across the province of Ontario, so the results are generalizable to the entire Ontario home care population (49). This study did not investigate the variation in effect between different geographic areas and this is an avenue for future research. When compared to the entire home care population of Canada, this sample of service users in the province of Ontario is typical to other areas of Canada (63). A study completed by the Health Council of Canada in 2012 utilized the RAI-HC to examine the characteristics of older adults aged 65 years and older using home care in the provinces of Yukon, British Columbia, Manitoba, Nova Scotia and Ontario (63). The study found that two thirds of service users were women, 40% of were aged 85 years or older, a third were married, the majority had at least one chronic condition, 20% had dementia and 25-40% had a history of falling (63). These characteristics were similar to all service users included in the study. Although the authors mention the characteristics of service users described in the Canada wide study are not entirely representative of the Canadian older adult population in general, the study provides information on important similarities and differences between provinces (63).

7.4.4 Causation

Causation must be examined when conducting an epidemiological study. There are nine main criteria for determining causation as specified by Hill (64): strength of association, consistency, specificity, temporality, biological gradient, plausibility, coherence, experimental evidence and analogy (64). The adjusted strength of association between depression and TBI was low (OR: 1.24, 95% CI: 1.12, 1.38) based on what was hypothesized from a review of the

literature. Further research is needed to confirm that there is in fact an association between depression and TBI. It is not possible to assess the consistency of the study, as there have been no other studies examining the relationship between depression and sustaining a TBI. However, this is the first study to examine the association between depression and TBI so the results cannot be compared to other studies. It is not possible to accurately determine the specificity of the study, as depression may lead to a variety of medical conditions. However, Hill mentions that specificity should not be over-emphasized when interpreting a causal relationship (80). Because the study was cross-sectional in nature we cannot absolutely confirm temporality. However, when social workers or nurses are administering the RAI-HC the items measuring the exposure of depression are measured as present if they have occurred in the past three days prior to the assessment (49). This does not necessarily mean that depression occurred before sustaining a TBI but it does indicate that depression may have occurred prior to sustaining a TBI. The dose-response, or biological gradient, of the association between depression and TBI was not examined in this study. The findings are biologically plausible, as depression is associated with an increased risk of falling (33-38) and falling is the main cause of TBI in older adults (1, 2, 6, 7). The study is coherent because the study results do not conflict with the known biology of depression. There is no experimental evidence of the association between depression and TBI, however there is experimental evidence suggesting that depression increases the risk of falling (31-37). Analogy cannot be judged, as studies have not investigated the association between other neurological conditions and sustaining a TBI in older adults.

7.4.5 Practical Applications

The strength of association between depression and TBI, after adjusting for confounders, was low (OR: 1.24, 95% CI: 1.12, 1.38). Interpreting the clinical significance of this result is difficult, as the association cannot be interpreted as causal. From a public health standpoint, the results of the study could be used to help inform policy makers responsible for primary preventative measures in home care across Ontario and potentially Canada to reduce the occurrence of TBI. Although the results were statistically significant the present study would not suggest changing any clinical protocols until a longitudinal study using validated measures is undertaken to determine the true association between depression and TBI.

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8. STRENGTHS AND LIMITATIONS

A major strength of this study was the ability to use a database that had a large sample size (554,313 total service users based on the inclusion criteria). The large sample size allowed a substantial number of TBIs (5215 total cases of TBI) to be captured for the case control study. Having such a large sample size gave the power to estimate odds ratios with precise confidence intervals. Having such a large overall sample size also ensured that the majority of cases could be matched to four controls to control for the varying effects of sex, age and date of initial assessment.

The OACCAC database collects home care data from persons across the province of Ontario, the largest province by population in Canada, which allows the results to be generalizable for a large portion of the Canadian population. Having population-based data is crucial for measuring TBI and its potential risk factors, as most studies have used hospitalization figures which may not represent the general population or be as accurate.

The OACCAC home care database contains longitudinal data from 2003 to 2013, which was another strength of the study. Utilizing data from such a long and recent time period allowed a ten-year trend analysis of TBI to be conducted, which is an important analysis to determine whether the incidence of TBI is decreasing or not. Understanding whether TBI is decreasing significantly among a certain group of service users is important information for policy makers and primary prevention healthcare professionals.

The RAI-HC is a comprehensive instrument with many variables, which ensured that many potential confounders could be controlled for and potential effect modifiers could be investigated during the multivariable analysis. Most of the items used to measure potential

confounders and effect modifiers were also validated by both national and international studies, giving the study more internal validity as whole.

A major limitation of this study was the use of a cross-sectional study design to determine the association between depression and sustaining a TBI. Using a cross-sectional design negates the ability to properly establish causality between depression and TBI, as we were not able to ensure that depression occurred before TBI. However, the goal of this study was to generate new hypotheses for the relationship between various chronic conditions and TBI. This is a phase one (1), or hypothesis generating study, and consequently future studies can use the information to conduct longitudinal cohort studies to properly establish relationships and causation.

A major limitation of this study was the inability to distinguish between mild, moderate and severe TBI in our outcome measure using the RAI-HC. The RAI-HC amalgamates all severities of TBI under one diagnosis of "head trauma" and for this reason it was not possible to measure the association between depression and each severity. It was not possible to determine the ORs and associated confidence intervals for each measured characteristics and the severity of TBI. It was also not possible to determine the annual cumulative incidence and assess the trend of incidence for each severity of TBI.

Another limitation of this study was the poor sensitivity of the TBI outcome measure from the RAI-HC. The low sensitivity likely means that the incidence calculations are likely an under-estimation of the true incidence and should consequently be interpreted with caution. However, for the etiologic study a sensitivity analysis was completed to take into account the low sensitivity. Having such a low sensitivity (0.23) decreased the OR substantially. Ideally the sensitivity would be much higher and may have been able to give us a more accurate

representation of the association between depression and sustaining a TBI. It would also be ideal if the RAI-HC contained a "gold standard" evaluation of head trauma that occurs among service users, like the Glasgow Coma Scale, however that may not be practical to administer in a home care setting.

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9. FUTURE DIRECTIONS

The most reliable and scientifically sound study design is a randomized controlled trial; however, for the purposes of investigating risk factors and characteristics associated with TBI it would not be appropriate. Future studies should try and build upon these results and conduct a higher-level study using a longitudinal design, like a cohort study. Depression may be associated with TBI and using validated population based measures with a longitudinal design will be able to accurately determine whether a causal relationship exists. Future studies should investigate TBI in other regions of Canada and focus on distinct populations (i.e., aboriginal or military populations) to measure how rates may vary depending on the region and population of study. Looking into how incidence varies between different CCAC catchment areas in Ontario would also be a useful study. Studies have determined which persons are at greatest risk of sustaining a TBI in the older adult population; however, studies should still be conducted to verify which persons are at risk in certain regions as there may be variations.

This study used population-based figures to determine the characteristics and incidence of service users who sustaining TBI in the older adult population, however more research is needed to compare the rates to hospitalization based figures in Ontario, Canada. Using hospital chart information would be a more valid measurement of TBI, which would increase the internal validity of the study. However, using hospitalization figures would limit the generalizability of the study and, based on the literature review, would under report the true incidence of TBI.

10. CONCLUSIONS

TBI is an important injury due to its significant burden on healthcare spending and its short and long-term impacts on older adults. Little is known regarding the risk factors for TBI in the older adult community dwelling population and the incidence has been under-studied. The descriptive study examined a variety of characteristics that may be associated with an increased risk of sustaining a TBI and determined the incidence and incidence trend of TBI in older using home care in Ontario. The etiologic study found that depression may be associated with sustaining a TBI and that the relationship between depression and TBI is likely influenced by other intrinsic characteristics. As the Canadian population ages, more information is needed on how common comorbid conditions, such as depression, may influence the occurrence of TBI, so primary preventative measures can be implemented to reduce its occurrence. This research has important implications for future researchers who seek to understand the relationship between various chronic conditions and sustaining a TBI in older adults.

11. REFLECTIONS

This thesis project was an incredible learning experience from start to finish. Investigating the role of such a prevalent mental health condition on an injury that has a number of negative consequences was very enjoyable. It will be interesting to see if my results have any effect on future studies investigating brain injury in older adults.

The most enjoyable aspect of this study was designing my own study with the guidance of my thesis committee. I found that learning from the ground up how a research question is developed and what study design is appropriate to be fascinating. Working with a small team brought a variety of ideas to the table and it was interesting to see how different backgrounds of health science contributed to the way a problem was viewed and approached.

Realizing that my results would hopefully be published was a large motivating factor for conducting this study to the best of my abilities. Whether it was cleaning the initial data, deciding what macro to use to match my cases to controls or running that first conditional regression analysis, it was all being done to get to that major goal of publication. Another enjoyable part of this project was browsing through various journal websites to try and select a journal that would fit my target audience. Prior to beginning this study, I had never thought about the process of trying to select a journal, and it turned out to be both difficult and exciting.

Learning to work with such a large dataset was daunting at the beginning; however, over time I realized exactly how much a single dataset could potentially contribute to health research. Even more daunting was opening up that first SAS user manual to try and tame a statistical beast in which I had no previous experience. However, like Dr. Kristman has told me many times, as an epidemiology student it is important to try and become familiar with as many statistical

packages as possible. I now wholeheartedly agree and am much more comfortable approaching new areas of epidemiological learning.

The results were able to show that there was a significant association between depression and sustaining a TBI. I found this research project to be very satisfying and it is my hope that my results will set the groundwork for future studies investigating brain injury in the Canadian population. I look forward to applying the skills I have learning during this Master's program when I attend medical school in the coming year.

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13. APPENDICES

Appendix A: Resident Assessment Instrument-Home Care

Minimum Data Set Home Care (MDS-HC)© Canadian Version

- Unless otherwise noted, score for last 3 days
- Examples of exceptions include IADLs/Continence/ Services/Treatments where status scored over last 7 days

Addressograph

SECTION AA: NAME AND IDENTIFICATION INFORMATION

1	NAME OF CLIENT	a. Last/Family Name b. First Name c. Middle Name/Initial
2	CASE RECORD NUMBER	
3a	HEALTH CARD NUMBER	a. Enter the client's health card number, or enter "**0**" if unknown or "**1**" if not applicable.
3b	PROVINCE/ TERRITORY ISSUING HEALTH CARD NO.	b. Enter the Province/Territory code issuing health card number. (See RAI-HC manual for province/ territory) and for missing/not applicable codes)
4	POSTAL CODE OF RESIDENCE	See RAI-HC manual for homeless/missing codes.

SECTION BB. PERSONAL ITEMS

1	SEX	**M.** Male **F.** Female
2a	BIRTH DATE	Year Month Day
2b	ESTIMATED BIRTH DATE	Birth date is estimated? **0.** No **1.** Yes
3	ABORIGINAL ORIGIN	Client's origin is Inuit, Métis or North American Indian **0.** No **1.** Yes
4	MARITAL STATUS	**1.** Never married **2.** Married **3.** Widowed **4.** Separated **5.** Divorced **6.** Other
5	LANGUAGE	a. Primary language (See RAI-HC manual for additional codes.) **ENG.** English **FRA.** French b. Interpreter needed **0.** No **1.** Yes
6	EDUCATION (Highest Level Completed)	**1.** No schooling **2.** 8th grade/less **3.** 9–11 grades **4.** High school **5.** Technical or trade school **6.** Some college/university **7.** Diploma/Bachelor's degree **8.** Graduate degree **9.** Unknown

7	RESPONSIBILITY/ ADVANCED DIRECTIVES	***(Code for responsibility/advanced directives)*** **0.** No **1.** Yes a. Client has a legal guardian/substitute decision-maker b. Client has advanced medical directives in place (for example, a do not hospitalize order)
8	RESPONSIBILITY FOR PAYMENT	***(Check all that apply)*** a. Provincial/territorial government plan b. Other province/territory c. Federal government—Veteran Affairs Canada d. Federal government—First Nations and Inuit Health Branch (FNIHB) e. Federal government—other (RCMP, Canadian Armed Forces federal penitentiary inmate, refugee) f. Worker's Compensation Board (WCB/WSIB) g. Canadian resident—private insurance pay h. Canadian resident—public trustee pay i. Canadian resident—self pay j. Other country resident—self pay k. Responsibility for payment unknown/unavailable

SECTION CC. REFERRAL ITEMS ***(Complete at Intake Only)***

1	DATE CASE OPENED/ REOPENED	Year Month Day
2	REASON FOR REFERRAL	**1.** Post hospital care **2.** Community chronic care **3.** Home placement screen **4.** Eligibility for home care **5.** Day care **6.** Other
3	UNDERSTANDING OF GOALS OF CARE	***(Code for client/family understanding of goals of care)*** **0.** No **1.** Yes a. Skilled nursing treatments b. Monitoring to avoid clinical complications c. Rehabilitation d. Client/family education e. Family respite f. Palliative care

Name of Client _____ Case Record # _____

4	TIME SINCE LAST HOSPITAL STAY	Time since discharge from last inpatient setting ***(Code for most recent instance in LAST 180 DAYS)*** **0**. Presently in hospital **1**. No hospitalization within 180 days **2**. Within last week **3**. Within 8 to 14 days **4**. Within 15 to 30 days **5**. More than 30 days ago	☐
5	WHERE LIVED AT TIME OF REFERRAL	**1**. Private home/apt. with no home care services **2**. Private home/apt. with home care services **3**. Board and care/assisted living/group home **4**. Residential care facility **5**. Other	☐
6	WHO LIVED WITH AT REFERRAL	**1**. Lived alone **2**. Lived with spouse only **3**. Lived with spouse and other(s) **4**. Lived with child (not spouse) **5**. Lived with other(s) (not spouse or children) **6**. Lived in group setting with non-relative(s)	☐
7	PRIOR RESIDENTIAL CARE FACILITY PLACEMENT	Resided in a residential care facility at anytime during **5 YEARS** prior to case opening **0**. No **1**. Yes	☐
8	RESIDENTIAL HISTORY	Moved to current residence within last two years. **0**. No **1**. Yes	☐

SECTION A. ASSESSMENT INFORMATION

1	ASSESSMENT REFERENCE DATE	***Date of assessment*** ☐☐☐☐ Year ☐☐ Month ☐☐ Day	
2	REASON FOR ASSESSMENT	***Type of assessment*** **1**. Initial assessment **2**. Follow-up assessment **3**. Routine assessment at fixed intervals **4**. Review within 30-day period prior to discharge from the program **5**. Review at return from hospital **6**. Change in status **7**. Other	☐

SECTION B. COGNITIVE PATTERNS

1	MEMORY RECALL ABILITY	***(Code for recall of what was learned or known)*** **0**. Memory OK **1**. Memory problem	
		a. Short-term memory OK—seems/appears to recall after 5 minutes	☐
		b. Procedural memory OK—can perform all or almost all steps in a multitask sequence without cues for initiation	☐
2	COGNITIVE SKILLS FOR DAILY DECISION-MAKING	a. How well client made decisions about organizing the day (e.g. when to get up or have meals, which clothes to wear or activities to do) **0**. *INDEPENDENT*—Decisions consistent/reasonable/safe **1**. *MODIFIED INDEPENDENCE*—Some difficulty in new situations only **2**. *MINIMALLY IMPAIRED*—In specific situations, decisions become poor or unsafe and cues/supervision necessary at those times **3**. *MODERATELY IMPAIRED*—Decisions consistently poor or unsafe, cues/supervision required at all times **4**. *SEVERELY IMPAIRED*—Never/rarely made decisions	☐
		b. Worsening of decision making as compared to status of **90 DAYS AGO** (or since last assessment if less than 90 days) **0**. No **1**. Yes	☐
3	INDICATORS OF DELIRIUM	a. Sudden or new onset/change in mental function over **LAST 7 DAYS** (including ability to pay attention, awareness of surroundings, being coherent, unpredictable variation over course of day) **0**. No **1**. Yes	☐
		b. In the **LAST 90 DAYS** (or since last assessment if less than 90 days), client has become agitated or disoriented such that his or her safety is endangered or client requires protection by others **0**. No **1**. Yes	☐

SECTION C. COMMUNICATION/HEARING PATTERNS

1	HEARING	***(With hearing appliance if used)*** **0**. *HEARS ADEQUATELY*—Normal talk, TV, phone, doorbell **1**. *MINIMAL DIFFICULTY*—When not in quiet setting **2**. *HEARS IN SPECIAL SITUATIONS ONLY*—Speaker has to adjust tonal quality and speak distinctly **3**. *HIGHLY IMPAIRED*—Absence of useful hearing	☐
2	MAKING SELF UNDER-STOOD (Expression)	***(Expressing information content—however able)*** **0**. *UNDERSTOOD*—Expresses ideas without difficulty **1**. *USUALLY UNDERSTOOD*—Difficulty finding words or finishing thoughts BUT if given time, little or no prompting required **2**. *OFTEN UNDERSTOOD*—Difficulty finding words or finishing thoughts, prompting usually required **3**. *SOMETIMES UNDERSTOOD*—Ability is limited to making concrete requests **4**. *RARELY/NEVER UNDERSTOOD*	☐
3	ABILITY TO UNDER-STAND OTHERS (Compre-hension)	***(Understands verbal information—however able)*** **0**. *UNDERSTANDS*—Clear comprehension **1**. *USUALLY UNDERSTANDS*—Misses some part/intent of message, BUT comprehends most conversation with little or no prompting **2**. *OFTEN UNDERSTANDS*—Misses some part/intent of message; with prompting can often comprehend conversation **3**. *SOMETIMES UNDERSTANDS*—Responds adequately to simple, direct communication **4**. *RARELY/NEVER UNDERSTANDS*	☐
4	COMMUNI-CATION DECLINE	Worsening in communication (making self understood or understanding others) as compared to status of **90 DAYS AGO** (or since last assessment if less than 90 days) **0**. No **1**. Yes	☐

Name of Client _____ Case Record # _____

SECTION D. VISION PATTERNS

1	VISION	***(Ability to see in adequate light and with glasses if used)*** **0**. *ADEQUATE*—Sees fine detail, including regular print in newspapers/books **1**. *IMPAIRED*—Sees large print, but no regular print in newspapers/books **2**. *MODERATELY IMPAIRED*—Limited vision; not able to see newspaper headlines, but can identify objects **3**. *HIGHLY IMPAIRED*—Object identification in question, but eyes appear to follow objects **4**. *SEVERELY IMPAIRED*—No vision or sees only light, colours, or shapes; eyes do not appear to follow objects	☐
2	VISUAL LIMITATION/ DIFFI-CULTIES	Saw halos or rings around lights, curtains over eyes, or flashes of lights **0**. No **1**. Yes	☐
3	VISION DECLINE	Worsening of vision as compared to status of **90 DAYS AGO** (or since last assessment if less than 90 days) **0**. No **1**. Yes	☐

SECTION E. MOOD AND BEHAVIOUR PATTERNS

1	INDICATORS OF DEPRESSION, ANXIETY, SAD MOOD	***(Code for observed indicators irrespective of the assumed cause)*** **0**. Indicator not exhibited in last 3 days **1**. Exhibited 1–2 of last 3 days **2**. Exhibited on each of last 3 days	
		a. **A FEELING OF SADNESS OR BEING DEPRESSED**, that life is not worth living, that nothing matters, that he or she is of no use to anyone or would rather be dead	☐
		b. **PERSISTENT ANGER WITH SELF OR OTHERS**—e.g. easily annoyed, anger at care received	☐
		c. **EXPRESSIONS OF WHAT APPEAR TO BE UNREALISTIC FEARS**—e.g. fear of being abandoned, left alone, being with others	☐
		d. **REPETITIVE HEALTH COMPLAINTS**—e.g. persistently seeks medical attention, obsessive concern with body functions	☐
		e. **REPETITIVE ANXIOUS COMPLAINTS, CONCERNS**—e.g. persistently seeks attention/ reassurance regarding schedules, meals, laundry, clothing, relationship issues	☐
		f. **SAD, PAINED, WORRIED FACIAL EXPRESSIONS**—e.g. furrowed brows	☐
		g. **RECURRENT CRYING, TEARFULNESS**	☐
		h. **WITHDRAWAL FROM ACTIVITIES OF INTEREST**—e.g. no interest in long standing activities or being with family/friends	☐
		i. **REDUCED SOCIAL INTERACTION**	☐
2	MOOD DECLINE	Mood indicators have become worse as compared to status of **90 days ago** (or since last assessment if less than 90 days) **0**. No **1**. Yes	☐
3	BEHAVIOURAL SYMPTOMS	Instances when client exhibited behavioural symptoms. If EXHIBITED, ease of altering the symptom when it occurred. **0**. Did not occur in last 3 days **1**. Occurred, easily altered **2**. Occurred, not easily altered	
		a. **WANDERING**—Moved with no rational purpose, seemingly oblivious to needs or safety	☐
		b. **VERBALLY ABUSIVE BEHAVIOURAL SYMPTOMS**—Threatened, screamed at, cursed at others	☐
		c. **PHYSICALLY ABUSIVE BEHAVIOURAL SYMPTOMS**—Hit, shoved, scratched, sexually abused others	☐
		d. **SOCIALLY INAPPROPRIATE/ DISRUPTIVE BEHAVIOURAL SYMPTOMS**—Disruptive sounds, noisiness, screaming, self-abusive acts, sexual behaviour or disrobing in public, smears/ throws food/feces, rummaging, repetitive behaviour, rises early and causes disruption	☐
		e. **RESISTS CARE**—Resisted taking medications/ injections, ADL assistance, eating, or changes in position	☐
4	CHANGES IN BEHAVIOUR SYMPTOMS	Behavioural symptoms have become worse or are less well tolerated by family as compared to **90 DAYS AGO** (or since last assessment if less than 90 days) **0**. No, or no change in behavioural symptoms or acceptance by family **1**. Yes	☐

SECTION F. SOCIAL FUNCTIONING

1	INVOLVE-MENT	a. At ease interacting with others (e.g. likes to spend time with others) **0**. At ease **1**. Not at ease	☐
		b. Openly expresses conflict or anger with family/friends **0**. No **1**. Yes	☐
2	CHANGE IN SOCIAL ACTIVITIES	As compared to **90 DAYS AGO** (or since last assessment if less than 90 days ago), decline in the client's level of participation in social, religious, occupational or other preferred activities. IF THERE WAS A DECLINE, client distressed by this fact **0**. No decline **1**. Decline, not distressed **2**. Decline, distressed	☐
3	ISOLATION	a. Length of time client is alone during the day (morning and afternoon) **0**. Never or hardly ever **1**. About one hour **2**. Long periods of time—e.g. all morning **3**. All of the time	☐
		b. Client says or indicates that he/she feels lonely **0**. No **1**. Yes	☐

SECTION G. INFORMAL SUPPORT SERVICES

1	TWO KEY INFORMAL HELPERS Primary (A) and Secondary (B)	NAME OF PRIMARY AND SECONDARY HELPERS a. (Last/Family Name) b. (First Name) c. (Last/Family Name) d. (First Name)	(A) Pri.	(B) Sec.
		e. Lives with client **0**. Yes **1**. No **2**. No such helper (skip other items in the appropriate column)	☐	☐
		f. Relationship to client **0**. Child or child-in-law **1**. Spouse **2**. Other relative **3**. Friend/neighbour	☐	☐

Name of Client _____ Case Record # _____

		Areas of help: **0**. Yes **1**. No	
		g. Advice or emotional support	☐ ☐
		h. IADL care	☐ ☐
		i. ADL care	☐ ☐
		If needed, willingness (with ability) to increase help: **0**. More than 2 hours per day **1**. 1–2 hours per day **2**. No	
		j. Emotional support	☐ ☐
		k. IADL care	☐ ☐
		l. ADL care	☐ ☐
2	CAREGIVER STATUS	***(Check all that apply)***	
		A caregiver is unable to continue in caring activities—e.g. decline in the health of the caregiver makes it difficult to continue	a. ☐
		Primary caregiver is not satisfied with support received from family and friends (e.g. other children of client)	b. ☐
		Primary caregiver expresses feelings of distress, anger or depression	c. ☐
		NONE OF ABOVE	d. ☐
3	EXTENT OF INFORMAL HELP (HOURS OF CARE, ROUNDED)	For instrumental and personal activities of daily living received over the **LAST 7 DAYS**, indicate extent of help from family, friends, and neighbours	**HOURS**
		a. Sum of time across five weekdays	☐☐☐
		b. Sum of time across two weekend days	☐☐☐

SECTION H. PHYSICAL FUNCTIONING:
- **IADL PERFORMANCE IN 7 DAYS**
- **ADL PERFORMANCE IN 3 DAYS**

1	**IADL SELF-PERFORMANCE**—Code for functioning in routine activities around the home or in the community during the **LAST 7 DAYS**.			
	(A) IADL SELF-PERFORMANCE CODE **(Code for client's performance during LAST 7 DAYS)** **0**. *IN*DEPENDENT—did on own **1**. SOME HELP—help some of the time **2**. FULL HELP—performed with help all of the time **3**. BY OTHERS—performed by others **8**. *ACTIVITY DID NOT OCCUR*			
	(B) IADL DIFFICULTY CODE How difficult it is (or would it be) for client to do activity on own **0**. *NO DIFFICULTY* **1**. *SOME DIFFICULTY*—e.g. needs some help, is very slow, or fatigues **2**. *GREAT DIFFICULTY*—e.g. little or no involvement in the activity is possible	**(A)** Performance	**(B)** Difficulty	
	a. **MEAL PREPARATION**—How meals are prepared (e.g. planning meals, cooking, assembling ingredients, setting out food and utensils)	☐	☐	
	b. **ORDINARY HOUSEWORK**—How ordinary work around the house is performed (e.g. doing dishes, dusting, making bed, tidying up, laundry)	☐	☐	
	c. **MANAGING FINANCES**—How bills are paid, cheque book is balanced, household expenses are balanced	☐	☐	
	d. **MANAGING MEDICATIONS**—How medications are managed (e.g. remembering to take medicines, opening bottles, taking correct drug dosages, giving injections, applying ointments)	☐	☐	
	e. **PHONE USE**—How telephone calls are made or received (with assistive devices such as large numbers on telephone, amplification as needed)	☐	☐	
	f. **SHOPPING**—How shopping is performed for food and household items (e.g. selecting items, managing money)	☐	☐	
	g. **TRANSPORTATION**—How client travels by vehicle (e.g. gets to places beyond walking distance)	☐	☐	
2	**ADL SELF-PERFORMANCE**—The following address the client's physical functioning in routine personal activities of daily life, for example, dressing, eating, etc. during the **LAST 3 DAYS, considering all episodes of these activities.** For clients who performed an activity independently, be sure to determine and record whether others encouraged the activity or were present to supervise or oversee the activity **(Note—For bathing, code for most dependent single episode in LAST 7 DAYS.)** **0**. *INDEPENDENT*—No help, setup, or oversight—OR—Help, setup, oversight provided only 1 or 2 times (with any task or subtask) **1**. *SETUP HELP ONLY*—Article or device provided within reach of client 3 or more times **2**. *SUPERVISION*—Oversight, encouragement or cueing provided 3 or more times during last 3 days—OR—Supervision (1 or more times) plus physical assistance provided only 1 or 2 times (for a total of 3 or more episodes of help or supervision) **3**. *LIMITED ASSISTANCE*—Client highly involved in activity; received physical help in guided manoeuvring of limbs or other non-weight bearing assistance 3 or more times —OR— Combination of non-weight bearing help with more help provided only 1 or 2 times during period (for a total of 3 or more episodes of physical help) **4**. *EXTENSIVE ASSISTANCE*—Client performed part of activity on own (50% or more of subtasks), but help of following type(s) were provided 3 or more times: — Weight-bearing support—OR— — Full performance by another during part (but not all) of last 3 days **5**. *MAXIMAL ASSISTANCE*—Client involved and completed less than 50% of subtasks on own (includes 2+ person assist), received weight bearing help or full performance of certain subtasks 3 or more times **6**. *TOTAL DEPENDENCE*—Full performance of activity by another **8**. *ACTIVITY DID NOT OCCUR* (regardless of ability)			
	a. **MOBILITY IN BED**—Including moving to and from lying position, turning side to side, and positioning body while in bed.	☐		
	b. **TRANSFER**—Including moving to and between surfaces—to/from bed, chair, wheelchair, standing position. (Note—Excludes to/from bath/toilet)	☐		
	c. **LOCOMOTION IN HOME**—(Note—If in wheelchair, self-sufficiency once in chair.)	☐		
	d. **LOCOMOTION OUTSIDE OF HOME**—(Note—If in wheelchair, self-sufficiency once in chair.)	☐		
	e. **DRESSING UPPER BODY**—How client dresses and undresses **(street clothes, underwear)** above the waist, includes prostheses, orthotics, fasteners, pullovers, etc.	☐		
	f. **DRESSING LOWER BODY**—How client dresses and undresses **(street clothes, underwear)** from the waist down, includes prostheses, orthotics, belts, pants, skirts, shoes, and fasteners.	☐		
	g. **EATING**—Including taking in food by any method, including tube feedings.	☐		
	h. **TOILET USE**—Including using the toilet room or commode, bedpan, urinal, transferring on/off toilet, cleaning self after toilet use or incontinent episode, changing pad, managing any special devices required (ostomy or catheter), and adjusting clothes.	☐		
	i. **PERSONAL HYGIENE**—Including combing hair, brushing teeth, shaving, applying makeup, washing/drying face and hands (EXCLUDE baths and showers).	☐		

Name of Client _____ Case Record # _____

	j.	**BATHING**—How client takes full-body bath/shower or sponge bath (**EXCLUDE** washing of back and hair). Includes how each part of body is bathed: arms, upper and lower legs, chest abdomen, perineal area. **Code for most dependent episode in LAST 7 DAYS.**	☐
3	ADL DECLINE	ADL status has become worse (i.e. now more impaired in self-performance) as compared to status **90 days ago** (or since last assessment if less than 90 days) **0**. No **1**. Yes	☐
4	PRIMARY MODES OF LOCOMO-TION	**0**. No assistive device **4**. Wheelchair **1**. Cane **8**. ACTIVITY DID NOT OCCUR **2**. Walker/crutch **3**. Scooter (e.g. Amigo)	
		a. Indoors	☐
		b. Outdoors	☐
5	STAIR CLIMBING	In the **last 3 days**, how client went up and down stairs (e.g. single or multiple steps, using handrail as needed). **0**. Up and down stairs without help **1**. Up and down stairs with help **2**. Not go up and down stairs	☐
6	STAMINA Text	a. In a typical week, during the **LAST 30 DAYS** (or since last assessment), code the number of days client usually went out of the house or building in which client lives (no matter how short a time period) **0**. Every day **2**. 1 day a week **1**. 2-6 days a week **3**. No days	☐
		b. Hours of physical activities in the last 3 days (e.g. walking, cleaning house, exercise) **0**. Two or more hours **1**. Less than two hours	☐
7	FUNCTIONAL POTENTIAL	***(Check all that apply)***	
		Client believes he/she capable of increased functional independence (ADL, IADL, mobility)	a. ☐
		Caregivers believe client is capable of increased functional independence (ADL, IADL, mobility)	b. ☐
		Good prospects of recovery from current disease or conditions, improved health status expected	c. ☐
		NONE OF ABOVE	d. ☐

SECTION I. CONTINENCE IN LAST 7 DAYS

1	BLADDER CONTINENCE	a. In **LAST 7 DAYS** (or since last assessment if less than 7 days) control of urinary bladder function (with appliances such as catheters or incontinence program employed) (Note—if dribbles, volume insufficient to soak through underpants) **0**. *CONTINENT*—Complete control; DOES NOT USE any type of catheter or other urinary collection device **1**. *CONTINENT WITH CATHETER*—Complete control with use of any type of catheter or urinary collection device that does not leak urine **2**. *USUALLY CONTINENT*—Incontinent episodes once a week or less **3**. *OCCASIONALLY INCONTINENT*—Incontinent episodes 2 or more times a week but not daily **4**. *FREQUENTLY INCONTINENT*—Tends to be incontinent daily, but some control present **5**. *INCONTINENT*—Inadequate control, multiple daily episodes **8**. *DID NOT OCCUR*—No urine output from bladder	☐
		b. Worsening of bladder incontinence as compared to status **90 days ago** (or since last assessment if less than 90 days) **0**. No **1**. Yes	☐
2	BLADDER DEVICES	(**Check all that apply in LAST 7 DAYS**—or since last assessment if less than 7 days)	
		Use of pads or briefs to protect against wetness	a.
		Use of an indwelling urinary catheter	b.
		NONE OF ABOVE	c.
3	BOWEL CONTINENCE	In **LAST 7 DAYS** (or since last assessment if less than 7 days), control of bowel movement (with appliance or bowel continence program if employed) **0**. *CONTINENT*—Complete control; DOES NOT USE ostomy device **1**. *CONTINENT WITH OSTOMY*—Complete control with use of ostomy device that does not leak stool **2**. *USUALLY CONTINENT*—Bowel incontinent episodes less than weekly **3**. *OCCASIONALLY INCONTINENT*—Bowel incontinent episodes once a week **4**. *FREQUENTLY INCONTINENT*—Bowel incontinent episodes 2-3 times a week **5**. *INCONTINENT*—Bowel incontinent all (or almost all) of the time **8**. *DID NOT OCCUR*—No bowel movement during entire 7 day assessment period	☐

SECTION J. DISEASE DIAGNOSES

1 DISEASES

Disease/infection that doctor has indicated is present and affects client's status, requires treatment, or symptom management. Also include if disease is monitored by a home care professional or is the reason for a hospitalization in LAST 90 DAYS (or since last assessment if less than 90 days).
(**blank**) Not present
1. Present—not subject to focused treatment or monitoring by home care professional
2. Present—monitored or treated by home care professional
(If no disease in list, check **J1ac**, *None of Above*)

HEART/CIRCULATION

- a. Cerebrovascular accident (stroke) ☐
- b. Congestive heart failure ☐
- c. Coronary artery disease ☐
- d. Hypertension ☐
- e. Irregularly Irregular pulse ☐
- f. Peripheral vascular disease ☐

NEUROLOGICAL

- g. Alzheimer's ☐
- h. Dementia other than Alzheimer's disease ☐
- i. Head trauma ☐
- j. Hemiplegia/ hemiparesis ☐
- k. Multiple sclerosis ☐

SENSES

- q. Cataract ☐
- r. Glaucoma ☐

PSYCHIATRIC/MOOD

- s. Any psychiatric diagnosis ☐

INFECTIONS

- t. HIV infection ☐
- u. Pneumonia ☐
- v. Tuberculosis ☐
- w. Urinary tract infection (**in LAST 30 DAYS**) ☐

OTHER DISEASES

- x. Cancer (in past 5 years) not including skin cancer ☐
- y. Diabetes ☐

Name of Client _____ Case Record # _____

		l. Parkinsonism		z. Emphysema/ COPD/ asthma	
				aa. Renal Failure	
		MUSCULO-SKELETAL			
		m. Arthritis		ab. Thyroid disease (hyper or hypo)	
		n. Hip fracture			
		o. Other fractures (e.g. wrist, vertebral)		ac. *NONE OF ABOVE*	
		p. Osteoporosis			
2	OTHER CURRENT OR MORE DETAILED DIAGNOSES AND ICD-10-CA CODES	a.			
		b.			
		c.			
		d.			

SECTION K. HEALTH CONDITIONS AND PREVENTIVE HEALTH MEASURES

1	PREVENTIVE HEALTH (PAST TWO YEARS)	**(Check all that apply—in PAST 2 YEARS)**			
		Blood pressure measured	a.	IF FEMALE: Received breast examination or mammography	d.
		Received influenza vaccination	b.		
		Test for blood in stool or screening endoscopy	c.	*NONE OF ABOVE*	e.
2	PROBLEM CONDITIONS PRESENT ON 2 OR MORE DAYS	**(Check all that were present on at least 2 of the last 3 days)**			
		Diarrhea	a.	Loss of appetite	d.
		Difficulty urinating or urinating 3 or more times at night	b.	Vomiting	e.
				NONE OF ABOVE	f.
		Fever	c.		
3	PROBLEM CONDITIONS	**(Check all present at any point during last 3 days)**			
		PHYSICAL HEALTH		**MENTAL HEALTH**	
		Chest pain/pressure at rest or on exertion	a.	Delusions	f.
				Hallucinations	g.
		No bowel movement in 3 days	b.	*NONE OF ABOVE*	h.
		Dizziness or lightheadedness	c.		
		Edema	d.		
		Shortness of breath	e.		
4	PAIN	a. Frequency with which client complains or shows evidence of pain **0.** No pain (score b–e as 0) **1.** Less than daily **2.** Daily—one period **3.** Daily—multiple periods (e.g. morning and evening)			
		b. Intensity of pain **0.** No pain **1.** Mild **2.** Moderate **3.** Severe **4.** Times when pain is horrible or excruciating			
		c. From client's point of view, pain intensity disrupts usual activities **0.** No **1.** Yes			
		d. Character of pain **0.** No pain **1.** Localized—single site **2.** Multiple sites			
		e. From client's point of view, medications adequately control pain **0.** Yes or no pain **1.** Medications do not adequately control pain **2.** Pain present, medication not taken			
5	FALLS FREQUENCY	Number of times fell in **LAST 90 DAYS** (or since last assessment if less than 90 days). If none, code "**0**", if more than 9, code "**9**".			
6	DANGER OF FALL	**(Code for danger of falling)** **0.** No **1.** Yes			
		a. Unsteady gait			
		b. Client limits going outdoors due to fear of falling (e.g. stopped using bus, goes out only with others)			
7	LIFESTYLE (Drinking/ Smoking)	**(Code for drinking or smoking)** **0.** No **1.** Yes			
		a. **In the LAST 90 DAYS** (or since last assessment if less than 90 days), client felt the need or was told by others to cut down on drinking, or others were concerned with client's drinking			
		b. **In the LAST 90 DAYS** (or since last assessment if less than 90 days), client had to have a drink first thing in the morning to steady nerves (i.e. an "eye opener") or has been in trouble because of drinking			
		c. Smoked or chewed tobacco daily			
8	HEALTH STATUS INDICATORS	**(Check all that apply)**			
		Client feels he/she is poor health (when asked)	a.	Treatments changed in **LAST 30 DAYS** (or since last assessment if less than 30 days) because of a new acute episode or condition	d.
		Has conditions or diseases that make cognition, ADL, mood, or behaviour patterns unstable (fluctuations, precarious, or deteriorating)	b.		
		Experiencing a flare-up of a recurrent or chronic problem	c.	Prognosis of less than six months to live—e.g. physician has told client or client's family that client has end-stage disease	e.
				NONE OF ABOVE	f.
9	OTHER STATUS INDICATORS	**(Check all that apply)**			
		Fearful of a family member or caregiver	a.	Physically restrained (e.g. limbs restrained, used bed rails, constrained to chair when sitting)	e.
		Unusually poor hygiene	b.		
		Unexplained injuries, broken bones, or burns	c.	*NONE OF ABOVE*	f.
		Neglected, abused, or mistreated	d.		

SECTION L. NUTRITION/HYDRATION STATUS

1	WEIGHT	**(Code for weight items)** **0.** No **1.** Yes	
		a. Unintended weight loss of 5% or more in the **LAST 30 DAYS** (or 10% or more in the **LAST 180 DAYS**)	
		b. Severe malnutrition (cachexia)	
		c. Morbid obesity	

Name of Client _____ Case Record # _____

2	CONSUMPTION	**(Code for consumption)** **0**. No **1**. Yes	
		a. In at least 2 of the last 3 days, ate one or fewer meals a day	
		b. **In last 3 days**, noticeable decrease in the amount of food client usually eats or fluids usually consumes	
		c. Insufficient fluid—did not consume all/almost all fluids during last 3 days	
		d. Enteral tube feeding	
3	SWALLOWING	**0**. *NORMAL*—Safe and efficient swallowing of all diet consistencies **1**. *REQUIRES DIET MODIFICATION TO SWALLOW SOLID FOODS* (mechanical diet or able to ingest specific foods only) **2**. *REQUIRES MODIFICATION TO SWALLOW SOLID FOODS AND LIQUIDS* (puree, thickened liquids) **3**. *COMBINED ORAL AND TUBE FEEDING* **4**. *NO ORAL INTAKE (NPO)*	

SECTION M. DENTAL STATUS (ORAL HEALTH)

1	ORAL STATUS	**(Check all that apply)**	
		Problem chewing (e.g. poor mastication, immobile jaw, surgical resection, decreased sensation/motor control, pain while eating)	a.
		Mouth is "dry" when eating a meal	b.
		Problem brushing teeth or dentures	c.
		NONE OF ABOVE	d.

SECTION N. SKIN CONDITION

1	SKIN PROBLEMS	Any troubling conditions or changes in skin condition (e.g. burns, bruises, rashes, itchiness, body lice, scabies) **0**. No **1**. Yes	
2	ULCERS (Pressure/ Stasis)	Presence of an ulcer anywhere on the body. Ulcers include any area of persistent skin redness (Stage 1); partial loss of skin layers (Stage 2); deep craters in the skin (Stage 3); breaks in skin exposing muscle or bone (Stage 4). [**Code 0 if no ulcer, otherwise record the highest ulcer stage (Stage 1–4).**]	
		a. **Pressure ulcer**—any lesion caused by pressure, shear forces, resulting in damage of underlying tissues	
		b. **Stasis ulcer**—open lesion caused by poor circulation in the lower extremities	
3	OTHER SKIN PROBLEMS REQUIRING TREATMENT	**(Check all that apply)**	
		Burns (second or third degree)	a.
		Open lesions other than ulcers, rashes, cuts (e.g. cancer)	b.
		Skin tears or cuts	c.
		Surgical wound	d.
		Corns, calluses, structural problems, infections, fungi	e.
		NONE OF ABOVE	f.
4	HISTORY OF RESOLVED PRESSURE ULCERS	Client previously had (at any time) or has an ulcer anywhere on the body. **0**. No **1**. Yes	
5	WOUND/ ULCER CARE	**(Check for formal care in LAST 7 DAYS)**	
		Antibiotics, systemic or topical	a.
		Dressings	b.
		Surgical wound care	c.
		Other wound/ulcer care (e.g. pressure relieving device, nutrition, turning, debridement)	d.
		NONE OF ABOVE	e.

SECTION O. ENVIRONMENTAL ASSESSMENT

1	HOME ENVIRONMENT	**[Check any of following that make home environment hazardous or uninhabitable (if none apply, check NONE OF ABOVE, if temporarily in institution, base assessment on home visit)]**	
		Lighting in evening (including inadequate or no lighting in living room, sleeping room, kitchen, toilet, corridors)	a.
		Flooring and carpeting (e.g. holes in floor, electric wires where client walks, scatter rugs)	b.
		Bathroom and toilet room (e.g. non-operating toilet, leaking pipes, no rails though needed, slippery bathtub, outside toilet)	c.
		Kitchen (e.g. dangerous stove, inoperative refrigerator, infestation by rats or bugs)	d.
		Heating and cooling (e.g. too hot in summer, too cold in winter, wood stove in a home with an asthmatic)	e.
		Personal safety (e.g. fear of violence, safety problem in going to mailbox or visiting neighbours, heavy traffic in street)	f.
		Access to home (e.g. difficulty entering/leaving home)	g.
		Access to rooms in house (e.g. unable to climb stairs)	h.
		NONE OF ABOVE	i.
2	LIVING ARRANGEMENT	a. As compared to 90 DAYS AGO (or since last assessment), client now lives with other persons—e.g. moved in with another person, other moved in with client **0**. No **1**. Yes	
		b. Client or primary caregiver feels that client would be better off in another living environment **0**. No **1**. Client only **2**. Caregiver only **3**. Client and caregiver	

SECTION P. SERVICE UTILIZATION (IN LAST 7 DAYS)

1	FORMAL CARE (Minutes rounded to even 10 minutes)	Extent of care or care management in **LAST 7 DAYS** (or since last assessment if less than 7 days) since involving			
		#of:	**(A) Days**	**(B) Hours**	**(C) Mins**
		a. Home health aides			
		b. Visiting nurses			
		c. Homemaking services			
		d. Meals			
		e. Volunteer services			
		f. Physical therapy			
		g. Occupational therapy			
		h. Speech therapy			
		i. Day care or day hospital			
		j. Social worker in home			

Name of Client _____ Case Record # _____

2	SPECIAL TREATMENTS, THERAPIES, PROGRAMS	Special treatments, therapies, and programs received or scheduled during the **LAST 7 DAYS** (or since last assessment if less than 7 days) and adherence to the required schedule. Includes services received in the home or on an outpatient basis. (**Blank**) Not applicable **1.** Scheduled, full adherence as prescribed **2.** Scheduled, partial adherence **3.** Scheduled, not received (If no treatments provided, check *NONE OF ABOVE* **P2aa**)	

RESPIRATORY TREATMENTS		**THERAPIES**	
a. Oxygen	☐	n. Exercise therapy	☐
b. Respirator for assistive breathing	☐	o. Occupational therapy	☐
c. All other respiratory treatments	☐	p. Physical therapy	☐
OTHER TREATMENTS		**PROGRAMS**	
d. Alcohol/drug treatment program	☐	q. Day centre	☐
		r. Day hospital	☐
e. Blood transfusion(s)	☐	s. Hospice care	☐
f. Chemotherapy	☐	t. Physician or clinic visit	☐
g. Dialysis	☐	u. Respite care	☐
h. IV infusion—central	☐	**SPECIAL PROCEDURES DONE IN HOME**	
i. IV infusion—peripheral	☐	v. Daily nurse monitoring (e.g. EKG, urinary output)	☐
j. Medication by injection	☐		
k. Ostomy care	☐	w. Nurse monitoring less than daily	☐
l. Radiation	☐	x. Medical alert bracelet or electronic security alert	☐
m. Tracheostomy care	☐		
		y. Skin treatment	☐
		z. Special diet	☐
		aa. *NONE OF ABOVE*	☐

3	MANAGEMENT OF EQUIPMENT (**In Last 3 Days**)	**Management codes:** **0.** Not used **1.** Managed on own **2.** Managed on own if laid out or with verbal reminders **3.** Partially performed by others **4.** Fully performed by others	
		a. Oxygen	☐
		b. IV	☐
		c. Catheter	☐
		d. Ostomy	☐

4	VISITS IN LAST 90 DAYS OR SINCE LAST ASSESSMENT	**Enter "0" if none, if more than 9, code "9"**	
		a. Number of times ADMITTED TO HOSPITAL with an overnight stay	☐
		b. Number of times VISITED EMERGENCY ROOM without an overnight stay	☐
		c. EMERGENT CARE—including unscheduled nursing, physician, or therapeutic visits to office or home	☐
5	TREATMENT GOALS	Any treatment goals that have been met in the **LAST 90 DAYS** (or since last assessment if less than 90 days)? **0.** No **1.** Yes	☐
6	OVERALL CHANGE IN CARE NEEDS	Overall self-sufficiency has changed significantly as compared to status of **90 DAYS AGO** (or since last assessment if less than 90 days) **0.** No change **1.** Improved—receives fewer supports **2.** Deteriorated—receives more support	☐
7	TRADE OFFS	Because of limited funds, during the last month, client made trade-offs among purchasing any of the following: prescribed medications, sufficient home heat, necessary physician care, adequate food, home care **0.** No **1.** Yes	☐

SECTION Q. MEDICATIONS			
1	NUMBER OF MEDICATIONS	Record the number of different medicines (prescriptions and over the counter), including eye drops, taken regularly or on an occasional basis in the **LAST 7 DAYS** (or since last assessment) *[If none, code "**0**", if more than 9, code "**9**".]*	☐
2	RECEIPT OF PSYCHO-TROPIC MEDICATION	Psychotropic medications taken in the **LAST 7 DAYS** (or since last assessment) [Note—Review client's medications with the list that applies to the following categories.] **0.** No **1.** Yes	
		a. Antipsychotic/neuroleptic	☐
		b. Anxiolytic	☐
		c. Antidepressant	☐
		d. Hypnotic	☐
3	MEDICAL OVERSIGHT	Physician reviewed client's medications as a whole in **LAST 180 DAYS** (or since last assessment) **0.** Discussed with at least one physician (or no medication taken) **1.** No single physician reviewed all medications	☐
4	COMPLIANCE/ ADHERENCE WITH MEDICA-TIONS	Compliant all or most of time with **medications** prescribed by physician (both during and between therapy visits) in **LAST 7 DAYS** **0.** Always compliant **1.** Compliant 80% of time or more **2.** Compliant less than 80% of time, including failure to purchase prescribed medications **3.** *NO MEDICATIONS PRESCRIBED*	☐

Name of Client _____ Case Record # _____

5	LIST OF ALL MEDICATIONS	List prescribed and nonprescribed medications taken in **LAST 7 DAYS** (or since last assessment) a. **Name**: Record the name of the medication. b. **Dose**: Record the dosage. c. **Form**: Code the route of Administration using the following list: **1**. By mouth (PO) **6**. Rectal (R) **2**. Sub lingual (SL) **7**. Topical **3**. Intramuscular (IM) **8**. Inhalation **4**. Intravenous (IV) **9**. Enteral tube **5**. Subcutaneous (SQ) **10**. Other d. **Freq**: Code the number of times per day, week, or month the medication is administered using the following list: ***PRN***. As necessary ***QOD***. Every other day ***QH***. Every hour ***QW***. Once each week ***Q2H***. Every two hours ***2W***. Two times every week ***Q3H***. Every three hours ***3W***. Three times every week ***Q4H***. Every four hours ***4W***. Four times every week ***Q6H***. Every six hours ***5W***. Five times every week ***Q8H***. Every eight hours ***6W***. Six times every week ***QD***. Once daily ***1M***. Once every month ***HS***. Bedtime ***2M***. Twice every month ***BID***. Two times daily (includes every 12 hrs) ***C***. Continuous ***TID***. Three times daily ***O***. Other ***QID***. Four times daily ***5D***. Five times daily e. **If PRN**: record number of doses taken in last 7 days.

	a. Name	b. Dose	c. Form	d. Freq	e. If PRN # of times taken in last 7 days
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					

☐ = when box blank, must enter number or letter ☐ a. = when letter in box, check if condition applies

SECTION R. ASSESSMENT INFORMATION

1	SIGNATURES OF PERSONS COMPLETING THE ASSESSMENT
	a. Signature of Assessment Coordinator
	b. Title of Assessment Coordinator
	c. Date Assessment Coordinator signed as complete ☐☐☐☐ Year ☐☐ Month ☐☐ Day

	Other Signatures	Title	Sections	Date
	d.			
	e.			
	f.			
	g.			
	h.			
	i.			

Appendix B: Text entries used to capture TBI using the RAI-HC.

Text Entries
"ABI ---- 2"
"ABI - 17JUL2009"
"ABI R/T CA BRAIN"
"ABI (MVA)"
"ABI - 2003"
"ABI - APRIL 19, 2012"
"ABI - AUGUST 2009"
"ABI - BASAL SKULL#/SUBDURAL HEMATOMA MAY 20"
"ABI - CLOSED HEAD INJURY"
"ABI - CRANIOSTOMY"
"ABI - DEVELOPMENTAL DELAY"
"ABI - DEVELOPMENTALLY CHALLENG"
"ABI DUE TO MVA"
"ABI FEBUARY 4/2012"
"ABI - FROM MVC IN 2004"
"ABI - HYPOXIA AFTER CARDIAC ARREST"
"ABI - HYPOXIA"
"ABI - HYPOXIC BRAIN INJURY 2008"
"ABI IN MVA"
"ABI LEFT SIDE WEAKNESS, RIGHT EYE BLINDNES"
"ABI - MARCH 2007"
"ABI - NOV 2102"
"ABI - OLD MVA"
"ABI - OLD MVC"
"ABI - PITUITARY LOSS"
"ABI - POOR MEMORY"
"ABI - POST CONCUSSION SYNDROME"
"ABI - POST CONCUSSIONS"
"ABI - R/T FALL"
"ABI - REMOTE"
"ABI SELF INFLICTED GUN SHOT W"
"ABI - SUBARACHNOID BLEED"
"ABI - SUBDURAL HEMATOMA"
"ABI - VIRAL MENINGITIS"
"ABI - WORKPLACE FALL-PERSONALITY CHANGE & C"
"ABI (D/T MEDICATION INDUCE"
"ABI (D/T MEDICATION INDUCED SE"
"ABI ?"
"ABI 2003"
"ABI- 2003"
"ABI 2004 HEAD INJURY"
"ABI 2004"
"ABI 2004, 2008 WITH CRANIECTOMY"
"ABI 2005"

"ABI 2006 - R"
"ABI 2006 DUE TO TRAUMA"
"ABI 2006 R/T MVA"
"ABI 2006"
"ABI 2007"
"ABI 2008 FROM MVA"
"ABI 2008"
"ABI 2008-BICYCLE ACCIDENT"
"ABI 2009"
"ABI -2009"
"ABI- 2009"
"ABI 2010 POST ANEURYSM"
"ABI 2010"
"ABI -2010"
"ABI 2011 D/T"
"ABI 2012 MVA"
"ABI CLIENT"
"ABI DUE TO CANCER SURGERY"
"ABI DUE TO DIABETIC COMA (2007"
"ABI DUE TO ENCEPHALITIS 2001"
"ABI DUE TO FALL - 13 APRIL, 2009"
"ABI DUE TO FALL AUG 16/2005"
"ABI DUE TO HEAD INJURY 2008"
"ABI DUE TO HEART ATTACK (COMA/ANAXIA)."
"ABI DUE TO HYPOGLYCEMIA"
"ABI- EPID AND SUBD HEMATOMA"
"ABI FEB. 2012"
"ABI FEB/08"
"ABI FELL OUT OF TRUCK"
"ABI FOLLOWING MVA"
"ABI FOM MVA"
"ABI FROM ~10 MVAS"
"ABI FROM A CONCUSSION TO H"
"ABI FROM ACCIDENT"
"ABI FROM AN MVA"
"ABI FROM ANEURYSM"
"ABI FROM ANOXIA"
"ABI FROM BEING HIT BY A CAR WHILE WALKING"
"ABI FROM BRAIN ANOXIA"
"ABI FROM BRAIN INJURY"
"ABI FROM BRAIN SURGERY"
"ABI FROM BRAIN TUMOR"
"ABI FROM CAR ACCIDENT MAY 2011"
"ABI FROM CEREBRAL BLEED AFTER ANEURYSM REPA"
"ABI FROM NVA MAY 2006”
"ABI FROM PHYSICAL ABUSE"

"ABI FROM PULMONARY EMBOLI"
"ABI FROM SEVERAL FALLS"
"ABI FROM TUMOR/SURGERY"
"ABI- FRONTAL LOBE INJURY"
"ABI IN 2003 FROM MVA"
"ABI IN 2006 DUE TO ACCIDENTAL DRUG OVERDOSE"
"ABI IN 2007 FROM FALL"
"ABI IN 2008 POST FALL, STRIKING HEAD"
"ABI IN 2008”
"ABI INJURY '"
"ABI INJURY -LACUNAR INFARCT"
"ABI INJURY"
"ABI INURY NOV-08"
"ABI JAN 2007"
"ABI JULY 5/06"
"ABI- JULY/08 D/T ASSAULT"
"ABI JUNE /06"
"ABI OBTAINED FROM MVA 07"
"ABI OPEN"
"ABI POSE MVA"
"ABI POST CRANIOTOMY FOR MENINGIOMA REMOVAL"
"ABI POST CVA"
"ABI POST ELECTROCTION INJURY"
"ABI POST FALL"
"ABI POST MI"
"ABI POST MVA"
"ABI POST MVC SEPT 2011"
"ABI POST R SUBDURAL HEMATO"
"ABI R/T ANEURYSMS"
"ABI RELATED TO HEAD TRAUMA"
"ABI RELATED TO MENINGIOMA"
"ABI RELATED TO MVA"
"ABI RT ANOXIC ENCEPHALOPATHY"
"ABI SAH"
"ABI SEC CVA"
"ABI SEC TO SDH 16 JUNE 2012"
"ABI SEC TO STROKE"
"ABI SECONDARY TO ACA ANEURYSM"
"ABI SECONDARY TO ANOXIA"
"ABI SECONDARY TO CABG SURGERY"
"ABI SECONDARY TO CARDIAC ARREST"
"ABI SECONDARY TO CVA"
"ABI SECONDARY TO MVA FEB. 12/09"
"ABI SECONDARY TO MVA"
"ABI SECONDARY TO MVA(DEC. 2009), LEFT HEMIP"
"ABI SECONDARY TO SAH"

"ABI SECONDARY TO SEPSIS AND HYPOGLYCEMIA"
"ABI -SEPT 2009"
"ABI SEPT 2012"
"ABI WITH DEV"
"ABI WITH FRONTAL LOBE DISABILITY (SUBDURAL"
"ABI WITH MOTOR CYCLE ACCID"
"ABI WITH RIGHT PARALYSIS (BRAIN ANEURYSM IN"
"ABI WITH SEIZURES"
"ABI"
"ABI"
"ABI, NO STMEMORY"
"ABI, RELATED TO BRAIN BLEE"
"ABI, SEIZURE DISORDER"
"ABI, SEVERE LEARNING DISAB"
"ABI, SHINGLES DEC/05"
"ABI, SPASTIC QUAD"
"ABI/HYPOXIA/CARDIAC ARREST"
"ABI/MVA"
"ABI/ORGANIC BRAIN DISORDER"
"ABI/RADIATION INDUCED TUMOURS/RESECTION"
"ABI/RT LEG TRAUMA SECONDARY TO MVA IN 1993"
"ABI/SEIZURE DISORDER"
"ABI--2004"
"ABI-ANEURYSM AUG. 2011, SUBARACHNOID HEMORR"
"ABI--ANEURYSM"
"ABI-CLOSED HEAD INJURY"
"ABI-CRAINOTOMY(SAH & SKULL"
"ABI--DIFFUSED ARACHNOID HEMORRHAGE"
"ABI--ENCEPHALOPATHY"
"ABI-EXPRESSIVE APHASIA"
"ABI--FRONTAL"
"ABI-MILD"
"ABI-MVA IN BANGLADESH 2004"
"ABI-MVA"
"ABI-POST MVA 2005"
"ABI-RADIATION FOR BRAIN CANCER"
"ABI-SUBARACHNOID HEMM"
"ABI-SURGERY FOR CEREBRAL ANUERYSM"
"ABI-TRAUMATI"
"ABI-TRAUMATIC"
"ABI-TRUCK ACCIDENT 2003"
"ACQUIRED BAIN INJURY FROM MVA 2011"
"ACQUIRED BARIN INJURY- INTERVENTRICULAR HEM"
"ACQUIRED BRA"
"ACQUIRED BRAIN INJURY"
"ACQUIRED BRAIN DEFECT"

"ACQUIRED BRAIN DISORDER POST MVA"
"ACQUIRED BRAIN INJUIRY"
"ACQUIRED BRAIN INJURY 2003 MVA"
"ACQUIRED BRAIN INJURY 2006"
"ACQUIRED BRAIN INJURY 2008"
"ACQUIRED BRAIN INJURY 2010"
"ACQUIRED BRAIN INJURY 2011"
"ACQUIRED BRAIN INJURY 2012"
"ACQUIRED BRAIN INJURY AFTER MI"
"ACQUIRED BRAIN INJURY AND BEHAVIOURAL DIFFI"
"ACQUIRED BRAIN INJURY AT A"
"ACQUIRED BRAIN INJURY CAUSED BY ALCHOLISIM"
"ACQUIRED BRAIN INJURY D/T ANOXIA"
"ACQUIRED BRAIN INJURY D/T EPISODES OF HYPOX"
"ACQUIRED BRAIN INJURY DUE CONTAMINATED SEAF"
"ACQUIRED BRAIN INJURY DUE TO CVA"
"ACQUIRED BRAIN INJURY DUE TO PULMONARY EMBO"
"ACQUIRED BRAIN INJURY FROM A M"
"ACQUIRED BRAIN INJURY FROM ACCIDENT."
"ACQUIRED BRAIN INJURY FROM EXP”
"ACQUIRED BRAIN INJURY FROM MVA"
"ACQUIRED BRAIN INJURY FROM RUP"
"ACQUIRED BRAIN INJURY FROM"
"ACQUIRED BRAIN INJURY IN M"
"ACQUIRED BRAIN INJURY JULY 2011"
"ACQUIRED BRAIN INJURY MVA"
"ACQUIRED BRAIN INJURY MVC 2007 FRACTURED SK"
"ACQUIRED BRAIN INJURY POST MVA"
"ACQUIRED BRAIN INJURY POST MVC"
"ACQUIRED BRAIN INJURY POST"
"ACQUIRED BRAIN INJURY R/A MI"
"ACQUIRED BRAIN INJURY R/T ANOXIA 2005"
"ACQUIRED BRAIN INJURY RELATED TO 2 RUPTURED"
"ACQUIRED BRAIN INJURY SEC. TO MVA(DEC. 2009"
"ACQUIRED BRAIN INJURY SECO"
"ACQUIRED BRAIN INJURY SECONDAR"
"ACQUIRED BRAIN INJURY SECODARY TO FALL"
"ACQUIRED BRAIN INJURY SECONDARY TO MOTOR VE"
"ACQUIRED BRAIN INJURY SECONDARY TO STROKE."
"ACQUIRED BRAIN INJURY- SHUNT"
"ACQUIRED BRAIN INJURY SYNDROME"
"ACQUIRED BRAIN INJURY WITH RT"
"ACQUIRED BRAIN INJURY WITH SEIZURE DISORDER"
"ACQUIRED BRAIN INJURY WITH WERNICKE'S APHAS"
"ACQUIRED BRAIN INJURY"
"ACQUIRED BRAIN INJURY(ABI)"

"ACQUIRED BRAIN INJURY-MVA 2004"
"ACQUIRED BRAIN INJURY-MVA”
"ACQUIRED BRAIN INJURY-POST CAR ACCIDENT"
"ACQUIRED BRAIN INJURYQ"
"ACQUIRED BRAIN INJURY--QUADRIPLEGIA"
"ACQUIRED BRAIN INJURY-RT FRONT"
"ACQUIRED BRAIN INURY"
"ACQUIRED BRIAN INJURY"
"C1-C2 FRACTURE/POST TRAUMATIC BRAIN INJURY"
"DEMENTIA / ACQUIRED BRAIN INJURY"
"DIAGNOSIS OF ACQUIRED BRAIN INJURY"
"EXTREMELY SEVERE TRAUMATIC BRAIN INJURY"
"HX OF TRAUMATIC BRAIN INJURY-"
"HX TRAUMATIC BRAIN INJURY IN 1"
"HX TRAUMATIC BRAIN INJURY,DEMENTIA"
"MVA- TBI"
"MVA-ABI"
"MVA-ACQUIRED BRAIN INJURY"
"MVA-TRAUMATIC BRAIN INJURY"
"QUERY ACQUIRED BRAIN INJURY? POST FALL"
"REMOTE ACQUIRED BRAIN INJURY"
"REMOTE TRAUMATIC BRAIN INJURY"
"SEIZURE ACTIVITY(ACQUIRED BRAIN INJURY)"
"SEIZURE DISORDER D/T TBI”
"SEVERE ACQUIRED BRAIN INJURY (ASSAULTED JUL"
"SEVERE TBI - JULY 29, 2009"
"SEVERE TBI FEB 2011 SDH"
"SEVERE TBI FR MVA."
"SEVERE TRAUMATIC ABI WITH APRAXIA DEC 2012"
"SEVERE TRAUMATIC BRAIN INJURY JULY 8, 2010"
"SEVERE TRAUMATIC BRAIN INJURY(ABI)"
"SEVERE TRAUMATIC BRAIN INJURY."
"TBI INJURY"
"TBI TRAMATIC BRAIN INJURY OCT 2009"
"TBI"
"TBI. / HEAD TRAUMA."
"TRAUMATIC ABI ON 14 MAY 2009."
"TRAUMATIC ACQUIRED BRAIN INJURY"
"TRAUMATIC BR"
"TRAUMATIC BRAI INJURY 2012"
"TRAUMATIC BRAIN INJURY 2003"
"TRAUMATIC BRAIN INJURY 2005"
"TRAUMATIC BRAIN INJURY 2012"
"TRAUMATIC BRAIN INJURY AFTER A FALL JAN 1ST"
"TRAUMATIC BRAIN INJURY D/T MVA"
"TRAUMATIC BRAIN INJURY -FALL AUG 2010"

"TRAUMATIC BRAIN INJURY FRO"
"TRAUMATIC BRAIN INJURY FROM FALL FR TRUCK"
"TRAUMATIC BRAIN INJURY IN PLAY"
"TRAUMATIC BRAIN INJURY MAR. 2012"
"TRAUMATIC BRAIN INJURY NOV"
"TRAUMATIC BRAIN INJURY NOVEMBER 5, 2010."
"TRAUMATIC BRAIN INJURY POST FALL 2010"
"TRAUMATIC BRAIN INJURY SECONDARY TO FALL"
"TRAUMATIC BRAIN INJURY TIM"
"TRAUMATIC BRAIN INJURY WIT"
"TRAUMATIC BRAIN INJURY"
"TRAUMATIC BRAIN INJURY, (CLOSED BRAIN INJUR"
"TRAUMATIC BRAIN INJURY, POST FALL"
"TRAUMATIC BRAIN INJURY."
"TRAUMATIC BRAIN INJURY/ TR"
"TRAUMATIC BRAIN INJURY-INJURED IN PHYSICAL"
"TRAUMATIC BRAIN TRAUMA D/T FAL"
"TRAUMATIC BRIAN INJURY"
"? CONCUSSION 2011 DEC. AFTER A"
"? CONCUSSION DEC 2007"
"? STROKE & CONCUSSION AUG/13"
"?CONCUSSION FR FALL & HEAD HIT"
"2002-FALL-CONCUSSION IN ME"
"CONCCUSION-AUG 2013"
"CONCOSSION"
"CONCUSION 2008"
"CONCUSION 2009"
"CONCUSION FALL 2007, RECOVERED"
"CONCUSION FOLLOWING FALL"
"CONCUSION FROM ASSULT"
"CONCUSION"
"CONCUSSION 2"
"CONCUSSION 2008"
"CONCUSSION 2009"
"CONCUSSION 2012"
"CONCUSSION 2013"
"CONCUSSION APRIL 2009"
"CONCUSSION APRIL 30/13"
"CONCUSSION ASTHMA"
"CONCUSSION D"
"CONCUSSION DEC 2007"
"CONCUSSION DUE TO FALL WITH SUBDURAL HEMATO"
"CONCUSSION FEB/10"
"CONCUSSION IN 2010 WITH HOSPITALIZATION"
"CONCUSSION IN 2010."
"CONCUSSION IN WW2"

"CONCUSSION J"
"CONCUSSION JULY 2011"
"CONCUSSION JUNE 19/07"
"CONCUSSION JUNE1, 2012"
"CONCUSSION M"
"CONCUSSION MAR 2012"
"CONCUSSION MAR 2013"
"CONCUSSION MARCH 31ST/13 POST"
"CONCUSSION NOV /11"
"CONCUSSION NOV./12"
"CONCUSSION NOV/11"
"CONCUSSION OCT '07"
"CONCUSSION OCT 2013"
"CONCUSSION OCTOBER 2008"
"CONCUSSION OF HEAD X 2"
"CONCUSSION PLAYING HOCKEY"
"CONCUSSION R/T FALL MARCH"
"CONCUSSION SEPT 2005"
"CONCUSSION SYMPTOMS ON ADM"
"CONCUSSION SYNDROME"
"CONCUSSION TO HEAD"
"CONCUSSION W"
"CONCUSSION W/LOC UNSPEC DURATION"
"CONCUSSION WHEN FELL JUNE/"
"CONCUSSION WITH NO LOC"
"CONCUSSION WITH RESIDUAL AMNESIA, WEAKENED"
"CONCUSSION WORK FALL 70,S"
"CONCUSSION X2 2012"
"CONCUSSION X2-KNOCKED OFF"
"CONCUSSION"
"CONCUSSION/# SKULL"
"CONCUSSION/BIKE ACCIENT"
"CONCUSSION/SEIZURE"
"CONCUSSION-2"
"CONCUSSIONS FROM FALLS"
"CONCUSSION'S SEVERAL TIMES"
"CONCUSSIONS"
"CONCUSSIONS--3"
"CONCUSSION-WHIP LASH"
"DIZZINESS FROM CONCUSSION"
"FALL - CONCUSIoN"
"FALL - CONCUSSION DEC/06"
"FALL CONCUSION 2004"
"FALL MILD CONCUSSION"
"FALL RESULTING IN CONCUSSION IN 2003 CLIENT"
"FALL WITH CONCUSSION OCT 14/13"

"FALL WITH CONCUSSION TO HEAD AND IMPACTION"
"FALL, CONCUSSION SEPT 08"
"FALL/CONCUSSION"
"FALLS - CONCUSSION"
"FELL CONCUSION 2004"
"FELL IN DEC/06, CONCUSSION"
"FRACTURED WRIST AND CONCUSION NOV/08"
"GRADE 3 CONCUSSION"
"HEAD CONCUSSION JAN 2011--"
"HEAD CONCUSSION SEP 8TH"
"HEAD INJURY - CONCUSSION DEC. 2012"
"HEAD INJURY - CONCUSSION"
"HEAD INJURY/CONCUSSION"
"HX CONCUSSION"
"HX CONCUSSION/SUB ARACHNOID HE"
"HX MULTIPLE CONCUSSION"
"HX OF CONCUSSIONS (4)"
"HX OF CONCUSSIONS PLAYING HOCK"
"HX OF CONCUSSIONS"
"MILD ABI (INJURED WHEN SUFFERED A HYPERGLYC"
"MILD ABI FROM MVA IN 2012"
"MILD ABI POST FALL IN 2008"
"MILD ABI"
"MILD BRAIN A"
"MILD BRAIN INJURY"
"MILD CONCUSS"
"MILD CONCUSSION FROM FALL"
"MILD CONCUSSION"
"MILD TBI POS"
"MILD TRAUMATIC BRAIN INJ"
"MINOR CONCUSSION"
"MULTIPLE CONCUSSIONS IN TH"
"MVA - CONCUSSION 2011"
"RECENT CONCUSSION FROM FALL"
"RECENT CONCUSSION"
"RECENT POSS. CONCUSSION."
"SEVERE CONCUSSION"
"UTI- FALL CONCUSSION"
"WHIPLASH /CONCUSSION SEPT"

Appendix C: Standardized Annual Cumulative Incidence Rate Calculations

Male standardized incidence rate calculations for the year 2003.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	25	1183	0.02113	1183	0.086	182
70-74	39	2023	0.01928	2023	0.15	289
75-79	64	3000	0.02133	3000	0.22	469
80-84	68	3510	0.01937	3510	0.26	504
85-89	31	2508	0.01236	2508	0.18	222
>90	22	1540	0.01429	1540	0.11	157
All ages		13764	0.11	13764		1823

Male standardized incidence rate calculations for the year 2004.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	47	1879	0.02501	1183	0.086	215
70-74	44	2925	0.01504	2023	0.15	226
75-79	52	4386	0.01186	3000	0.22	261
80-84	72	5338	0.01349	3510	0.26	351
85-89	40	3658	0.01093	2508	0.18	197
>90	15	2154	0.00696	1540	0.11	77
All ages			0.0833	13764		1327

Male standardized incidence rate calculations for the year 2005.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	34	1776	0.01914	1183	0.086	165
70-74	32	2719	0.01177	2023	0.15	177
75-79	56	3864	0.01449	3000	0.22	319
80-84	39	4583	0.00851	3510	0.26	221
85-89	32	3188	0.01004	2508	0.18	181
>90	14	1826	0.00767	1540	0.11	84
All ages		17956	0.072	13764		1147

Male standardized incidence rate calculations for the year 2006.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	26	1665	0.01562	1183	0.086	134
70-74	24	2374	0.01011	2023	0.15	152
75-79	41	3514	0.01167	3000	0.22	257
80-84	52	4115	0.01264	3510	0.26	329
85-89	27	2968	0.00910	2508	0.18	164
>90	13	1590	0.00818	1540	0.11	90
All ages		16226	0.067	13764		1126

Male standardized incidence rate calculations for the year 2007.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	16	1559	0.01026	1183	0.086	88
70-74	26	2256	0.01152	2023	0.15	173
75-79	25	3331	0.00751	3000	0.22	165
80-84	50	3897	0.01283	3510	0.26	334
85-89	21	2885	0.00728	2508	0.18	131
>90	7	1446	0.00484	1540	0.11	53
All ages		15374	0.054	13764		944

Male standardized incidence rate calculations for the year 2008.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	20	1478	0.01235	1183	0.086	106
70-74	23	2081	0.01105	2023	0.15	166
75-79	36	3020	0.01192	3000	0.22	262
80-84	26	3700	0.00703	3510	0.26	183
85-89	20	2901	0.00689	2508	0.18	124
>90	4	1395	0.00287	1540	0.11	32
All ages		14575	0.052	13764		873

Male standardized incidence rate calculations for the year 2009.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	17	1380	0.01232	1183	0.086	106
70-74	14	1774	0.00789	2023	0.15	118
75-79	26	2676	0.00972	3000	0.22	214
80-84	25	3223	0.00776	3510	0.26	202
85-89	16	2519	0.00635	2508	0.18	114
>90	6	1259	0.00477	1540	0.11	52
All ages		12831	0.049	13764		806

Male standardized incidence rate calculations for the year 2010.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	13	1270	0.01024	1183	0.086	88
70-74	17	1534	0.01108	2023	0.15	166
75-79	24	2213	0.01085	3000	0.22	239
80-84	19	2608	0.00729	3510	0.26	190
85-89	21	2092	0.01004	2508	0.18	181
>90	15	1029	0.01458	1540	0.11	160
All ages		10746	0.064	13764		1024

Male standardized incidence rate calculations for the year 2011.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	99	3349	0.02956	1183	0.086	254
70-74	71	4437	0.01600	2023	0.15	240
75-79	112	6649	0.01684	3000	0.22	370
80-84	108	8883	0.01216	3510	0.26	316
85-89	76	7967	0.00954	2508	0.18	172
>90	47	4745	0.00991	1540	0.11	109
All ages		36030	0.094	13764		1461

Male standardized incidence rate calculations for the year 2012.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	35	1776	0.01971	1183	0.086	170
70-74	45	2334	0.01928	2023	0.15	289
75-79	42	3191	0.01316	3000	0.22	290
80-84	43	4238	0.01015	3510	0.26	264
85-89	37	3750	0.00987	2508	0.18	178
>90	16	2146	0.00746	1540	0.11	82
All ages		17435	0.080	13764		1273

Male standardized incidence rate calculations for the year 2013.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	43	2398	0.01793	1183	0.086	154
70-74	50	3243	0.01542	2023	0.15	231
75-79	67	4764	0.01406	3000	0.22	309
80-84	78	6765	0.01153	3510	0.26	300
85-89	57	6252	0.00912	2508	0.18	164
>90	20	3837	0.00521	1540	0.11	57
All ages		27259	0.073	13764		1215

Female standardized incidence rate calculations for the year 2003.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	28	1701	0.01646	1701	0.05	82
70-74	52	3308	0.01572	3308	0.11	173
75-79	57	5716	0.00997	5716	0.18	179
80-84	81	8353	0.00970	8353	0.27	262
85-89	67	7181	0.00933	7181	0.23	215
>90	42	5050	0.00832	5050	0.16	133
All ages		31309	0.070	31309		1044

Female standardized incidence rate calculations for the year 2004.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	28	2569	0.01090	1701	0.05	55
70-74	51	4559	0.01119	3308	0.11	123
75-79	66	7700	0.00857	5716	0.18	154
80-84	98	10979	0.00893	8353	0.27	241
85-89	71	8700	0.00816	7181	0.23	188
>90	44	6340	0.00694	5050	0.16	111
All ages		40847	0.055	31309		872

Female standardized incidence rate calculations for the year 2004.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	16	2163	0.00740	1701	0.05	37
70-74	38	3679	0.01033	3308	0.11	114
75-79	37	5995	0.00617	5716	0.18	111
80-84	66	8268	0.00798	8353	0.27	215
85-89	51	6172	0.00826	7181	0.23	190
>90	30	4277	0.00701	5050	0.16	112
All ages		30554	0.047	31309		779

Female standardized incidence rate calculations for the year 2004.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	20	1937	0.01033	1701	0.05	52
70-74	30	3094	0.00970	3308	0.11	107
75-79	41	5001	0.00820	5716	0.18	148
80-84	44	6771	0.00650	8353	0.27	176
85-89	46	5479	0.00840	7181	0.23	193
>90	22	3447	0.00638	5050	0.16	102
All ages		25729	0.05	31309		778

Female standardized incidence rate calculations for the year 2007.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	15	1851	0.00810	1701	0.05	41
70-74	22	2793	0.00788	3308	0.11	87
75-79	36	4278	0.00842	5716	0.18	152
80-84	46	5895	0.00780	8353	0.27	211
85-89	36	4989	0.00722	7181	0.23	166
>90	13	3066	0.00424	5050	0.16	68
All ages		22872	0.044	31309		725

Female standardized incidence rate calculations for the year 2008.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	9	1702	0.00529	1701	0.05	26
70-74	18	2619	0.00687	3308	0.11	76
75-79	32	4037	0.00793	5716	0.18	143
80-84	42	5559	0.00756	8353	0.27	204
85-89	29	4764	0.00609	7181	0.23	140
>90	16	2772	0.00577	5050	0.16	92
All ages		21453	0.04	31309		681

Female standardized incidence rate calculations for the year 2009.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	9	1501	0.006	1701	0.05	30
70-74	14	2218	0.00631	3308	0.11	69
75-79	17	3579	0.00475	5716	0.18	86
80-84	39	4333	0.009	8353	0.27	243
85-89	27	4105	0.00658	7181	0.23	151
>90	13	2322	0.006	5050	0.16	96
All ages		18058	0.039	31309		675

Female standardized incidence rate calculations for the year 2010.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	8	1365	0.000733	1701	0.05	4
70-74	17	1858	0.00915	3308	0.11	101
75-79	15	2966	0.00506	5716	0.18	91
80-84	30	3798	0.0079	8353	0.27	213
85-89	15	3358	0.00447	7181	0.23	103
>90	12	1990	0.00603	5050	0.16	96
All ages		15335	0.033	31309		608

Female standardized incidence rate calculations for the year 2011.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	75	4741	0.01582	1701	0.05	79
70-74	67	6711	0.00998	3308	0.11	110
75-79	115	11180	0.01029	5716	0.18	185
80-84	118	17105	0.0069	8353	0.27	186
85-89	148	19125	0.00774	7181	0.23	178
>90	74	14056	0.00526	5050	0.16	84
All ages		72918	0.056	31309		822

Female standardized incidence rate calculations for the year 2012.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	16	2192	0.00730	1701	0.05	37
70-74	34	3002	0.01133	3308	0.11	125
75-79	30	4657	0.006442	5716	0.18	116
80-84	34	6861	0.004956	8353	0.27	134
85-89	55	6993	0.00787	7181	0.23	181
>90	17	4921	0.00345	5050	0.16	55
All ages		28626	0.041	31309		648

Female standardized incidence rate calculations for the year 2013.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	36	3095	0.01163	1701	0.05	58
70-74	47	4419	0.01064	3308	0.11	117
75-79	69	6944	0.00994	5716	0.18	179
80-84	74	10411	0.00711	8353	0.27	192
85-89	75	10995	0.00682	7181	0.23	157
>90	33	8180	0.00403	5050	0.16	64
All ages		44044	0.05	31309		767

Overall standardized incidence rate calculations for the year 2003.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	53	2884	0.01838	2884	0.064	118
70-74	91	5331	0.01707	5331	0.1183	202
75-79	121	8716	0.01388	8718	0.1934	268
80-84	149	11863	0.01256	11864	0.2632	331
85-89	98	9689	0.01011	9689	0.2149	217
>90	64	6590	0.00971	6591	0.1462	142
All ages		45073	0.08	45077		1278

Overall standardized incidence rate calculations for the year 2004.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	75	4448	0.01686	2884	0.064	108
70-74	95	7484	0.01269	5331	0.1183	150
75-79	118	12086	0.00976	8718	0.1934	185
80-84	170	16317	0.01042	11864	0.2632	274
85-89	111	12358	0.00898	9689	0.2149	189
>90	59	8494	0.00695	6591	0.1462	97
All ages		61187	0.066	45077		1003

Overall standardized incidence rate calculations for the year 2005.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	50	3939	0.01269	2884	0.064	81
70-74	70	6398	0.01094	5331	0.1183	129
75-79	93	9859	0.00943	8718	0.1934	182
80-84	105	12851	0.00817	11864	0.2632	215
85-89	83	9360	0.00887	9689	0.2149	191
>90	44	6103	0.00721	6591	0.1462	105
All ages		48510	0.058	45077		903

Overall standardized incidence rate calculations for the year 2006.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	46	3602	0.01277	2884	0.064	82
70-74	54	5468	0.00988	5331	0.1183	117
75-79	82	8515	0.00963	8718	0.1934	186
80-84	96	10886	0.00882	11864	0.2632	232
85-89	73	8447	0.00864	9689	0.2149	186
>90	35	5037	0.00695	6591	0.1462	102
All ages		41955	0.057	45077		905

Overall standardized incidence rate calculations for the year 2007.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	31	3410	0.00909	2884	0.064	58
70-74	48	5049	0.00951	5331	0.1183	113
75-79	61	7609	0.00802	8718	0.1934	155
80-84	96	9792	0.00980	11864	0.2632	258
85-89	57	7874	0.00724	9689	0.2149	156
>90	20	4512	0.00443	6591	0.1462	65
All ages		38246	0.048	45077		805

Overall standardized incidence rate calculations for the year 2008.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	29	3180	0.00912	2884	0.064	58
70-74	41	4700	0.00872	5331	0.1183	103
75-79	68	7057	0.00964	8718	0.1934	186
80-84	68	9259	0.00734	11864	0.2632	193
85-89	49	7665	0.00639	9689	0.2149	137
>90	20	4167	0.00480	6591	0.1462	70
All ages		36028	0.046	45077		747

Overall standardized incidence rate calculations for the year 2009.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	26	2881	0.00902	2884	0.064	58
70-74	28	3992	0.00701	5331	0.1183	83
75-79	43	6255	0.00687	8718	0.1934	133
80-84	64	7556	0.00847	11864	0.2632	223
85-89	43	6624	0.00649	9689	0.2149	139
>90	19	3581	0.00531	6591	0.1462	78
All ages		30889	0.043	45077		723

Overall standardized incidence rate calculations for the year 2010.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	21	2635	0.00797	2884	0.064	51
70-74	34	3392	0.01002	5331	0.1183	121
75-79	39	5179	0.00753	8718	0.1934	146
80-84	49	6406	0.00765	11864	0.2632	201
85-89	36	5450	0.00661	9689	0.2149	142
>90	27	3019	0.00894	6591	0.1462	131
All ages		26081	0.049	45077		792

Overall standardized incidence rate calculations for the year 2011.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	174	8090	0.02151	2884	0.064	138
70-74	138	11148	0.01238	5331	0.1183	146
75-79	227	17829	0.01273	8718	0.1934	246
80-84	226	25988	0.00870	11864	0.2632	229
85-89	224	27092	0.00827	9689	0.2149	178
>90	121	18801	0.0044	6591	0.1462	94
All ages		108948	0.068	45077		1031

Overall standardized incidence rate calculations for the year 2012.

Age	Count	Population at Risk	Crude Rate (per 100,000)	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	51	3968	0.01285	2884	0.064	82
70-74	79	5336	0.01481	5331	0.1183	175
75-79	72	7848	0.00917	8718	0.1934	177
80-84	77	11099	0.00694	11864	0.2632	183
85-89	92	10743	0.00856	9689	0.2149	184
>90	33	7067	0.00467	6591	0.1462	68
All ages		46061	0.057	45077		869

Overall standardized incidence rate calculations for the year 2013.

Age	Count	Population at Risk	Crude Rate	ON 2003 Population (Standard)	Age Distribution of Standard Population	
65-69	79	5493	0.01438	2884	0.064	92
70-74	97	7662	0.01266	5331	0.1183	150
75-79	136	11708	0.01162	8718	0.1934	225
80-84	152	17176	0.00885	11864	0.2632	233
85-89	132	17247	0.00767	9689	0.2149	165
>90	53	12017	0.00441	6591	0.1462	64
All ages		71303	0.06	45077		929

Appendix D: Model Building Strategy

Bivariate confounding assessment between TBI and the following variables:

Confounders	P-Value
Aboriginal origin	0.2346
Education level	<0.0001
History of falling	<0.0001
Alzheimer's	<0.0001
Dementia	<0.0001
Parkinsonism	0.9265
Antidepressant Use	<0.0001

Bivariate effect modification assessment between TBI and the following variables:

Effect Modification	P-Value
Depression * history of falling	<0.0001
Depression * education level	<0.0001
Depression * Alzheimer's	<0.0001
Depression * dementia	0.31
Depression * parkinsonism	0.33
Depression * antidepressant	0.1668

Effect modifiers: history of falling, education level and Alzheimer's.

Gold standard model: dementia, history of falling, education level and Alzheimer's.

Adjusted parsimonious model: history of falling, education level and Alzheimer's.

14. CURRICULUM VITAE

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Lakehead University, September 2013-present
Advisors: Dr. Vicki Kristman, Dr. Michel Bédard & Dr. Lynn Martin
Thesis: Traumatic Brain Injury in Older Adults: A Descriptive and Etiologic Analysis

B.Sc. Honours Biology
St. Francis Xavier University, Graduated 2013
Advisors: Dr. Cory Bishop & Dr. Lori Graham
Thesis: The Influence of Single Species Bacterial Biofilms on the Metamorphosis of *Lytechinus variegatus* and *Ciona intestinalis* Larvae

Academic Honors

Lakehead Department of Health Sciences Research Scholarship, 2015
SHARP International Symposium Conference Travel Grant, 2014
Ontario Graduate Scholarship, 2014-2015
Lakehead University Academic All-Canadian, 2013-2014
CSEB National Student Conference Travel Grant, 2013
Lakehead University Graduate Studies Bursaries (x4), 2013-2014
Lakehead University Graduate Studies Entrance Award, 2013
The Leo P. Chiasson Award for Most Outstanding Graduating Student in Biology, 2009-2013
St. FX University President's Circle of Young Alumni Award, 2009-2013
St. FX University Alumni Recognition Award, 2013
St. FX University Academic All-Canadian, 2011-2012 & 2012-2013
St. FX Entrance Scholarship, 2009-2013
CIS Leadership Award, 2011-2015
CIS Cross Country Student-Athlete Community Service Award, 2012
AUS Cross Country Student-Athlete Community Service Award, 2012

Research Experience

Graduate Research Scholar, January 2015-present
Mentor: Dr. Vicki Kristman, Lakehead University

Graduate Assistantship, September 2013-present
Mentor: Dr. Vicki Kristman, Lakehead University

Honors Thesis, 2012-2013
Mentors: Dr. Cory Bishop & Dr. Lori Graham, St. Francis Xavier University

Research Assistant, 2011-2012
Mentors: Dr. Cory Bishop & Kate McNeil, St. Francis Xavier University

Research Assistant, 2011
Mentor: Dr. Julius Elrich, St. Francis Xavier University

Academic Publications

McGuire CR, *Kristman VL, Shaw WS, Williams-Whitt K, Reguly P, & Soklaridis S.* Supervisor Autonomy and Considerate Leadership Style are Associated with Supervisors' Likelihood to Accommodate Back Injured Workers. Journal of Occupational Rehabilitation (in press). DOI:10.1007/s10926-015-9567-4.

Conference Presentations

McGuire CR, *Kristman VL, Shaw WS, Williams-Whitt K, Reguly P, & Soklaridis S.* Supervisors autonomy, considerate leadership style and disability management policies and practices are associated with supervisors' likelihood to accommodate back-injured workers. St. Joseph's Care Group- Showcase of Health Research Conference. Thunder Bay, ON. February 6th, 2015. (Poster Presentation).

McGuire CR, *Kristman VL, Shaw WS, Williams-Whitt K, Reguly P, & Soklaridis S.* Supervisor Autonomy and Considerate Leadership Style are Associated with Supervisors' Likelihood to Accommodate Back Injured Workers. 7th International Symposium: Safety & Health in Agricultural & Rural Populations Conference. Saskatoon, SK. October 19th-22nd, 2014. (Poster Presentation).

McGuire CR, *Kristman VL, Shaw WS, Williams-Whitt K, Reguly P, & Soklaridis S.* Supervisor Autonomy and Considerate Leadership Style are Associated with Supervisors' Likelihood to Accommodate Back Injured Workers. Work Disability Prevention and Integration Conference. Toronto, ON. September 28th- 30th, 2014. (Podium Presentation).

McGuire CR*, Kristman VL, & Reguly P*. Traumatic Brain Injury in Older Adults: A Descriptive & Etiologic Analyses. Canadian Society of Epidemiology and Biostatistics National Student Conference. Hamilton, ON. May 9th-10th, 2014. (Podium Presentation).

Academic Services

CSEB Newsletter Editorial Team, September 2014-present
Assistant Editor- Journal on Developmental Disabilities, January 2014-present