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**ORIGINAL REPORT**

# DIFFERENTIAL PROFILES FOR PATIENTS WITH TRAUMATIC AND NON-TRAUMATIC BRAIN INJURY

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***Objective:*** **To profile the demographic, clinical and environmental characteristics of persons with acquired brain injury receiving inpatient rehabilitation services in Canada.**
***Design:*** **This study utilizes data from the Canadian Institute for Health Information's National Rehabilitation Reporting System, between April 2001 and March 2006. The data were collected from publicly insured institutions providing inpatient rehabilitation across Canada. The main outcome measures examined were demographic and clinical characteristics.**
***Participants:*** **Adults with brain injury by traumatic (*n* = 2675) vs non-traumatic causes (*n* = 2759).**
***Results:*** **Approximately half of acquired brain injury patients receiving inpatient rehabilitation had non-traumatic causes of brain injury. Traumatic brain injury patients were more likely to be younger, male, from rural areas, and to make greater gains in rehabilitation. Differences were found in the types and numbers of comorbidities. However, patients from these 2 groups had similar lengths of rehabilitation stay.**
***Conclusion:*** **These findings support a differential profile of patients by brain injury aetiology. This has relevance for staff training, resource allocation and future research.**

*Key words:* brain injuries; rehabilitation; treatment outcome.

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## INTRODUCTION

An acquired brain injury (ABI) is damage to the brain occurring after birth caused either by trauma (traumatic brain injury; TBI) or through a medical problem or disease process such as neoplasm, vascular causes, inflammation or metabolic toxicity (non-traumatic brain injury; NTBI) (1). Patients with an ABI from both traumatic and non-traumatic causes are often treated in the same rehabilitation facilities or inpatient rehabilitation units in hospitals. Few studies have focused on patients with a NTBI as a rehabilitation diagnostic group and how they differ from patients with a TBI (2). In contrast, a number of studies comparing non-traumatic vs traumatic spinal cord injuries demonstrate differences that have important implications for both rehabilitation processes and outcomes for individuals with non-traumatic spinal cord injury (3, 4).

Ottenbacher et al. (5) examined 13,275 patients with brain dysfunction from 1994 to 2001, using data collected by the Uniform Data System for Medical Rehabilitation. This impressive study compared demographic and clinical characteristics of patients with brain dysfunction with patients from other diagnostic groups, and the impact on resource utilization. Comparisons, however, were not made between traumatic and non-traumatic brain dysfunction. Given the wide range of diagnoses within this broad diagnostic category, it is important to understand the characteristics of these two types of brain injury and their unique impact on resource utilization. This information could better inform managers and clinicians about the resource implications of treating patients with each specific diagnosis within the brain dysfunction category. For instance, diagnostic groupings associated with older age or specific comorbidities may have implications for staff training or expertise needed in the inpatient rehabilitation setting, and for further post-acute care.

A recent study explored differences in rate of recovery and functional outcome in case-matched patients with TBI vs NTBI, during inpatient rehabilitation and at 1 year post-injury, in a Canadian rehabilitation setting. This study showed greater functional recovery among patients with a TBI than patients with a NTBI (2). These informative analyses, however, need to be examined in a larger sample consisting of a greater number of institutions. Overall, previous studies have focused mostly on TBI cases and have only used small sample sizes of NTBI cases from single facilities (2).

The current study advances this research by profiling the demographic and clinical characteristics of persons with an ABI, receiving inpatient rehabilitation services in Canada, from a population-based perspective. To our knowledge, this is the first population-based study of persons with an ABI receiving inpatient rehabilitation in Canada to be published in the peer-reviewed literature, and the only study based on a publicly-insured population worldwide. We hypothesized that patients with a NTBI would be older and would have more comorbidities.

## METHODS

### *Data source*

The primary data were collected from the National Rehabilitation Reporting System (NRS), a data source developed by the Canadian Institute for Health Information (CIHI) in order to support rehabilitation services, planning activities, and policy development. This data source provides information on clinical outcomes and on the characteristics of various rehabilitation activities. One of the advantages of this data source is that it is not composed exclusively of data from large rehabilitation hospitals, but also includes data from rehabilitation units within acute care hospitals. There are a greater number of these units than there are large rehabilitation hospitals, and rehabilitation units within acute care settings are more common in less populated areas. Therefore, this data source is more representative of the population because it presents data beyond free-standing inpatient rehabilitation hospitals. Most data (60.5%) come from the province of Ontario where NRS data collection is mandatory for all funded inpatient rehabilitation beds. In Canada, provinces and territories provide universal insurance that covers medically necessary physician and hospital services. Hospital care, therefore, is available to all Ontarians, and all Canadians, on equal financial terms; thus the data reported here capture the entire set of hospitalizations for TBI.

The NRS designates rehabilitation client groups (RCGs) to describe case mix. Designation of a client into one of these groups is based on the health condition that best describes the reason for admission to the rehabilitation programme. The health conditions used for designation include orthopaedic conditions, stroke, brain dysfunction, amputation of the limb, spinal cord dysfunction, and medically complex conditions. In this study, we focused only on the "brain dysfunction" category, which includes cases from both traumatic and non-traumatic causes. The non-traumatic brain dysfunction RCG includes aetiologies such as anoxia, ruptured intracranial aneurysms, neoplasm, encephalitis, or metabolic toxicity; the traumatic brain dysfunction RCG includes "cases with motor or cognitive disorders secondary to trauma" (1, p. B-1). These RCGs match our designations of the NTBI group and the TBI group, respectively.

This research received ethics approval from the Toronto Rehabilitation Institute.

### *Key variables*

The measured variables were classified into 3 categories: demographic characteristics, clinical characteristics and environmental variables. Each category contained several distinct variables.

### *Demographic characteristics*

Sociodemographic characteristics collected include age, gender, language and geographic location. Languages other than English were indicated when the patient required an interpreter. This is an important variable given the linguistic diversity of the Canadian population. The patient's residence was characterized as being in an urban or rural area based on the geocoding files from Statistics Canada (6). Geographic variables were considered important as this has relevance for discharge planning and the planning of services for further longer term care. Providing care across large geographical, but sparsely populated, areas is of great policy relevance in the Canadian context. Information on race is not commonly collected in Canadian administrative databases and so is not represented in this study.

### *Clinical characteristics*

*Type of acquired brain injury.* The NTBI group captured diagnoses such as aneurysms, subarachnoid haemorrhage, neoplasms, metastases, anoxia, inflammation of the brain (such as encephalitis, meningitis), or metabolic toxicity that resulted in brain injury. We did not have information about the distribution of all these specific diagnoses within this designation. The TBI group included injuries due to an external force, such as a fall, motor vehicle crash or being struck by an object.

*Level of disability.* The Functional Independence Measure (FIM®) instrument (7) was used rigorously to collect data to provide the basis for level of disability recorded at admission and upon discharge. The staff of rehabilitation centres receive training and certification in the use of this instrument. The FIM instrument is composed of 18 items, each rated on a 7-point ordinal scale. A higher total FIM rating is indicative of higher functioning in activities of daily living. The FIM instrument can be further divided into the Motor FIM subscale and the Cognitive FIM subscale. The Motor FIM subscale describes the physical ability of the patient, while the Cognitive FIM subscale measures cognition and communication through 5 factors: comprehension, expression, social interaction, problem-solving and memory (8–10).

*Comorbidity.* Diagnostic codes from the NRS were used to identify comorbidity. The NRS captures up to 10 comorbidities for each patient. For this variable, we documented the type of comorbidity and presented a frequency distribution of each type for patients with a NTBI and with a TBI. Comorbid mental health conditions were examined separately as they are frequently associated with ABI (11).

*Length of stay.* Rehabilitation length of stay was the number of days between the date of admission and the date of discharge from the facility providing inpatient rehabilitation services, excluding any service interruptions.

### *Statistical analysis*

The statistics used in this descriptive study were frequency distributions and measures of central tendency. $\chi^2$ and *t*-test/Wilcoxon statistics were used, depending on the distribution of the data, to examine differences between characteristics of persons with a NTBI vs those with a TBI. All cell sizes less than 5 were suppressed to protect confidentiality.

## RESULTS

Admission and discharge characteristics were reviewed for 5434 ABI patients receiving inpatient medical rehabilitation services from April 2001 through March 2006. The data were collected from facilities providing inpatient rehabilitation services across Canada, with 3282 patients from such facilities in Ontario. In this data-set, 49.2% of patients had a TBI and 50.8% of patients had a NTBI.

### *Demographic characteristics*

*Age and gender.* This study included patients in the age range 16–100 years at time of admission to rehabilitation. The mean age of all patients with ABI was 53 years (standard deviation (SD) = 20.1). For persons with a TBI, the mean age was 47.0 years (SD = 20.9), which was significantly lower than the mean age (58.8 years; SD = 17.5) of patients with NTBI. Since the age distribution was not normally distributed, we categorized age into 3 groups: under 30, between 30 and 70, and 70+ years, since these categories best captured 3 distinct peaks in the data. The largest group of ABI patients was the 30–70 years age group (59.7% of all ABI clients). Approximately 16.6% of patients were under 30 years old and the remaining 23.7% were over 70 years old.

Among the patients with an ABI, 2085 (38.4%) were female and 3349 (61.6%) were male. The ratio of female to male patients admitted to rehabilitation programmes increased with age: the youngest age group (under 30 years) had the largest proportion of male patients (74% male and 26% female); the

proportion of female patients increased to 37% in the middle age group; males and females were equally represented (50.5% male and 49.5% female) in the oldest age group (age over 70 years). According to the $\chi^2$ test (df = 2, $p < 0.0001$), the associations of gender by age categories were statistically significant. Overall, the mean age was 57.7 years for female and 50.1 years for male ABI patients.

When the data were divided into subgroups by cause of injury, the NTBI group had a significantly larger proportion of female patients than the TBI group (df = 1, $p < 0.0001$).

*Language.* Over 92% of ABI patients in this study were English speaking. The proportions of English speakers in the NTBI group and the TBI group were not significantly different.

*Geographic location: rurality.* Approximately 80% of patients with an ABI lived in urban areas. The distributions of type of injury between rural and urban areas were significantly different ($\chi^2$ test with df = 2, $p < 0.0001$). Significantly more TBI patients lived in rural vs urban areas (Table I).

*Clinical characteristics*

*Functional Independence Measure ratings.* The mean total FIM rating at admission for patients with a NTBI was 76.8 (SD = 26.5); this was significantly lower than the mean total FIM rating of 79.4 for patients with a TBI (Table I). After separating the total FIM rating into motor and cognitive FIM subscales, the differences between the NTBI and TBI groups became more apparent. Compared with patients with NTBI, the TBI group had higher mean motor ratings but similar cognitive mean ratings at admission. However, after completing rehabilitation, the TBI group showed greater improvement on both motor and cognitive function abilities, resulting in higher discharge motor and cognitive FIM ratings compared with NTBI patients. All these differences were statistically significant.

*Rehabilitation length of stay.* The mean length of stay of ABI patients was 50 days (SD = 55.8) and the median was 36 days. This means that half the ABI patients stayed in inpatient rehabilitation for 36 days or less. Twenty-five percent of patients stayed under 20 days. Approximately 10% of patients with ABI stayed in inpatient rehabilitation for over 3 months.

The mean length of stay for patients in the NTBI group was 50.1 days (SD = 52.5). This was virtually the same as for the TBI group, which had a mean rehabilitation length of stay of 49.5 days (SD = 59). Standard deviations indicated a wide range of lengths of stay.

*Comorbidity.* The mean number of comorbidities for patients with an ABI was 3.7 (SD = 2.9). On average, patients with a NTBI had 3.9 (SD = 3.0) comorbidity diagnoses, slightly more (*t*-test $p < 0.0001$) than patients with a TBI (mean = 3.5, SD = 2.9). According to the diagnostic codes from the NRS, 18 types of comorbidities were represented in this data-set. In the ABI group the main diagnostic categories represented were mental health (30.5%), circulatory system (38.8%) and nervous system (36.1%). Table II shows the frequency distribution of major categories of comorbidity for the patients with ABI.

The NTBI group had a significantly higher percentage of mental health diagnoses ($\chi^2$ with df = 1, $p = 0.0008$) (Table II), compared with the TBI group. Table III shows the frequency of types of mental health comorbidities. Among 5434 ABI patients, 1658 patients had at least 1 mental health disorder. Confusion was the most frequently diagnosed mental health condition for the TBI group (42.3%); in the NTBI group, depressive disorder was most frequently diagnosed (34.1%).

Table I. *Characteristics of patients with non-traumatic brain injury (NTBI) and traumatic brain injury (TBI)*

| | NTBI (*n* = 2759) | TBI (*n* = 2675) | *p*-value |
|---|---|---|---|
| Age, years, mean (SD) | 58.8 (17.5) | 47.8 (20.9) | < 0.0001 |
| Gender, *n* (%) | | | |
| Female | 1348 (48.9) | 737 (27.5) | < 0.0001 |
| Male | 1411 (51.1) | 1938 (72.5) | |
| Language, *n* (%) | | | |
| English | 2553 (92.5) | 2468 (92.3) | 0.7202 |
| Other | 206 (7.5) | 207 (7.7) | |
| Rurality, *n* (%) | | | |
| Rural | 393 (14.2) | 551 (20.6) | < 0.0001 |
| Urban | 2285 (82.8) | 2032 (76) | |
| Unknown | 81 (2.9) | 92 (3.4) | |
| FIM – admission, mean (SD) | | | |
| Total | 76.8 (26.5) | 79.4 (28.9) | 0.0004 |
| Motor | 54.9 (22.2) | 58.5 (24.2) | < 0.0001 |
| Cognitive | 21.8 (8.1) | 21 (7.8) | < 0.0001 |
| FIM – discharge, mean (SD) | | | |
| Total | 96.2 (26.6) | 103.9 (23.4) | < 0.0001 |
| Motor | 71.1 (21.3) | 77.8 (18.9) | < 0.0001 |
| Cognitive | 25.1 (7.4) | 26.1 (6.7) | < 0.0001 |
| FIM – change, mean (SD) | | | |
| Total | 19 (19.3) | 24.3 (21.4) | < 0.0001 |
| Motor | 15.7 (16.2) | 19.2 (18.5) | < 0.0001 |
| Cognitive | 3.3 (5) | 5.1 (5.5) | < 0.0001 |
| Rehabilitation LOS, mean (SD) | 50.1 (52.5) | 49.5 (59) | < 0.0001 |
| Number of co-morbidities | 3.9 (3) | 3.5 (2.9) | < 0.0001 |

SD: standard deviation; FIM: Functional Independence Measure; LOS: length of stay.

Table II. *Frequency distribution of major diagnostic comorbidities for patients with acquired brain injury (ABI), non-traumatic brain injury (NTBI) and traumatic brain injury (TBI)*

| | ABI (*n* = 5434) Frequency *n* (%) | NTBI (*n* = 2759) Frequency *n* (%) | TBI (*n* = 2675) Frequency *n* (%) |
|---|---|---|---|
| Mental health | 1658 (30.5) | 899 (32.6) | 759 (28.4) |
| Circulatory system | 2108 (38.8) | 1415 (51.3) | 693 (25.9) |
| Nervous system | 1962 (36.1) | 1219 (44.2) | 743 (27.8) |
| Endocrine, nutritional, metabolic and immune system | 1173 (21.6) | 752 (27.3) | 421 (15.7) |
| musculoskeletal system | 1034 (19) | 629 (22.8) | 405 (15.1) |
| Genitourinary system | 909 (16.7) | 583 (21.1) | 326 (12.2) |

Table III. *Frequency distribution of types of comorbidities for mental health*

| | ABI ($n$=1658) $n$ (%) | NTBI ($n$=899) $n$ (%) | TBI ($n$=759) $n$ (%) |
|---|---|---|---|
| Other depressive disorder, not elsewhere classified | 459 (27.7) | 307 (34.1) | 152 (20) |
| Alcohol dependence | 352 (21.2) | 113 (12.6) | 239 (31.5) |
| Drug dependence | 132 (8) | 66 (7.3) | 66 (8.7) |
| Confusion (not otherwise specified) | 597 (36) | 276 (30.7) | 321 (42.3) |
| Senile and pre-senile dementia, excludes Alzheimer's disease | 116 (7) | 76 (8.5) | 40 (5.3) |
| Affective psychoses, includes manic depression and bipolar affective disorders | 154 (9.3) | 102 (11.3) | 52 (6.9) |
| Personality disorders, includes aggression and other antisocial behaviour | 101 (6.1) | 44 (4.9) | 57 (7.5) |
| Others | 319 (19.2) | 213 (23.7) | 106 (14) |

ABI: acquired brain injury; NTBI: non-traumatic brain injury; TBI: traumatic brain injury.

TBI clients, however, had higher percentage of alcohol abuse comorbidity than NTBI clients (31.5% vs 12.6%).

## DISCUSSION

This study investigated demographic and clinical characteristics in a large population of adults with an ABI across Canada. Patients with a TBI were compared with patients with brain injury from non-traumatic causes. As far as we know, this is the first study comparing these diagnostic groups using population-level data in Canada. Our study showed that these two diagnostic groups differ significantly in a range of demographic and clinical characteristics. Patients with a TBI were significantly younger, more likely to be male, and lived in urban areas.

The difference in ages between the groups has implications for staff training, particularly for the NTBI population. With the ageing of our population, it is anticipated that there will be a greater demand for inpatient rehabilitation from older persons with NTBI diagnoses, and an increased demand for long-term care facilities for those who cannot return home after rehabilitation. Inpatient rehabilitation facilities and units, and their staff, must be increasingly prepared to address the needs of clients who are older and who have more comorbid illnesses. Indeed, over 20% of patients overall were over 70 years of age. Our mean age for the entire sample, however, was only slightly higher than found in a large US sample (5).

Over 70% of patients with a TBI were male. A similarly high proportion of males was also found in a study using the Traumatic Brain Injury Model Systems national data-set in the USA (12). As the age of both patient groups (TBI and NTBI) increased, the percentage of female patients also increased. TBI is frequently associated with risk-taking behaviours of younger males; however, as the population ages, other factors, such as increased likelihood of falls, frailty and age-related illnesses, likely cause ABIs in men and women equally. A greater number of patients with a NTBI in inpatient settings also means increasing numbers of women who may have specific gender-related needs that require programme modifications. The higher number of patients with a TBI from rural communities has implications for availability of more specialized services. At this time, these specialized services are most likely to be available in major cities in Canada. Innovative strategies such as tele-rehabilitation are warranted.

Patients with a TBI had significantly higher total FIM ratings at admission and at discharge; they also had a greater overall change in FIM during the course of inpatient rehabilitation. The 7.6 FIM rating difference at discharge suggests that NTBIs require more mins of daily care (13). Despite the slightly lower mean admission cognitive FIM rating for patients with a TBI, they showed a greater improvement during rehabilitation; this resulted in a higher average cognitive FIM rating at discharge compared with the NTBI group. These effects may be somewhat explained by the underlying pathophysiology of the NTBI, age differences, or perhaps lack of rehabilitation services designed specifically for the more heterogeneous case mix categorized under NTBI. This finding supports previous work by Cullen et al. (2). However, the average amount of rehabilitation as measured by length of stay for both the TBI and NTBI groups was, on average, the same in this study. Compared with results from the US, Canadian patients appear to enter inpatient rehabilitation with higher FIM ratings and have much longer lengths of stay. Ottenbacher et al. (5) documented that the average admission and discharge FIM ratings were 60.8 and 91.3, respectively, with a median length of stay of 18 days. We expect that higher FIM ratings on admission in Canadian settings are due to a longer inpatient acute care stay. In a large US study, the median onset to admission into inpatient rehabilitation from the initial acute care admission was 14 days (5). Unfortunately, we did not have similar acute care data to compare across studies, and a sizable proportion of patients were not referred directly from acute care.

Overall, the ABI inpatient rehabilitation population has a notable number of comorbidities. Psychiatric comorbidities have been documented in other studies (10). The most frequently diagnosed mental health condition for the TBI group was confusion; for the NTBI group depressive disorder was most frequently diagnosed. Confusion is a vague term used by the NRS database and is an expected sequelae in early recovery from brain injury, whereas depression suggests that more mental health services may be required for patients according to their cause of injury. A more detailed examination of the impact of comorbidities on the rehabilitation process is warranted.

This is the only investigation we are aware of that compares characteristics of brain injury by type of condition, from a large population-based perspective in a publicly insured population. One of the limitations of this research is that data from acute care are not linked with the NRS, which would provide acute care measures of severity of injury, such as Glasgow Coma Score, Injury Severity Score, acute care length of stay or mechanism of injury. Nevertheless, the aim of this paper was to profile an inpatient population and many acute care measures may not accurately reflect post-acute functional status. We had a large sample and as such small differences achieved statistical significance. In addition, our examination of case mix was restricted to two broad ABI groupings, because detailed information based on smaller sub-groups, for instance persons who sustained a brain injury caused by brain infections, was not available at this time.

In conclusion, these data provide valuable information on current consumers of inpatient rehabilitation services in a Canadian setting. There are significant differences between the profiles of patients with NTBIs and with TBIs receiving inpatient rehabilitation. It is interesting that the mean age of patients receiving inpatient rehabilitation in this study is higher than that found in many other published studies; this will be an important consideration for future planning, given the current demographic trends in the Western world. With these changes in demographics, we anticipate that inpatient rehabilitation centres will continue to see older clients with significant comorbidity. Moreover, there is relatively sparse literature on rehabilitation and recovery of patients with NTBIs as a group. This is an important area for further investigation, and should include a longer time-frame of study.

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We certify that no party having a direct interest in the results of the research supporting this article, financial or otherwise, has or will confer a benefit on us or on any organization with which we are associated.

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