Traumatic brain injury is a major cause of injury and death in New Zealand. Treasury estimates that TBI has the second greatest impact on employment and income, after stroke. Literature suggests that TBI is more common among prisoners and that there is a modest causal link between TBI and crime. Yet little is known about prevalence of TBI for other parts of the justice system.

This paper explores the extent of recorded TBI prior to interaction with the justice system. ‘Recorded’ refers to TBI cases resulting in hospitalisation or where an ACC claim was accepted. This means prevalence rates in this report will underestimate the true extent of TBI, since there are people who experience a TBI and are not admitted to hospital and do not make an ACC claim.

This analysis was conducted in the Integrated Data Infrastructure (IDI). The ACC data definition of TBI was replicated for this analysis.

Key findings:

• A large proportion of people interacting with the justice sector in 2015 have had a prior recorded TBI – 34% of people proceeded against by Police; 36% of people charged in court; 40% of people starting a community sentence; 47% of people remanded in custody and 46% of people starting a prison sentence.

• This compares with a 13% rate among the public.

• There is variation in these rates by sex and ethnicity – male offenders are more likely to have a prior recorded TBI than females. European, Māori and offenders of Middle Eastern, Latin American or African ethnicity have higher rates of prior recorded TBI, while Asian offenders have lower rates. This sex and ethnicity variation is similar in the public.

• Offenders with prior recorded TBI have higher re-offending rates, higher number of re-offences, more likely to have a conviction for a violence or sexual offence and are younger at age of first charge.

• Even when controlling for a range of other factors, having a prior TBI is strongly associated with re-offending.

1 (McKinlay, Corrigan, Horwood, & Fergusson, 2014)
2 (Schofield, et al., 2015)
3 Defined as the usually resident population aged 10 years and over in the 2013 Census.
The most common cause of TBI for people in prison is assault, whereas the most common cause of TBI for the general public is from falls/trips/slips. It is not possible to classify the severity of prior recorded TBI (e.g. mild/moderate/severe) with the current IDI data. Evidence suggests that effective measures to reduce the incidence of TBI, particularly among children and young people, would help reduce crime as well as improving health and wellbeing.

**Traumatic Brain Injury alters brain function**

TBI is an alteration in brain function caused by an external force. It can be caused by a blow, shake, or jolt to the head or body, or a penetrating injury that disrupts the function of the brain. A concussion is a form of mild traumatic brain injury (ACC definition).

**Literature on TBI in New Zealand**

*Traumatic Brain Injury is a serious issue among the public*

TBI is a major cause of injury and death in New Zealand. TBI is the leading cause of long-term disability in children and adults aged up to 35 years. One study showed that in 2010 approximately 13% of the NZ population had experienced at least one TBI event at some point in their lives. Treasury has identified that TBIs are second only to stroke for their impacts on employment and income. Over half of ACC serious-claims are related to TBI.

A study conducted the National Institute for Stroke and Applied Neuroscience at Auckland University of Technology estimated that over 36,000 new traumatic brain injuries occur each year, 95% of which are mild. The majority do not seek medical assistance or access support from ACC. While the clear majority of TBIs are mild, even mild injuries can lead to often undetected long lasting health issues including post-concussion symptoms, epilepsy, depression, and cognitive defects.

*Rates of Traumatic Brain Injury appear higher for people in the justice system*

There is some existing literature that quantifies the extent of TBI amongst those interacting with the justice system. A 2005 New Zealand Prisoner Health Survey showed that 64% of people in prison have a self-reported head injury (64% for males, 53% for females). Respondents were asked if they ever had had a head injury where they became unconscious or blacked out. This survey was a relatively small sample of 423 people in prison and based on self-reported head injury rather than medical diagnoses of TBI.

A 2017 New Zealand study found that 95% of females in prison presented with a history of TBI. Younger age at first injury was associated with an increased risk of mental health problems. This

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4 (Te Ao, et al., 2015)
5 (Feigin, et al., 2013)
6 (Te Ao, et al., 2015)
7 (Dixon, 2015)
8 (ACC, 2017)
9 (Feigin, et al., 2013)
10 (Starkey, 2013)
11 (Ministry of Health, 2006)
12 (Woolhouse, McKinlay, & Grace, 2017)
survey had a small sample size (n=38) and was based on self-reported measures of depression, anxiety, and stress, sleep, and history of TBI.

International literature reports a wide range of estimates, partially reflecting different definitions of TBI\(^\text{13}\). A 2010 meta-analysis estimated the prevalence of TBI in offender populations. Without adjusting for differing definitions of TBI, methods of determination, proportion of males in the sample, or the similarities of the sample populations, the overall estimated prevalence of TBI in the overall offender population was 60.25% (95% CI: 48.08 to 72.41)\(^\text{14}\).

There is evidence suggesting a causal link between TBI and criminality

A 2017 systematic review investigated whether TBI in childhood was associated with later risk taking behaviour. The authors found mixed evidence on the association between childhood TBI and later offending behaviour\(^\text{15}\).

The review found six articles, based on four separate studies. All of the included studies were observational and therefore rated as having a low quality of evidence based on GRADE criteria\(^\text{16}\). Three articles indicated a relationship between childhood TBI and increased problematic substance use in adolescence and young adulthood. Three articles supported an association between childhood TBI and later offending behaviour; however two articles did not support this link.

The review concludes that more research is warranted to explore the association between childhood TBI and later risk behaviour as the relationship is not currently understood\(^\text{17}\). The authors recommend that future research should build on existing longitudinal research with continued use of medical records for identifying TBI and inclusion of a non-brain-related trauma group to control for general injury effects.

Schofield et al.\(^\text{18}\) used linked data in an Australian whole-population retrospective cohort study. Results supported a modest causal link between TBC and criminality.

Results published in 2014, from a longitudinal study of children born in Christchurch, indicated an association between TBI and self-reported arrests, property offences, and violent offences\(^\text{19}\). The researchers found that participants who had a TBI between 16 and 21 years of age, there was a significant increase in the risk of arrests from 21 to 25 years of age. People with a TBI had 2.5 times the risk of arrest than people who had not experienced a TBI\(^\text{20}\).

More current and comprehensive information is needed

While this presents some existing literature, the extent of TBI for people in other parts of the justice sector are is largely unknown. Prisoners are only a small part of the justice sector, and the findings for prisoners may not necessarily be the same for all offenders.

Additionally, some of the studies on prisoners are based on small sample sizes or are quite out-of-date.

\(^\text{13}\) (Parsonage, 2016)
\(^\text{14}\) (Shiroma, Ferguson, & Pickelsimer, 2010)
\(^\text{15}\) (Kennedy, Cohen, & Munaf`o, 2017)
\(^\text{16}\) (Andrews, et al., 2013)
\(^\text{17}\) (Kennedy, Cohen, & Munaf`o, 2017)
\(^\text{18}\) (Schofield, et al., 2015)
\(^\text{19}\) (McKinlay, Corrigan, Horwood, & Fergusson, 2014)
\(^\text{20}\) (McKinlay, Corrigan, Horwood, & Fergusson, 2014)
As such there is need for more comprehensive and current information on the extent of prior TBI across the justice sector.

Analysis methods

Data was drawn from multiple sources

This analysis uses the linked Ministry of Health (MoH), Accident Compensation Corporation (ACC), and Justice data in the Integrated Data Infrastructure (IDI) held at Statistics New Zealand. The specific data sources used include:

- The National Minimum Dataset (NMDS) – Ministry of Health
- Work and non-work compensation claims – ACC
- Recorded crime offenders data (RCOS) – NZ Police
- Charges disposed in court – Ministry of Justice
- Sentencing and remand data – Department of Corrections
- 2013 Census data – Statistics NZ

The National Minimum Dataset was used to identify TBI-related hospital discharges

The National Minimum Dataset (NMDS) includes all publicly funded hospital discharges starting from 1988. The dataset excludes events from privately funded hospitals.

The NMDS data includes inpatients, day patients and short stay emergency department (SSED) events. SSED are hospital events where patients are admitted for longer than 3 hours (which is the current threshold for admission) and less than 2 days, with emergency department specialty codes. SSED visits were only complete in this dataset from July 2012. This is particularly important for this analysis because around 40% of TBI events were short stay emergency department events during the years of complete data.

The ACC claims data was used to identify TBI-related ACC claims

This dataset contains all claims made due to work-related or non-work related injury. This dataset is the most complete and comprehensive source of national statistics on injuries. The data starts in 1994, although there is incompleteness in the TBI events recorded prior to 1999.

The data collection in the IDI records all claims to ACC that have been accepted (or ‘interim accept’ or ‘pending accept’) under the Accident Compensation Act 2001. The vast majority (90%) of the ACC claim data is when medical fees only are paid out.

Prior recorded TBI was defined using several indicators

The definition of TBI used this analysis was the existing ACC definition of TBI across both ACC and NMDS data. This is because the ACC definition of TBI:

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21 The charges data in the IDI includes data for all people charged in court (including Youth Court). People with name suppression will not link to the IDI spine.


24 We are grateful for advice received from Agnes Guevara (ACC) and Meisha Nicolson (MoH).
Appendix A contains the full list of codes used to define prior recorded TBI. Appendix B shows the contribution to overall prevalence from the NMDS and ACC sources and compares prevalence rates if the MoH definition was used for the NMDS data.

Through the rest of this document, TBI means ‘prior recorded TBI’ unless otherwise stated.

We analysed the number of people who had a prior recorded TBI before the justice interaction date in 2015. This is all people in the justice system in 2015, not just people with first justice interaction. This means the prior recorded TBI may have occurred during or after an earlier justice interaction.

**Results**

**TBI increases further along the justice pipeline**

Table 1 presents the overall prevalence of TBI for different points in the justice sector.

This shows that the rate of prior TBI in the justice sector ranges from being two and half times higher, to three and half times higher than the general public rate. The rate of TBI is higher further along justice pipeline, and highest for people remanded in custody (47%) and in prison (46%).

Of people who experience a prior TBI, the average number of TBIs is also higher further along the justice pipeline. For example people starting a prison sentence have had on average 1.8 prior recorded TBIs compared to 1.3 in the general public.

<table>
<thead>
<tr>
<th></th>
<th>General population</th>
<th>Police: People proceeded against</th>
<th>Courts: People charged</th>
<th>Corrections: People starting community sentence</th>
<th>Corrections: People remanded in custody</th>
<th>Corrections: People starting prison sentence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Whether had prior recorded traumatic brain injury</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13%</td>
<td>34%</td>
<td>36%</td>
<td>40%</td>
<td>47%</td>
<td>46%</td>
<td></td>
</tr>
<tr>
<td><strong>For people with prior TBI, average number of TBIs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.3</td>
<td>1.6</td>
<td>1.6</td>
<td>1.7</td>
<td>1.8</td>
<td>1.8</td>
<td></td>
</tr>
</tbody>
</table>

The prevalence of TBI was calculated for each of 2013, 2014, and 2015 to assess the trends over time (only 2015 results presented in Table 1 except for the general population which was based on 2013.

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25 The specific dates used were: People proceeded against – first date of proceeding in 2015; People charged – first court date in 2015; People starting community sentence – date first community sentence started in 2015; People remanded in custody – date first period of remand started in 2015; People starting prison sentence – date first prison sentence started in 2015.

26 Census usually resident population aged 10 years and over, with prior recorded TBI before Census night 5 March 2013.
Census data). As expected the prevalence of TBI increased over these three years since an extra two years of data gives a longer opportunity to experience a TBI. Between 2013 and 2015 the rate increased between 1 and 2 percentage points for each justice interaction.

The experience of prior TBI could have been recently before Justice interaction or many years earlier. For example we found that for people with a TBI, 29% of people had their last recorded TBI ten or more years before their Police proceeding. Another 58% had their last TBI between 1 year and 10 years before, and 13% had their latest TBI in the year prior to justice sector interaction.

A 2017 study by Woolhouse et al.\(^ {27} \) found that younger age at first injury was associated with an increased risk of mental illness. The authors categorised the age of first TBI into the two groups of between 0 to 9 years of age and 10 years and over. We repeated this categorisation, and Table 2 presents the prevalence rates of first recorded TBI for different points in the justice sector.

The results in Table 2 show that the rate of people who experience a TBI in their first 10 years of life is similar between the general public and people proceeded against by Police. The percentage of people with their first TBI being before the age of 10 years decreases further along the justice sector.

<table>
<thead>
<tr>
<th>For people with prior recorded TBI, age at first recorded TBI</th>
<th>General population</th>
<th>Police: People proceeded against</th>
<th>Courts: People charged</th>
<th>Corrections: People starting community sentence</th>
<th>Corrections: People remanded in custody</th>
<th>Corrections: People starting prison sentence</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 9 years of age (%)</td>
<td>17%</td>
<td>18%</td>
<td>14%</td>
<td>12%</td>
<td>13%</td>
<td>11%</td>
</tr>
<tr>
<td>10 years or older (%)</td>
<td>83%</td>
<td>82%</td>
<td>86%</td>
<td>88%</td>
<td>87%</td>
<td>89%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

### Prevalence of TBI varies by sex and ethnicity

The demographic differences in prevalence rates of prior TBI are shown in Table 3.

From this, we can see that males were more likely than females to have a prior TBI across all justice sector interactions and in the general public. Refer to the ‘causes of TBI’ section for detail on how causes of TBI differ between males and females.

In the justice system people of Māori, European or Middle Eastern, Latin American or African ethnicity had the highest rates of TBI. People of Asian ethnicity in the general public and across all justice interactions had the lowest rates of prior TBI.\(^ {28} \)

\(^ {27} \) (Woolhouse, McKinlay, & Grace, 2017)

\(^ {28} \) Keep in mind with the ethnicity comparisons that migration patterns and length of time overseas can reduce the window of opportunity for having a TBI recorded in New Zealand. Similarly there may be differences by ethnicity in hospital attendance or ACC claim after a TBI.
Table 3: Prevalence of prior recorded TBI for people interacting with the justice system in 2015, by sex and ethnicity

<table>
<thead>
<tr>
<th></th>
<th>General population</th>
<th>Police: People proceeded against</th>
<th>Courts: People charged</th>
<th>Corrections: People starting community sentence</th>
<th>Corrections: People remanded in custody</th>
<th>Corrections: People starting prison sentence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whether had prior recorded traumatic brain injury</td>
<td>Overall - Whether had prior recorded 13%</td>
<td>34%</td>
<td>36%</td>
<td>40%</td>
<td>47%</td>
<td>46%</td>
</tr>
<tr>
<td>Sex - Male</td>
<td>16%</td>
<td>37%</td>
<td>39%</td>
<td>43%</td>
<td>48%</td>
<td>47%</td>
</tr>
<tr>
<td>Sex - Female</td>
<td>10%</td>
<td>26%</td>
<td>27%</td>
<td>31%</td>
<td>39%</td>
<td>38%</td>
</tr>
<tr>
<td>Ethnicity - European</td>
<td>14%</td>
<td>38%</td>
<td>40%</td>
<td>43%</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Ethnicity - Māori</td>
<td>18%</td>
<td>38%</td>
<td>39%</td>
<td>41%</td>
<td>48%</td>
<td>48%</td>
</tr>
<tr>
<td>Ethnicity - Pacific</td>
<td>13%</td>
<td>32%</td>
<td>34%</td>
<td>37%</td>
<td>46%</td>
<td>46%</td>
</tr>
<tr>
<td>Ethnicity - Asian</td>
<td>6%</td>
<td>20%</td>
<td>21%</td>
<td>27%</td>
<td>29%</td>
<td>28%</td>
</tr>
<tr>
<td>Ethnicity - MELAA²⁹</td>
<td>14%</td>
<td>37%</td>
<td>40%</td>
<td>44%</td>
<td>51%</td>
<td>52%</td>
</tr>
<tr>
<td>Ethnicity - Other</td>
<td>12%</td>
<td>34%</td>
<td>35%</td>
<td>39%</td>
<td>48%</td>
<td>49%</td>
</tr>
</tbody>
</table>

Of people who had a prior TBI, males had a slightly higher average number of TBIs than females. For example, males proceeded against by Police had on average 1.6 TBIs compared to females 1.5, and there was only minor variation by ethnicity.

Table 4 shows the comparison of age of first TBI by sex and ethnicity. 19% of Māori proceeded against by Police reported their first TBI before the age of 10 years. This compares to 13% of people of Asian ethnicity. This is also similar to the general population ranking, where Māori (22%) and Pacific people (24%) were most likely to experience their first TBI before the age of 10 years.

²⁹ MELAA = Middle Eastern, Latin American or African.
### Table 4: For people with prior recorded TBI, whether first TBI was before age 10 years, by sex and ethnicity

<table>
<thead>
<tr>
<th></th>
<th>General population</th>
<th>Police: People proceeded against</th>
<th>Courts: People charged</th>
<th>Corrections: People starting community sentence</th>
<th>Corrections: People remanded in custody</th>
<th>Corrections: People starting prison sentence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex - Male</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>18%</td>
<td>18%</td>
<td>15%</td>
<td>12%</td>
<td>13%</td>
<td>11%</td>
</tr>
<tr>
<td><strong>Sex - Female</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>16%</td>
<td>16%</td>
<td>13%</td>
<td>11%</td>
<td>13%</td>
<td>10%</td>
</tr>
<tr>
<td><strong>Ethnicity - European</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>European</td>
<td>17%</td>
<td>18%</td>
<td>15%</td>
<td>12%</td>
<td>12%</td>
<td>11%</td>
</tr>
<tr>
<td><strong>Ethnicity - Māori</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Māori</td>
<td>22%</td>
<td>19%</td>
<td>15%</td>
<td>12%</td>
<td>13%</td>
<td>11%</td>
</tr>
<tr>
<td><strong>Ethnicity - Pacific</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pacific</td>
<td>24%</td>
<td>18%</td>
<td>14%</td>
<td>12%</td>
<td>13%</td>
<td>9%</td>
</tr>
<tr>
<td><strong>Ethnicity - Asian</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td>19%</td>
<td>13%</td>
<td>10%</td>
<td>9%</td>
<td>11%</td>
<td>15%</td>
</tr>
<tr>
<td><strong>Ethnicity - MELAA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MELAA</td>
<td>18%</td>
<td>17%</td>
<td>14%</td>
<td>12%</td>
<td>12%</td>
<td>14%</td>
</tr>
<tr>
<td><strong>Ethnicity - Other</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>12%</td>
<td>11%</td>
<td>9%</td>
<td>8%</td>
<td>7%</td>
<td>9%</td>
</tr>
</tbody>
</table>

Note percentages are based off relatively small numbers (between 10 and 50) for some of the Corrections interactions (specifically for females, Asian and other ethnicities).

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**TBI is related to mental health & addiction service use**

Relationships exist between various mental health issues, addiction, and TBI. Having a head injury roughly doubles the likelihood that someone with no prior psychiatric history will go on to develop a diagnosable mental health issue\(^{30}\). There is evidence that TBI is linked with higher levels of depression, anxiety and sleep difficulties\(^{31}\). Depression is reported to occur in 22% to 50% of those with a history of TBI, and women with a history of TBI may have an increased risk of substance abuse and mental health issues\(^{32}\).

While mental health issues are associated with criminality, there a much stronger association between having a mental illness and being a victim of crime\(^{33}\). A 2012 meta-analysis found that the odds of a person with mental illness experiencing physical, sexual, or domestic violence were 3.86 times higher than among adults with no disabilities\(^{34}\).

---

\(^{30}\) (Parsonage, 2016)  
\(^{31}\) (Woolhouse, McKinlay, & Grace, 2017)  
\(^{32}\) (Woolhouse, McKinlay, & Grace, 2017)  
\(^{33}\) (Hart, de Vet, Moran, Hatch, & Dean, 2012)  
\(^{34}\) (Hughes, et al., 2012)
The links between TBI, mental illness, and criminality are complex, and the literature has not yet established clear causal pathways. Many possibilities exist. For example, people dependent on alcohol may be particularly prone to falls and other causes of TBI, or poor mental health may increase violent victimisation, which in turn may increase the risk of addiction\textsuperscript{35}. Regardless the interactions between TBI, mental health and addiction, and justice are unclear and require further investigation.

The IDI data can be used to analyse the association between prior recorded TBI and use of mental health and addiction services\textsuperscript{36}. Table 5 compares the use of mental health and addiction services 12 months either side of justice sector interaction for people with and without a prior recorded TBI.

This data shows that over half (52\%) of people charged in court who have a prior recorded TBI used mental health or addiction services 12 months either side of their first charge in 2013.

\begin{table}[h]
\centering
\begin{tabular}{|l|c|c|}
\hline
\textbf{Whether used mental health and addiction services} & \textbf{General population} & \textbf{Courts: People charged} \\
\hline
Prior recorded TBI & 23\% & 52\% \\
No prior recorded TBI & 17\% & 38\% \\
Total & 18\% & 43\% \\
\hline
\end{tabular}
\caption{Whether used mental health and addiction services by whether have prior recorded TBI, for people charged in court in 2013 and the public}
\end{table}

The 52\% of people charged in court with a prior recorded TBI who used mental health or addiction services used the following types of services:

- 19\% mental health services only
- 16\% addiction services only
- 17\% both mental health and addiction services

\textbf{Causes of TBI are different for people interacting with the justice system}

We can analyse cause of injury in the ACC data, and as seen in Appendix B this accounts for approximately three-quarters of people with a recorded TBI across the justice sector and the public.

Using exploratory categories of causes of traumatic brain injuries, table 6 presents the causes of TBI at different people across the justice system. This shows that people in the justice sector are more likely than the general public to have a TBI caused from:

- an assault;
- other contact with a person, or;
- a vehicle related incident

\textsuperscript{35} (Hart, de Vet, Moran, Hatch, & Dean, 2012)

\textsuperscript{36} Use of mental health and addiction services includes:
- Specialist mental health and addiction services (from PRIMHD data)
- Pharmaceuticals dispensed related to mental health or addiction (from Pharms data)
- Hospitalisation with mental health or addiction as the principal diagnosis (from NMDS data)
People in the general public were more likely to have a TBI caused by a fall/slip/trip or from playing sports or recreation related.

Assault is the most common cause of TBI for people in prison, people remanded in custody, people starting a community sentence and people charged in court.

Table 6: For people with prior recorded TBI, cause of injury (for TBI recorded in ACC data)

<table>
<thead>
<tr>
<th></th>
<th>General population</th>
<th>Police: People proceeded against</th>
<th>Courts: People charged</th>
<th>Corrections: People starting community sentence</th>
<th>Corrections: People remanded in custody</th>
<th>Corrections: People starting prison sentence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall / trip / slip (not sport related)</td>
<td>27%</td>
<td>21%</td>
<td>19%</td>
<td>20%</td>
<td>20%</td>
<td>19%</td>
</tr>
<tr>
<td>Sport / recreation</td>
<td>20%</td>
<td>20%</td>
<td>18%</td>
<td>16%</td>
<td>15%</td>
<td>14%</td>
</tr>
<tr>
<td>Vehicle / riding related</td>
<td>11%</td>
<td>17%</td>
<td>18%</td>
<td>18%</td>
<td>18%</td>
<td>17%</td>
</tr>
<tr>
<td>Contact with object</td>
<td>11%</td>
<td>12%</td>
<td>12%</td>
<td>12%</td>
<td>13%</td>
<td>12%</td>
</tr>
<tr>
<td>Work related</td>
<td>11%</td>
<td>7%</td>
<td>7%</td>
<td>8%</td>
<td>5%</td>
<td>6%</td>
</tr>
<tr>
<td>Assault</td>
<td>5%</td>
<td>18%</td>
<td>20%</td>
<td>22%</td>
<td>27%</td>
<td>28%</td>
</tr>
<tr>
<td>Other contact with person</td>
<td>4%</td>
<td>11%</td>
<td>12%</td>
<td>13%</td>
<td>15%</td>
<td>16%</td>
</tr>
</tbody>
</table>

*Other more minor causes not included in table above. Note percentages will not sum to 100% due to people experiencing multiple prior TBIs with different causes.*

Causes of TBI varied by age and sex. People in both the general public and the justice system who experienced a TBI before age 10 was more likely to be caused by fall / trip /slip than older people. Sport related TBIs were more likely to be the cause when people were over the age of 10, and more likely for males than for females. There were high rates of unknown cause for TBIs experienced by people under the age of 10.

For people in prison, a similar percentage of males and females had experienced a TBI due to assault, but for females there was a higher rate of TBIs caused by contact with objects, while males had a higher rate of TBIs caused by sport or recreation.

**Offending characteristics are different for people with TBI**

Comparing the offending characteristics of people charged in court for people with prior recorded TBI and no prior recorded TBI, we find:

- People charged in court with prior TBI have a higher re-offending rate that people charged in court without a prior TBI (43% compared to 32%)
- Of people charged in court who reoffend, people with a prior TBI have on average a higher number of re-offences (on average 9.6 compared to 8.1 charges)
- People charged in court with prior TBI are more likely to have a conviction for a violence or sexual offence in the prior 10 years, when compared to people without a prior TBI (37% compared to 23%)

- People charged in court who experienced a prior TBI before their first ever charge in court, were younger on average at their first charge than compared to people without a prior TBI (average age of 21 years compared to 24 years of age).

**TBI is related to offending even when accounting for other variables**

While the descriptive analysis above demonstrates that people with a prior recorded TBI have higher reoffending rates and have more serious offending characteristics, it is unclear whether this association would remain when accounting for other variables. For example, males are more likely to have a prior recorded TBI, and males also have higher reoffending rates. This raises the question of whether the higher reoffending rate for people with prior recorded TBI is due to the TBI or the confounding sex differences.

To answer this question, we also modelled the data to control for potential confounders using a logistic regression model. We modelled reoffending (yes/no) as a function of sex, age, ethnicity, NZ deprivation, and offending characteristics (including whether ever been in prison / remanded in custody, and number of prior convictions).

We found that roughly half of the effect of TBI is related to differences in ever being in prison / remanded in custody, being younger and of Māori ethnicity. The other half is solely related to the effect of TBI. Interestingly, whether someone had a prior TBI is more strongly associated with reoffending than whether someone was male (once controlling for the other variables).

Note with this type of statistical analysis, we cannot demonstrate causality – that is, that TBI has caused offending (while controlling for other variables). Rather, this model demonstrates that the roughly half of the association between offending and TBI still remains even after accounting for other variables.

This logistic regression model was used to compare differences in reoffending. We also used another exploratory technique to examine differences in predicting future offending in the next 5 years with a broader range of social measures using a gradient boosting machine learning technique. This analysis found the ranking in predicting future offending was in the order of:

1. Education suspensions, stand-downs and truancy history
2. Age
3. Sex
4. Child, youth and family interaction history
5. Ethnicity
6. **A prior recorded TBI**
7. ...... many other variables including highest qualification, NZ deprivation score, being a state housing tenant, mental health and addiction service use, etc.

This shows the ranking of having a prior recorded TBI was high up the ranking list, even higher than characteristics such as qualification and being a Housing NZ tenant in predicting future offending.

**This analysis has some limitations**

This analysis of prior traumatic brain injury is based on incidents that have been recorded in hospital or with an accepted ACC claim. This will therefore be an undercount of total experiences of

---

37 Using XGBOOST gradient boosting in R, and using cross validation to tune the parameters.
prior TBI since many people may not be hospitalised or submit an ACC claim. ACC estimates that the majority of people who experience TBI do not seek medical assistance or report this to ACC. Furthermore, for people who do seek medical assistance, research has shown that the medical staff under utilise the ICD head injury codes.

For these two reasons, the estimates presented in this analysis are likely to be significantly undercounted.

Further to this major caveat, there are the following limitations to this analysis:

- **Only people who link to the IDI spine are included in this analysis.** The IDI spine is the primary linking data that all other person level datasets are linked to. It includes as many individuals as possible (while retaining quality links) for the target population using Inland Revenue tax data, Department of Internal Affairs birth data, and Ministry of Business, Immigration and Employment visa data (excluding short term visitors such as tourists). We have only included people who link to the spine in the denominators for any percentage calculations.

- **Full time series data is not available.** This analysis looks at ever measures of prior TBI – that is whether they have had a prior recorded TBI at some point in their lifetime. However, as noted above, the NMDS starts in 1988 (and 2012 for complete short-stay data) and the complete ACC data starts in 1999. TBI occurring before these dates will not be included.

### Prevention and treatment of TBI

Understanding the prevalence of TBI can support decisions about broader prevention and treatment interventions.

Because of the impact of TBI in New Zealand, ACC has a TBI Strategy and Action Plan, with a focus on prevention of TBI[^40^]. The plan describes existing programmes designed to prevent TBI which focus on caregivers of infants, children and older people, alcohol and drug-related harm, and sport. In the plan, ACC outlines goals to increase their prevention efforts by focusing on sexual and family violence.

Some types of mild TBI have clear and well-evidenced means of prevention in the academic literature. For example, there is strong evidence that wearing a helmet reduces the incidence of TBI for motorcyclists and bicyclists[^41^]. Because of the variability in causes of TBI, prevention requires multiple avenues of intervention.

Literature suggests that TBI can be extremely varied making identification, classification of severity, and treatment difficult[^42^]. ACC provides guidelines for medical practitioners to help them identify TBI and its severity, as well as how to approach treatment[^43^]. Treatment can include a combination of medication and several therapeutic interventions[^44^].

[^38^]: ACC, 2017
[^39^]: Barker-Collo, Theadom, Jones, Feigin, & Kahan, 2016
[^40^]: ACC, 2017
[^41^]: Cassidy, et al., 2004
[^42^]: Algattas & Huang, 2013
[^43^]: The New Zealand Guidelines Group, 2007
[^44^]: Silver, McAllister, & Yudofsky, 2011
Suggested areas for further analysis

These papers aim to generate discussion among users on information needs. Ideas for further analysis include:

- Working closely with clinicians to develop a method to categorise severity of TBI (into mild/moderate/severe categories) in both the ACC and NMDS data. With this categorisation we can analyse how the severity of TBI differs between people interacting with the justice sector and the general public.

- Work closely with clinician to also understand and analyse cumulative effects from multiple TBIs.

- Analysis of the association between TBI and other outcomes or protective factors against crime. These could include housing, employment, education, benefit receipt, and others.

If these or other areas of subsequent analysis would be useful, contact Laura Crawford (laura.crawford@justice.govt.nz) or Louise Rutherford (louise.rutherford@justice.govt.nz).

IDI disclaimer

The results in this paper are not official statistics, they have been created for research purposes from the Integrated Data Infrastructure (IDI), managed by Statistics New Zealand.

The opinions, findings, recommendations, and conclusions expressed in this paper are those of the author(s), not Statistics NZ, the Ministry of Health, ACC or the Ministry of Justice.

Access to the anonymised data used in this study was provided by Statistics NZ in accordance with security and confidentiality provisions of the Statistics Act 1975. Only people authorised by the Statistics Act 1975 are allowed to see data about a particular person, household, business, or organisation, and the results in this paper have been confidentialised to protect these groups from identification.

Careful consideration has been given to the privacy, security, and confidentiality issues associated with using administrative and survey data in the IDI. Further detail can be found in the Privacy impact assessment for the Integrated Data Infrastructure available from www.stats.govt.nz.
Bibliography


Appendix A: Codes used to identify TBI
ACC and MoH have differing data definitions of TBI. The ACC definition is broader than the MoH definition.

For this analysis, we have used the broader ACC definition for both the NMDS and ACC datasets. Appendix B includes the comparison of prevalence rates if the MoH definition was applied to the NMDS instead.

Table A1: Codes used to identify TBI

<table>
<thead>
<tr>
<th>CODES USED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>
| The ACC definition of traumatic brain injury was used for this analysis. The specific codes were obtained from the ACC Clinical Services team. 

The ACC data uses the following coding system to classify injury data: Read codes, ICD-9 and ICD-10. Read codes are generally used by general practitioners on the ACC45 claim form, whereas hospitals generally use the ICD-9 or the later version of ICD-10 codes. Hence for the NMDS data, only the corresponding ICD-9 or ICD-10 codes are used.

Note:
- Codes included in the ACC TBI definition but not ever used in either the ACC or NMDS data are excluded from the tables below.
- The highlighted rows are the 10 most common codes used in the combined ACC and NMDS data for a quick understanding of the largest contributors to prevalence rates.
- For the NMDS data, any TBI diagnosis was included (rather than just principal diagnosis).

<table>
<thead>
<tr>
<th>Read Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>E2A2.</td>
<td>Post-traumatic brain syndrome</td>
</tr>
<tr>
<td>F284.</td>
<td>Compression of brain</td>
</tr>
<tr>
<td>G2...</td>
<td>Birth trauma, asphyxia and hypoxia</td>
</tr>
<tr>
<td>Q20..</td>
<td>Birth trauma</td>
</tr>
<tr>
<td>Q200.</td>
<td>Subdural and cerebral haemorrhage due to birth trauma</td>
</tr>
<tr>
<td>Q2000.</td>
<td>Cerebral haemorrhage unspecified, due to birth trauma</td>
</tr>
<tr>
<td>Q20001.</td>
<td>Subdural haemorrhage unspecified, due to birth trauma</td>
</tr>
<tr>
<td>Q20002.</td>
<td>Local subdural haematoma due to birth trauma</td>
</tr>
<tr>
<td>Q2004.</td>
<td>Brain injury due to birth trauma NOS</td>
</tr>
<tr>
<td>Q2005.</td>
<td>Cerebral haematoma in fetus or newborn</td>
</tr>
<tr>
<td>Q21...</td>
<td>Intracerebral hypoxia and birth asphyxia</td>
</tr>
<tr>
<td>Q2131.</td>
<td>Liveborn with labour hypoxia</td>
</tr>
<tr>
<td>Q215.</td>
<td>Severe birth asphyxia - Apgar score less than 4 at 1 minute</td>
</tr>
<tr>
<td>Q4113.</td>
<td>Intraventricular haemorrhage due to birth injury</td>
</tr>
<tr>
<td>Q412.</td>
<td>Perinatal subarachnoid haemorrhage</td>
</tr>
<tr>
<td>Q488.</td>
<td>Neonatal cerebral ischaemia</td>
</tr>
<tr>
<td>Q489.</td>
<td>Acquired periventricular cysts of newborn</td>
</tr>
<tr>
<td>Q48A.</td>
<td>Neonatal cerebral leukomalacia</td>
</tr>
<tr>
<td>S0...</td>
<td>Fracture of skull</td>
</tr>
<tr>
<td>S00.</td>
<td>Parietal bone fracture</td>
</tr>
<tr>
<td>S0000.</td>
<td>Closed fracture vault of skull without intracranial injury</td>
</tr>
<tr>
<td>S00002.</td>
<td>Closed #skull vlt no intracranial injury, unspec state consc</td>
</tr>
<tr>
<td>S00005.</td>
<td>Closed #skull vlt no intracranial inj, &gt;24hr LOC not restored</td>
</tr>
<tr>
<td>S001.</td>
<td>Closed fracture vault of skull with intracranial injury</td>
</tr>
<tr>
<td>S0010.</td>
<td>Closed #skull vlt + intracranial injury, no loss of consc</td>
</tr>
<tr>
<td>S0011.</td>
<td>Closed #skull vlt + intracranial injury, no loss of consc</td>
</tr>
<tr>
<td>S0012.</td>
<td>Closed #skull vlt + intracranial injury, &gt;1hr loss of consc</td>
</tr>
<tr>
<td>S0014.</td>
<td>Closed #skull vlt + intracranial injury, &gt;24hr LOC recovery</td>
</tr>
<tr>
<td>S0015.</td>
<td>Closed #skull vlt + intracranial inj, &gt;24hr LOC not restored</td>
</tr>
<tr>
<td>S0016.</td>
<td>Closed #skull vlt + intracranial injury, LOC unspec duration</td>
</tr>
<tr>
<td>S002.</td>
<td>Open fracture vault of skull without intracranial injury</td>
</tr>
<tr>
<td>S003.</td>
<td>Open fracture vault of skull with intracranial injury</td>
</tr>
<tr>
<td>S0030.</td>
<td>Open #skull vlt + intracranial injury, unspec state of consc</td>
</tr>
<tr>
<td>S0031.</td>
<td>Open #skull vlt + intracranial injury, no loss of consc</td>
</tr>
<tr>
<td>S0032.</td>
<td>Open #skull vlt + intracranial injury, &lt;1hr loss of consc</td>
</tr>
</tbody>
</table>

ICD = International Classification of Diseases
S0033  Open #skull vlt + intracranial injury, 1-24hr loss of consc
S0034  Open #skull vlt + intracranial injury, >24hrs LOC + recovery
S0035  Open #skull vlt + intracranial inj, >24hr LOC not restored
S010.  Closed fracture base of skull without intracranial injury
S011.  Closed fracture base of skull with intracranial injury
S0110  Closed #skull base + intracranial inj, unspec state of consc
S0111  Closed #skull base + intracranial injury, no loss of consc
S0112  Closed #skull base + intracranial injury, <1hr loss of consc
S0113  Closed #skull base + intracranial injury, 1-24hr loss consc
S0114  Closed #skull base + intracranial injury, >24hr LOC + recovery
S0115  Closed #skull base + intracranial inj, >24hr LOC not restored
S0116  Closed #skull base + intracranial injury, LOC unspec duration
S0120  Open #skull base no intracranial inj, unspec state of consc
S013.  Open fracture base of skull with intracranial injury
S0130  Open #skull base + intracranial injury, unspec state of consc
S0131  Open #skull base + intracranial injury, no loss of consc
S0132  Open #skull base + intracranial injury, <1hr loss of consc
S0133  Open #skull base + intracranial injury, 1-24hr loss of consc
S0134  Open #skull base + intracranial injury, >24hr LOC + recovery
S0130.  Closed fracture of skull NOS without intracranial injury
S01301  Closed #skull NOS no intracranial inj, no loss of consc
S01302  Closed #skull NOS no intracranial inj, <1hr loss of consc
S01303  Closed #skull NOS no intracranial inj, 1-24hr loss of consc
S01301  Closed fracture of skull NOS with intracranial injury
S013010  Closed #skull NOS + intracranial inj, unspec state of consc
S013011  Closed #skull NOS + intracranial inj, no loss of consc
S013012  Closed #skull NOS + intracranial inj, <1hr loss of consc
S013013  Closed #skull NOS + intracranial inj, 1-24hrs loss of consc
S013014  Closed #skull NOS + intracranial inj, >24hrs LOC + recovery
S013015  Closed #skull NOS + intracranial inj, >24hr LOC not restored
S013016  Closed #skull NOS + intracranial inj, LOC unspec duration
S032.  Open #skull NOS without mention of intracranial injury
S033.  Open fracture of skull NOS with intracranial injury
S0334  Open #skull NOS + intracranial inj, >24hrs LOC + recovery
S0335  Open #skull NOS + intracranial inj, >24hrs LOC not restored
S0336  Open #skull NOS + intracranial inj, LOC unspec duration
S040.  Multi #skull face+other bones, closed, no intracranial injury
S041.  Multi #skull face+other bones, closed + intracranial injury
S0410  Closed #skull face, multi + intracranial inj, unspec consc
S0411  Closed #skull face, multi + intracranial inj, no loss consc
S0412  Closed #skull face, multi + intracranial inj, <1hr LOC
S0413  Closed #skull face, multi + intracranial inj, 1-24hrs LOC
S0414  Closed #skull face, multi+intracran inj, >24hr LOC + recovery
S0415  Closed #skull face, multi+intracran inj, >24hr LOC restored
S0416  Closed #skull face, multi+intracran inj, LOC unspec duration
S043.  Multi #skull face + other bones, open + intracranial injury
S0430  Open #skull face, multi + intracranial inj, unspec consc
S0434  Open #skull face, multi + intracranial inj, >24hr LOC + recovery
S0436  Open #skull face, multi + intracranial inj, LOC unspec duration
S6...  Intracranial injury excluding those with skull fracture
S66.  Concussion
S660.  Concussion with no loss of consciousness
S6601.  Concussion with less than 1 hour loss of consciousness
S6605.  Concussion with loss of consciousness of unspec duration
S681.  Cortex laceration and contusion
S610.  Closed cerebral contusion
S611.  Open cerebral contusion
S614.  Closed hindbrain contusion
S62.  Traumatic cerebral haemorrhage
S620.  Middle meningeal haemorrhage following injury
S6200  Subarachnoid h'ge inj no open intracran wound + unspec consc
S6201  Subarachnoid h'ge inj no open intracran wound + loss consc
S6202  Subarachnoid h'ge inj no open intracran wound + unspec consc
S6203  Subarachnoid h'ge inj no open intracran wound + 1-24hr LOC
S6204  Subarachnoid h'ge inj no open intracran wound +24hr LOC + recovery
S6205  Subarachnoid h'ge inj no open intracran wound +LOC unspec duration
S621.  Open traumatic subarachnoid haemorrhage
S6210  Subarachnoid h'ge inj + open intracran wound + unspec consc
S6211  Subarachnoid h'ge inj + open intracran wound + no LOC
S6212  Subarachnoid h'ge inj + open intracran wound + <1hr loss consc
S6213  Subarachnoid h'ge inj + open intracran wound + 1-24hr loss consc
S6214  Subarachnoid h'ge inj + open intracran wound + 24hr LOC + recovery
S6215  Subarachnoid h'ge inj + open intracran wound +24hr LOC + recovery
S6216  Subarachnoid h'ge inj + open intracran wound +LOC unspec duration
S622.  Closed traumatic subdural haemorrhage
S6220  Subdural haemorrhage injury no open intracranial wound + unspec consc
S6221  Subdural h'ge inj no open intracranial wound +no loss consc
S6222  Subdural h'ge inj no open intracranial wound + <1hr loss consc
S6223  Subdural h'ge inj no open intracranial wound +1-24hr loss consc
S6224  Subdural h'ge inj no open intracranial wound +24 LOC + recovery
S6225  Subdural h'ge inj no open intracranial wound +24hr LOC + recovery
ICD-9 code  Description
310.2  Postconcussion Syndrome
431  Intracerebral Hemorrhage
436  Cerebrovascular Disease, Acute, But Ill-defined
800  Fracture of Vault of Skull, Includes Parietal and Frontal Bone
800.04 Fracture of Vault of Skull, Includes Parietal and Frontal Bone, Closed without Mention of Intracranial Injury, with
Prolonged [More than 24 Hours] Loss of Consciousness and Return to Pre-existing Conscious Level
800.05 Fracture of Vault of Skull, Includes Parietal and Frontal Bone, Closed without Mention of Intracranial Injury, with
Prolonged [More than 24 Hours] Loss of Consciousness and Without Return to Pre-existing Conscious Level
800.06 Fracture of Vault of Skull, Includes Parietal and Frontal Bone, Closed without Mention of Intracranial Injury, with Loss of
Consciousness of Unspecified Duration

800.9
Nature, with No Loss of Consciousness
Fracture of Vault of Skull, Includes Parietal and Frontal Bone, Open with Intracranial Injury of Other and Unspecified Nature, with No Loss of Consciousness

801.0
Temporal Bone, Closed, without Mention of Intracranial Injury
Fracture of Base of Skull; Anterior; Middle; Posterior; Occiput Bone; Orbital Roof; Ethmoid; Frontal; Sphenoid Bone;

801.00
Temporal Bone, Closed, without Mention of Intracranial Injury, Unspecified State of Consciousness
Fracture of Base of Skull; Anterior; Middle; Posterior; Occiput Bone; Orbital Roof; Ethmoid; Frontal; Sphenoid Bone;

801.02
Temporal Bone, Closed, without Mention of Intracranial Injury, with Brief [Less than One Hour] Loss of Consciousness
Fracture of Base of Skull; Anterior; Middle; Posterior; Occiput Bone; Orbital Roof; Ethmoid; Frontal; Sphenoid Bone;

801.09
Temporal Bone, Closed, without Mention of Intracranial Injury, with Unspecified Concussion
Fracture of Base of Skull; Anterior; Middle; Posterior; Occiput Bone; Orbital Roof; Ethmoid; Frontal; Sphenoid Bone; Unspecified State of Consciousness

801.1
Temporal Bone, Closed, with Cerebral Laceration and Contusion
Fracture of Base of Skull; Anterior; Middle; Posterior; Occiput Bone; Orbital Roof; Ethmoid; Frontal; Sphenoid Bone; Unspecified State of Consciousness

801.91
Temporal Bone, Open with Intracranial Injury of Other and Unspecified Nature, with No Loss of Consciousness

803
Other and Unqualified Skull Fractures, Closed without Mention of Brain Injury

803.00
Other and Unqualified Skull Fractures, Closed without Mention of Brain Injury, Unspecified State of Consciousness

804
Multiple Fractures Involving Skull or Face with Other Bones, Closed without Mention of Intracranial Injury

804.00
Multiple Fractures Involving Skull or Face with Other Bones, Closed without Mention of Intracranial Injury, Unspecified State of Consciousness

850
Concussion

850.0
Concussion with No Loss of Consciousness

850.2
Concussion with Moderate Loss of Consciousness

850.3
Concussion with Prolonged Loss of Consciousness and Return to Pre-existing Conscious Level

850.5
Concussion with Loss of Consciousness of Unspecified Duration

850.9
Concussion, Unspecified

851
Cerebral Laceration and Contusion

851.0
Cortex (Cerebral) Contusion without Mention of Open Intracranial Wound

851.00
Cortex (Cerebral) Contusion without Mention of Open Intracranial Wound, Unspecified State of Consciousness

851.03
Cortex (Cerebral) Contusion, without Mention of Open Intracranial Wound, with Moderate (1-24 Hours) Loss of Consciousness

851.05
Cortex (Cerebral) Contusion, without Mention of Open Intracranial Wound, with Prolonged (More than 24 Hours) Loss of Consciousness without Return to Pre-existing Conscious Level

851.10
Cortex (Cerebral) Contusion with Open Intracranial Wound, Unspecified State of Consciousness

851.19
Cortex (Cerebral) Contusion with Open Intracranial Wound, Unspecified Concussion

851.42
Cerebellar or Brain Stem Contusion without Mention of Open Intracranial Wound, with Brief [Less than One Hour] Loss of Consciousness

851.43
Cerebellar or Brain Stem Contusion without Mention of Open Intracranial Wound, with Moderate (1-24 Hours) Loss of Consciousness

851.46
Cerebellar or Brain Stem Contusion without Mention of Open Intracranial Wound, with Loss of Consciousness of Unspecified Duration

851.49
Cerebellar or Brain Stem Contusion without Mention of Open Intracranial Wound with Concussion, Unspecified

851.62
Cerebellar or Brain Stem Laceration and Contusion without Mention of Open Intracranial Wound, with Brief [Less than One Hour] Loss of Consciousness

851.85
Other and Unspecified Cerebral Laceration and Contusion, without Mention of Open Intracranial Wound, with Prolonged (More than 24 Hours) Loss of Consciousness without Return to Pre-existing Conscious Level

851.93
Other and Unspecified Cerebral Laceration and Contusion, with Open Intracranial Wound, with Moderate (1-24 Hours) Loss of Consciousness

851.95
Other and Unspecified Cerebral Laceration and Contusion, with Open Intracranial Wound, with Prolonged (More than 24 Hours) Loss of Consciousness without Return to Pre-existing Conscious Level

852
Subarachnoid, Subdural, and Extradural Hemorrhage, Following Injury

852.0
Subarachnoid Hemorrhage Following Injury without Mention of Open Intracranial Wound

852.02
Subarachnoid Hemorrhage Following Injury without Mention of Open Intracranial Wound, with Brief [Less than One Hour] Loss of Consciousness

852.09
Subarachnoid Hemorrhage Following Injury without Mention of Open Intracranial Wound, with Concussion, Unspecified

852.1
Subarachnoid Hemorrhage Following Injury, with Open Intracranial Wound

852.10
Subarachnoid Hemorrhage Following Injury, with Open Intracranial Wound, Unspecified State of Consciousness

852.13
Subarachnoid Hemorrhage Following Injury, with Open Intracranial Wound, with Moderate (1-24 Hours) Loss of Consciousness

852.2
Subdural Hemorrhage Following Injury, without Mention of Open Intracranial Wound

852.21
Subdural Hemorrhage Following Injury, without Mention of Open Intracranial Wound, with No Loss of Consciousness

852.26
Subdural Hemorrhage Following Injury, without Mention of Open Intracranial Wound, with Loss of Consciousness of Unspecified Duration

852.29
Subdural Hemorrhage Following Injury with Open Intracranial Wound, with Concussion, Unspecified

852.39
Subdural Hemorrhage Following Injury with Open Intracranial Wound, with Concussion, Unspecified

852.56
Extradural Hemorrhage Following Injury with Open Intracranial Wound, with Loss of Consciousness of Unspecified Duration

853
Intracranial Hemorrhage Following Injury, Other and Unspecified

853.0
Intracranial Hemorrhage Following Injury without Mention of Open Intracranial Wound, Other and Unspecified

853.00
Intracranial Hemorrhage Following Injury without Mention of Open Intracranial Wound, Unspecified State of Consciousness, Other and Unspecified

853.01
Intracranial Hemorrhage Following Injury without Mention of Open Intracranial Wound, with No Loss of Consciousness

853.02
Intracranial Hemorrhage Following Injury without Mention of Open Intracranial Wound, with Brief [Less than One Hour] Loss of Consciousness

853.06
Intracranial Hemorrhage Following Injury without Mention of Open Intracranial Wound, Unspecified Duration, Other and Unspecified

853.09
Intracranial Hemorrhage Following Injury without Mention of Open Intracranial Wound, with Concussion, Unspecified, Other and Unspecified

853.19
Intracranial Hemorrhage Following Injury with Open Intracranial Wound, with Concussion, Unspecified, Other and Unspecified

854
Brain Injury, Other and Unspecified Nature

854.0
Brain Injury, Other and Unspecified Nature without Mention of Open Cranial Wound

854.01
Brain Injury, Other and Unspecified Nature without Mention of Open Cranial Wound, with No Loss of Consciousness
<table>
<thead>
<tr>
<th>ICD-10 code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>854.02</td>
<td>Brain Injury, Other and Unspecified Nature without Mention of Open Cranial Wound, with Brief (Less than 1 Hour) Loss Of Consciousness</td>
</tr>
<tr>
<td>854.03</td>
<td>Brain Injury, Other and Unspecified Nature without Mention of Open Cranial Wound, with Moderate (1-24 Hours) Loss Of Consciousness</td>
</tr>
<tr>
<td>854.04</td>
<td>Brain Injury, Other and Unspecified Nature without Mention of Open Cranial Wound, with Prolonged (More than 24 Hours) Loss Of Consciousness and Return to Pre-existing Conscious Level</td>
</tr>
<tr>
<td>854.06</td>
<td>Brain Injury, Other and Unspecified Nature without Mention of Open Cranial Wound, with Loss of Consciousness of Unspecified Duration</td>
</tr>
<tr>
<td>854.09</td>
<td>Brain Injury, Other and Unspecified Nature without Mention of Open Cranial Wound, with Concussion, Unspecified</td>
</tr>
<tr>
<td>854.10</td>
<td>Brain Injury, Other and Unspecified Nature with Open Cranial Wound</td>
</tr>
<tr>
<td>854.11</td>
<td>Brain Injury, Other and Unspecified Nature with Open Cranial Wound, Unspecified State of Consciousness</td>
</tr>
<tr>
<td>854.12</td>
<td>Brain Injury, Other and Unspecified Nature with Open Cranial Wound with No Loss of Consciousness</td>
</tr>
<tr>
<td>854.13</td>
<td>Brain Injury, Other and Unspecified Nature with Open Cranial Wound with Brief (Less than 1 Hour) Loss of Consciousness</td>
</tr>
<tr>
<td>854.14</td>
<td>Brain Injury, Other and Unspecified Nature with Open Cranial Wound, with Loss of Consciousness of Unspecified Duration</td>
</tr>
<tr>
<td>854.15</td>
<td>Brain Injury, Other and Unspecified Nature with Open Cranial Wound, with Concussion, Unspecified</td>
</tr>
<tr>
<td>873.13</td>
<td>Open Wound, Scalp, Complicated</td>
</tr>
<tr>
<td>900.9</td>
<td>Injury to Unspecified Blood Vessel of Head and Neck</td>
</tr>
<tr>
<td>907.0</td>
<td>Late Effect of Intracranial Injury without Mention of Skull Fracture</td>
</tr>
<tr>
<td>920</td>
<td>Contusion of Face, Scalp, and Neck Except Eye(s), Including Cheek, Ear (Auricle), Gum, Lip, Mandibular-Joint Area, Nose, Throat</td>
</tr>
<tr>
<td>921</td>
<td>Contusion of Eye and Adnexa</td>
</tr>
<tr>
<td>941</td>
<td>Burn of Face, Head, and Neck</td>
</tr>
<tr>
<td>941.0</td>
<td>Burn of Face, Head and Neck, Unspecified Degree</td>
</tr>
<tr>
<td>951.2</td>
<td>Injury to Trigeminal Nerve; Fifth Cranial Nerve</td>
</tr>
<tr>
<td>951.4</td>
<td>Injury to Facial Nerve; Seventh Cranial Nerve</td>
</tr>
<tr>
<td>982.8</td>
<td>Toxic Effect of Solvents Other than Petroleum Based; Other Nonpetroleum-based Solvents; Acetone</td>
</tr>
<tr>
<td>984.9</td>
<td>Toxic Effects of Lead and Its Compounds (Including Fumes), Unspecified Lead Compound</td>
</tr>
<tr>
<td>986</td>
<td>Toxic Effects of Carbon Monoxide</td>
</tr>
<tr>
<td>987</td>
<td>Toxic Effect of Other Gases, Fumes, or Vapors</td>
</tr>
<tr>
<td>997.9</td>
<td>Certain Adverse Effects Not Elsewhere Classified, Allergy, Unspecified</td>
</tr>
<tr>
<td>E905.3</td>
<td>Venomous Animals and Plants as the Cause of Poisoning and Toxic Reactions; Hornets, Wasps, and Bees</td>
</tr>
</tbody>
</table>

### 310.2 Postconcussion syndrome
- **F072** Postconcussional syndrome
- **G200** Subdural and cerebral haemorrhage due to birth trauma
- **G206** Cerebral oedema due to birth injury
- **Q2121** Liveborn with prelabour hypoxia
- **Q4111** Intraventric (nontraumatic) haemorrhage grade 2 fet newborn
- **Q4112** Intraventricular haemorrhage due to birth injury
- **Q412** Perinatal subarachnoid haemorrhage

### S0000 Closed fracture vault of skull with intracranial injury
- **S0000** Open skull vlt + intracranial injury, unspecified state of consc
- **S0001** Open #skull vlt + intracranial injury, no loss of consc
- **S0002** Open #skull vlt + intracranial injury, <1hr loss of consc
- **S0003** Open #skull vlt + intracranial injury, 1-24hr loss of consc
- **S0004** Open #skull vlt + intracranial injury, >24hr LOC + recovery
- **S0005** Open #skull vlt + intracranial inj, in 24hr LOC not restored

### S010 Open wound of scalp
- **S011** Closed fracture base of skull with intracranial injury
- **S012** Open skull base + intracranial injury, unspecified state of consc
- **S013** Open skull base + intracranial injury, no loss of consc
- **S014** Open skull base + intracranial injury, 1-24hr loss of consc
- **S015** Open skull base + intracranial injury, >24hr LOC + recovery
- **S016** Open skull base + intracranial injury, LOC unspecified duration
- **S020** Fracture of vault of skull
- **S021** Fracture of base of skull
- **S027** Multiple fractures involving skull and facial bones
- **S028** Fractures of other skull and facial bones
- **S029** Fracture of skull and facial bones, part unspecified
- **S031** Closed fracture of skull NOS with intracranial injury
- **S033** Open fracture of skull NOS with intracranial injury
- **S041** Multi #skull/face + other bones, closed + intracranial injury
- **S043** Multi #skull/face + other bones, open + intracranial injury

### S0600 Concussion
- **S0601** Loss of consciousness of unspecified duration
- **S0602** Loss of consciousness of brief duration [less than 30 minute
- **S0603** Loss of consciousness of moderate duration [30 minutes to 24
- **S0604** Loss of consciousness of prolonged duration [more than 24 ho
- **S061** Traumatic cerebral oedema
- **S0620** Diffuse cerebral and cerebellar brain injury, unspecified
- **S0621** Diffuse cerebral contusions
- **S0622** Diffuse cerebellar contusions
- **S0623** Multiple intracerebral and cerebellar haematomas
<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S0630</td>
<td>Focal cerebral and cerebellar injury, unspecified</td>
</tr>
<tr>
<td>S0631</td>
<td>Focal cerebral contusion</td>
</tr>
<tr>
<td>S0633</td>
<td>Focal cerebral haematoma</td>
</tr>
<tr>
<td>S064</td>
<td>Epidural haemorrhage</td>
</tr>
<tr>
<td>S065</td>
<td>Traumatic subdural haemorrhage</td>
</tr>
<tr>
<td>S066</td>
<td>Traumatic subarachnoid haemorrhage</td>
</tr>
<tr>
<td>S067</td>
<td>Other intracranial injuries</td>
</tr>
<tr>
<td>S069</td>
<td>Intracranial injury, unspecified</td>
</tr>
<tr>
<td>S080</td>
<td>Avulsion of scalp</td>
</tr>
<tr>
<td>S099</td>
<td>Unspecified injury of head</td>
</tr>
<tr>
<td>S620</td>
<td>Closed traumatic subarachnoid haemorrhage</td>
</tr>
<tr>
<td>S621</td>
<td>Open traumatic subarachnoid haemorrhage</td>
</tr>
<tr>
<td>S6210</td>
<td>Subarachnoid h'ge inj + open intracran wound + unspec consc</td>
</tr>
<tr>
<td>S6211</td>
<td>Subarachnoid h'ge inj + open intracranial wound + no LOC</td>
</tr>
<tr>
<td>S6212</td>
<td>Subarachnoid h'ge inj + open intracran wound+&lt;1hr loss consc</td>
</tr>
<tr>
<td>S6213</td>
<td>Subarachnoid h'ge inj + open intracran wond+1-24hr loss consc</td>
</tr>
<tr>
<td>S6214</td>
<td>Subarachnoid h'ge inj + open intracran wond+&gt;24hr LOC + recovery</td>
</tr>
<tr>
<td>S6215</td>
<td>Subarachnoid h'ge inj + open intracran wond+&gt;24hr LOC - restored</td>
</tr>
<tr>
<td>S6216</td>
<td>Subarachnoid h'ge inj + open intracran wond+LOC unspec duration</td>
</tr>
<tr>
<td>S6220</td>
<td>Subdural haemorrhage injury no open intracranial wond + unspec consc</td>
</tr>
<tr>
<td>S6221</td>
<td>Subdural h'ge inj no open intracranial wound+no loss consc</td>
</tr>
<tr>
<td>S6222</td>
<td>Subdural h'ge inj no open intracranial wound+&lt;1hr loss consc</td>
</tr>
<tr>
<td>S6223</td>
<td>Subdural h'ge inj no open intracranial wond+1-24hr loss consc</td>
</tr>
<tr>
<td>S6224</td>
<td>Subdural h'ge inj no open intracranial wond+&gt;24 LOC + recovery</td>
</tr>
<tr>
<td>S6230</td>
<td>Subdural h'ge inj + open intracranial wound + unspec consc</td>
</tr>
<tr>
<td>S6231</td>
<td>Subdural h'ge inj + open intracranial wound+no loss consc</td>
</tr>
<tr>
<td>S6232</td>
<td>Subdural h'ge inj + open intracranial wound+&lt;1hr loss consc</td>
</tr>
<tr>
<td>S6233</td>
<td>Subdural h'ge inj + open intracranial wond+1-24hr loss consc</td>
</tr>
<tr>
<td>S6234</td>
<td>Subdural h'ge inj + open intracranial wond+&gt;24hr LOC + recovery</td>
</tr>
<tr>
<td>S624</td>
<td>Closed traumatic extradural haemorrhage</td>
</tr>
<tr>
<td>S6250</td>
<td>Extradural h'ge inj + open intracranial wond + unspec consc</td>
</tr>
<tr>
<td>S6251</td>
<td>Extradural h'ge inj + open intracranial wound+no loss consc</td>
</tr>
<tr>
<td>S6252</td>
<td>Extradural h'ge inj + open intracranial wond+&lt;1hr loss consc</td>
</tr>
<tr>
<td>S627</td>
<td>Traumatic subarachnoid haemorrhage</td>
</tr>
<tr>
<td>S628</td>
<td>Traumatic subdural haemorrhage</td>
</tr>
<tr>
<td>S6300</td>
<td>Oth cerebral h'ge inj no open intracran wond+unspec consc</td>
</tr>
<tr>
<td>S6301</td>
<td>Oth cerebral h'ge inj no open intracranial wond+no loss consc</td>
</tr>
<tr>
<td>S6302</td>
<td>Oth cerebral h'ge inj no open intracranial wond+&lt;1hr loss consc</td>
</tr>
<tr>
<td>S6303</td>
<td>Oth cerebral h'ge inj no open intracranial wond+1-24hr LOC</td>
</tr>
<tr>
<td>S6304</td>
<td>Oth cereb h'ge inj no open intracranial wond+&gt;24hr LOC + recovery</td>
</tr>
<tr>
<td>S6305</td>
<td>Oth cereb h'ge inj no open intracranial wond+&gt;24hr LOC - restored</td>
</tr>
<tr>
<td>S6310</td>
<td>Oth cerebral h'ge inj + open intracranial wond + unspec consc</td>
</tr>
<tr>
<td>S6311</td>
<td>Oth cerebral h'ge inj + open intracranial wond+no loss consc</td>
</tr>
<tr>
<td>S6312</td>
<td>Oth cerebral h'ge inj + open intracranial wond+1hr loss consc</td>
</tr>
<tr>
<td>S640</td>
<td>Intracranial injury NOS no open intracranial wound</td>
</tr>
<tr>
<td>S641</td>
<td>Intracranial injury NOS + open intracranial wound</td>
</tr>
<tr>
<td>S642</td>
<td>Traumatic cerebral oedema</td>
</tr>
<tr>
<td>S643</td>
<td>Diffuse brain injury</td>
</tr>
<tr>
<td>S644</td>
<td>Focal brain injury</td>
</tr>
</tbody>
</table>
Appendix B: Contribution from ACC and NMDS, and comparing TBI definition

Part A: Contribution from ACC and / or NMDS data
The following table presents the overall contribution to recorded prior TBI from the ACC data and / or the NMDS data. This shows that approximately three-quarters of recorded TBI was sourced from ACC data.

Table B1: Contribution to whether recorded prior TBI from ACC and / or NMDS data

<table>
<thead>
<tr>
<th></th>
<th>ACC data only</th>
<th>Both ACC and NMDS</th>
<th>NMDS data only</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>General population</td>
<td>61%</td>
<td>14%</td>
<td>25%</td>
<td>100%</td>
</tr>
<tr>
<td>Police: People proceeded against</td>
<td>49%</td>
<td>27%</td>
<td>24%</td>
<td>100%</td>
</tr>
<tr>
<td>Courts: People charged</td>
<td>47%</td>
<td>28%</td>
<td>25%</td>
<td>100%</td>
</tr>
<tr>
<td>Corrections: People starting community sentence</td>
<td>44%</td>
<td>30%</td>
<td>26%</td>
<td>100%</td>
</tr>
<tr>
<td>Corrections: People remanded in custody</td>
<td>39%</td>
<td>35%</td>
<td>27%</td>
<td>100%</td>
</tr>
<tr>
<td>Corrections: People starting prison sentence</td>
<td>38%</td>
<td>35%</td>
<td>27%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Part B: Comparing TBI definition
As mentioned in Appendix A, the ACC definition of TBI is broader than the MoH definition of TBI. The ACC definition includes things like toxicity, birth trauma, and open wounds which may influence brain functioning. We decided for this analysis to use the broader TBI definition on both the ACC and NMDS data. Overall this increased the prevalence rates by a few percentage points.

This appendix compares the prevalence rates under the two definitions, that is:

1. Definition 1 (used for analysis): Apply the ACC broader TBI definition to both the ACC and NMDS data.
2. Definition 2: Use the broader ACC TBI definition for the ACC data only, and use the narrower MoH TBI definition for the NMDS data.
### Table B2: Whether had prior recorded TBI – comparing data definitions

<table>
<thead>
<tr>
<th>Definition</th>
<th>General population</th>
<th>Police: People proceeded against</th>
<th>Courts: People charged</th>
<th>Corrections: People starting community sentence</th>
<th>Corrections: People remanded in custody</th>
<th>Corrections: People starting prison sentence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition 1</td>
<td>13%</td>
<td>34%</td>
<td>36%</td>
<td>40%</td>
<td>47%</td>
<td>46%</td>
</tr>
<tr>
<td>Definition 2</td>
<td>12%</td>
<td>31%</td>
<td>32%</td>
<td>36%</td>
<td>41%</td>
<td>41%</td>
</tr>
</tbody>
</table>

The MoH TBI definition includes the following codes:

**ICD-9**
800-801.9, 803-804.9, 850-854

**ICD-10-AM-v6**

- S0600 Concussion
- S0601 Loss of consciousness of unspecified duration
- S0602 Loss of consciousness of brief duration [less than 30 minutes]
- S0603 Loss of consciousness of moderate duration [30 minutes to 24 hours]
- S0604 LOC of prolonged duration [more than 24 hours] with return to pre-existing conscious level
- S0605 LOC of prolonged duration [more than 24 hours] without return to pre-existing conscious level
- S061 Traumatic cerebral oedema
- S0620 Diffuse cerebral and cerebellar brain injury, unspecified
- S0621 Diffuse cerebral contusions
- S0622 Diffuse cerebellar contusions
- S0623 Multiple intracerebral and cerebellar haematomas
- S0628 Other diffuse cerebral and cerebellar injury
- S0630 Focal cerebral and cerebellar injury, unspecified
- S0631 Focal cerebral contusion
- S0632 Focal cerebellar contusion
- S0633 Focal cerebral haematoma
- S0634 Focal cerebellar haematoma
- S0638 Other focal cerebral and cerebellar injury
- S064 Epidural haemorrhage
- S065 Traumatic subdural haemorrhage
- S066 Traumatic subarachnoid haemorrhage
- S068 Other intracranial injuries
- S069 Intracranial injury, unspecified

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*Census usually resident population aged 10 years and over, with prior recorded TBI before Census night 5 March 2013.*
Appendix C: Prior recorded TBI for victims

This paper has focused on offenders and alleged offenders in the criminal justice system. We also analysed the rate of prior traumatic brain injury for selected victims in the NZ Police Recorded Crime Victims Statistics (RCVS) dataset.

This dataset only includes offences when there is an identifiable victim (eg. drug offences are out of scope). Furthermore, the vast majority of victims of burglary offences cannot link to the IDI spine since Police records theses as household offences rather than personal offences.

This means people recorded against the following divisions are included in victim analysis:

- 01 homicide and related offences
- 02 acts intended to cause injury
- 03 sexual assault and related offences
- 05 abduction, harassment and other offences against the person
- 06 robbery, extortion and related offences
- 07 unlawful entry with intent/burglary, break and enter
- 08 theft and related offences
- 12 property damage and environmental pollution

<table>
<thead>
<tr>
<th>Whether had prior recorded traumatic brain injury</th>
<th>General population</th>
<th>Police: People victimised</th>
</tr>
</thead>
<tbody>
<tr>
<td>13%</td>
<td>22%</td>
<td></td>
</tr>
</tbody>
</table>

Analysis by demographics (age, sex, and ethnicity) is available on request.