JUSTICE SECTOR

Crime and Justice Insights

Traumatic brain injury and the criminal justice system

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Traumatic brain injury (TBI) 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[1] and that there is a modest causal link between TBI and crime[2]. 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[3].
- 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.

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- 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.[4] TBI is the leading cause of long-term disability in children and adults aged up to 35 years.[5] 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.[6] Treasury has identified that TBIs are second only to stroke for their impacts on employment and income[7]. Over half of ACC serious-claims are related to TBI[8].

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[9]. 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.[10]

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)[11]. 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.[12] Younger age at first injury was associated with an increased risk of mental health problems. This

[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[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)[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[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[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[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.[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[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[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.

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[13] (Parsonage, 2016)

[14] (Shiroma, Ferguson, & Pickelsimer, 2010)

[15] (Kennedy, Cohen, & Munaf`o, 2017)

[16] (Andrews, et al., 2013)

[17] (Kennedy, Cohen, & Munaf`o, 2017)

[18] (Schofield, et al., 2015)

[19] (McKinlay, Corrigan, Horwood, & Fergusson, 2014)

[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[21]
- Sentencing and remand data – Department of Corrections
- 2013 Census data – Statistics NZ

The National Minimum Dataset[22] 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[23] 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.[24] 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.

[22] Further information on the NMDS can be obtained from http://www.health.govt.nz/nz-health-statistics/national-collections-and-surveys/collections/national-minimum-dataset-hospital-events

[23] Further information on the ACC data in the IDI can be obtained from http://archive.stats.govt.nz/browse_for_stats/snapshots-of-nz/integrated-data-infrastructure/idi-data/acc-injury-claims-data.aspx

[24] We are grateful for advice received from Agnes Guevara (ACC) and Meisha Nicolson (MoH).

1. is broader than the MoH definition, and
2. includes things like toxicity, birth trauma, and open wounds which may influence brain functioning.

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.[25] 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 1: Prevalence of prior recorded TBI for people interacting with the justice system in 2015

	General population[26]	**Police:** People proceeded against	**Courts:** People charged	**Corrections:** People starting community sentence	**Corrections:** People remanded in custody	**Corrections:** People starting prison sentence
Whether had prior recorded traumatic brain injury	13%	34%	36%	40%	47%	46%
For people with prior TBI, average number of TBIs	1.3	1.6	1.6	1.7	1.8	1.8

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

[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 2: Age of first recorded TBI for people interacting with the justice system in 2015

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

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

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

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

	General population	Police: People proceeded against	Courts: People charged	Corrections: People starting community sentence	Corrections: People remanded in custody	Corrections: People starting prison sentence
For people with prior TBI, whether first TBI recorded before age 10 years						
Sex - Male	18%	18%	15%	12%	13%	11%
Sex - Female	16%	16%	13%	11%	13%	10%
Ethnicity - European	17%	18%	15%	12%	12%	11%
Ethnicity - Māori	22%	19%	15%	12%	13%	11%
Ethnicity - Pacific	24%	18%	14%	12%	13%	9%
Ethnicity - Asian	19%	13%	10%	9%	11%	15%
Ethnicity - MELAA	18%	17%	14%	12%	12%	14%
Ethnicity - Other	12%	11%	9%	8%	7%	9%

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).

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[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[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.

Table 5: Whether used mental health and addiction services by whether have prior recorded TBI, for people charged in court in 2013 and the public

	General population	**Courts:** People charged
Whether used mental health and addiction services		
Prior recorded TBI	23%	52%
No prior recorded TBI	17%	38%
Total	**18%**	**43%**

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

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

[35] (Hart, de Vet, Moran, Hatch, & Dean, 2012)

[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)

	General population	**Police:** People proceeded against	**Courts:** People charged	**Corrections:** People starting community sentence	**Corrections:** People remanded in custody	**Corrections:** People starting prison sentence
For people with prior TBI, cause of injury						
Fall / trip / slip (not sport related)	27%	21%	19%	20%	20%	19%
Sport / recreation	20%	20%	18%	16%	15%	14%
Vehicle / riding related	11%	17%	18%	18%	18%	17%
Contact with object	11%	12%	12%	12%	13%	12%
Work related	11%	7%	7%	8%	5%	6%
Assault	5%	18%	20%	22%	27%	28%
Other contact with person	4%	11%	12%	13%	15%	16%

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[37]. 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.[38] Furthermore, for people who do seek medical assistance, research has shown that the medical staff under utilise the ICD head injury codes.[39]

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

ACC. (2017). *Traumatic Brain Injury Strategy and Action Plan 2017–2021.* Wellington: Author.

Andrews, J. C., Schunemann, H. J., Oxman, A. D., Pottie, K., J, M. J., Coello, P. A., et al. (2013). GRADE guidelines: 15. Going from evidence to recommendation-determinants of a recommendation's direction and strength. *Journal of Clinical Epidemiology , 66*, 726-735.

Barker-Collo, S., Theadom, A., Jones, K., Feigin, V., & Kahan, M. (2016). Accuracy of an International Classification of Diseases Code Surveillance System in the Identification of Traumatic Brain Injury. *Neuroepidemiology , 47*, 46-52.

Dixon, S. (2015). *The Employment and Income Effects of Eight Chronic and Acute Health Conditions: New Zealand Treasury Working Paper 15/15.* Wellington: The New Zealand Treasury.

Feigin, V. L., Theadom, A., Barker-Collo, S., Starkey, N. J., McPherson, K., Kahan, M., et al. (2013). Incidence of traumatic brain injury across all ages and the full disease spectrum: a population based prospective study in New Zealand. *The Lancet Neurology , 12* (1), 53-64.

Hart, C., de Vet, R., Moran, P., Hatch, S. L., & Dean, K. (2012). A UK population-based study of the relationship between mental disorder and victimisation. *Social psychiatry and psychiatric epidemiology , 47* (10), 1581-1590.

Hughes, K., Bellis, M. A., Jones, L., Wood, S., Bates, G., Eckley, L., et al. (2012). Prevalence and risk of violence against adults with disabilities: a systematic review and meta-analysis of observational studies. *The Lancet , 379*, 1621–1629.

Kennedy, E., Cohen, M., & Munaf`o, M. (2017). Childhood Traumatic Brain Injury and the Associations With Risk Behavior in Adolescence and Young Adulthood: A Systematic Review. *Journal of Head Trauma and Rehabilitation , 32* (6), 425–432.

McKinlay, A., Corrigan, J., Horwood, L. J., & Fergusson, D. M. (2014). Substance Abuse and Criminal Activities Following Traumatic Brain Injury in Childhood, Adolescence, and Early Adulthood. *Journal of Head Trauma and Rehabilitation , 29* (6), 498–506.

Ministry of Health. (2006). *Results from the Prisoner Health Survey 2005.* Wellington: Ministry of Health.

Parsonage, M. (2016). *Traumatic brain injury and offending.* Birmingham: Centre for Mental Health.

Schofield, P. W., Malacova, E., Preen, D. B., D'Este, C., Tate, R., Reekie, J., et al. (2015). Does Traumatic Brain Injury Lead to Criminality? A Whole- Population Retrospective Cohort Study Using Linked Data. *PLoS ONE , 10* (7), e0132558.

Shiroma, E. J., Ferguson, P. L., & Pickelsimer, E. E. (2010). Prevalence of Traumatic Brain Injury in an Offender Population: A Meta-Analysis. *Journal of Correctional Health Care , 16* (2), 147-159.

Starkey, N. (2013). Traumatic Brain Injury in New Zealand: A Silent Epidemic? *Psychology Aotearoa , 5* (1), 18-21.

Te Ao, B., Tobias, M., Ameratunga, S., McPherson, K., Theadom, A., Dowell, A., et al. (2015). Burden of Traumatic Brain Injury in New Zealand: Incidence, Prevalence and Disability-Adjusted Life Years. *Neuroepidemiology , 44*, 255-261.

Woolhouse, R., McKinlay, A., & Grace, R. (2017). Women in Prison With Traumatic Brain Injury: Prevalence, Mechanism, and Impact on Mental Health. *International Journal of Offender Therapy and Comparative Criminology* , 1-16.

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

CODES USED

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[45]. 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).

Read Code	Description
E2A2.	Post-traumatic brain syndrome
F284.	Compression of brain
Q2...	Birth trauma, asphyxia and hypoxia
Q20..	Birth trauma
Q200.	Subdural and cerebral haemorrhage due to birth trauma
Q2000	Cerebral haemorrhage unspecified, due to birth trauma
Q2001	Subdural haemorrhage unspecified, due to birth trauma
Q2002	Local subdural haematoma due to birth trauma
Q2004	Brain injury due to birth trauma NOS
Q2005	Cerebral haematoma in fetus or newborn
Q21..	Intrauterine hypoxia and birth asphyxia
Q2131	Liveborn with labour hypoxia
Q215.	Severe birth asphyxia - apgar score less than 4 at 1 minute
Q4113	Intraventricular haemorrhage due to birth injury
Q412.	Perinatal subarachnoid haemorrhage
Q488.	Neonatal cerebral ischaemia
Q489.	Acquired periventricular cysts of newborn
Q48A.	Neonatal cerebral leukomalacia
S0...	Fracture of skull
S00..	Parietal bone fracture
S000.	Closed fracture vault of skull without intracranial injury
S0000	Closed #skull vlt no intracranial injury, unspec state consc
S0002	Closed #skull vlt no intracranial injury, <1hr loss of consc
S0005	Closed #skull vlt no intracranial inj,>24hr LOC not restored
S001.	Closed fracture vault of skull with intracranial injury
S0010	Closed #skull vlt + intracranial injury, unspec state consc
S0011	Closed #skull vlt + intracranial injury, no loss of consc
S0012	Closed #skull vlt + intracranial injury, <1hr loss of consc
S0014	Closed #skull vlt + intracranial injury, >24hr LOC+recovery
S0015	Closed #skull vlt + intracranial inj, >24hr LOC not restored
S0016	Closed #skull vlt + intracranial injury, LOC unspec duration
S002.	Open fracture vault of skull without intracranial injury
S003.	Open fracture vault of skull with intracranial injury
S0030	Open #skull vlt + intracranial injury, unspec state of consc
S0031	Open #skull vlt + intracranial injury, no loss of consc
S0032	Open #skull vlt + intracranial injury, <1hr loss of consc

[45] ICD = International Classification of Diseases

S0033	Open #skull vlt + intracranial injury, 1-24hr loss of consc
S0034	Open #skull vlt + intracranial injury, >24hr 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 bse + intracranial inj, unspec state of consc
S0111	Closed #skull bse + intracranial injury, no loss of consc
S0112	Closed #skull bse + intracranial injury, <1hr loss of consc
S0113	Closed #skull bse + intracranial injury, 1-24hr loss consc
S0114	Closed #skull bse + intracranial injury, >24hr LOC+recovery
S0115	Closed #skull bse + intracranial inj, >24hr LOC not restored
S0116	Closed #skull bse + intracranial injury, LOC unspec duration
S0120	Open #skull bse no intracranial inj, unspec state of consc
S013.	Open fracture base of skull with intracranial injury
S0130	Open #skull bse + intracranial injury, unspec state of consc
S0131	Open #skull bse + intracranial injury, no loss of consc
S0132	Open #skull bse + intracranial injury, <1hr loss of consc
S0133	Open #skull bse + intracranial injury, 1-24hr loss of consc
S0134	Open #skull bse + intracranial injury, >24hr LOC + recovery
S030.	Closed fracture of skull NOS without intracranial injury
S0301	Closed #skull NOS no intracranial inj, no loss of consc
S0302	Closed #skull NOS no intracranial inj, <1hr loss of consc
S0303	Closed #skull NOS no intracranial inj, 1-24hr loss of consc
S031.	Closed fracture of skull NOS with intracranial injury
S0310	Closed #skull NOS + intracranial inj, unspec state of consc
S0311	Closed #skull NOS + intracranial inj, no loss of consc
S0312	Closed #skull NOS + intracranial inj, <1hr loss of consc
S0313	Closed #skull NOS + intracranial inj, 1-24hrs loss of consc
S0314	Closed #skull NOS + intracranial inj, >24hrs LOC + recovery
S0315	Closed #skull NOS + intracranial inj, >24hr LOC not restored
S0316	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.	Mult #skull/face+other bones, closed, no intracranial injury
S041.	Mult #skull/face+other bones, closed + intracranial injury
S0410	Closed #skull/face, mult + intracranial inj, unspec consc
S0411	Closed #skull/face, mult + intracranial inj, no loss consc
S0412	Closed #skull/face, mult + intracranial inj, <1hr LOC
S0413	Closed #skull/face, mult + intracranial inj, 1-24hrs LOC
S0414	Closed #skull/face, mult+intracran inj, >24hr LOC+recovery
S0415	Closed #skull/face, multi+intracran inj, >24hr LOC-restored
S0416	Closed #skull/face,mult + intracran inj, LOC unspec duration
S043.	Mult #skull/face + other bones, open + intracranial injury
S0430	Open #skull/face, mult + intracranial inj, unspec consc
S0434	Open #skull/face, mult + intracran inj, >24hr LOC + recovery
S0436	Open #skull/face, mult + intracran inj, LOC unspec duration
S6...	Intracranial injury excluding those with skull fracture
S60..	Concussion
S600.	Concussion with no loss of consciousness
S601.	Concussion with less than 1 hour loss of consciousness
S605.	Concussion with loss of consciousness of unspec duration
S61..	Cortex laceration and contusion
S610.	Closed cerebral contusion
S611.	Open cerebral contusion
S614.	Closed hindbrain contusion
S62..	Traumatic cerebral haemorrhage
S620.	Middle meningeal haemmorhage following injury
S6200	Subarachnoid h'ge inj no open intracran wound + unspec consc
S6201	Subarachnoid h'ge inj no open intracran wnd+no loss consc
S6202	Subarachnoid h'ge inj no open intracran wnd+<1hr loss consc
S6203	Subarachnoid h'ge inj no open intracran wound + 1-24hr LOC
S6204	Subarachnoid h'ge inj no open intracran wnd+>24 LOC+recovery
S6205	Subarach h'ge inj no open intracran wnd+>24hrs LOC-restored
S6206	Subarach h'ge inj no open intracran wnd+LOC unspec duration
S621.	Open traumatic subarachnoid haemorrhage
S6210	Subarachnoid h'ge inj + open intracran wound + unspec consc
S6211	Subarachnoid h'ge inj + open intracranial wound + no LOC
S6212	Subarachnoid h'ge inj + open intracran wound+<1hr loss consc
S6213	Subarachnoid h'ge inj + open intracran wnd+1-24hr loss consc
S6214	Subarach h'ge inj + open intracran wnd +>24hr LOC + recovery
S6215	Subarach h'ge inj + open intracran wnd+>24hr LOC -restored
S6216	Subarach h'ge inj + open intracran wnd+LOC unspec duration
S622.	Closed traumatic subdural haemorrhage
S6220	Subdural haemorrage injury no open intracranial wnd + 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 intracran wnd+1-24hr loss consc
S6224	Subdural h'ge inj no open intracranial wnd+>24 LOC +recovery
S6225	Subdural h'ge inj no open intracran wnd+>24hr LOC -restored

S6226	Subdural h'ge inj no open intracran wnd+LOC unspec duration
S623.	Open traumatic subdural haemorrhage
S6230	Subdural h'ge inj + open intracranial wound + unspec consc
S6231	Subdural h'ge inj + open intracranial wound+no loss consc
S6232	Subdural h'ge inj + open intracranial wound+<1hr loss consc
S6233	Subdural h'ge inj + open intracranial wnd+1-24hr loss consc
S6234	Subdural h'ge inj + open intracran wound+>24hr LOC +recovery
S6235	Subdural h'ge inj + open intracran wnd+>24hr LOC -restored
S6236	Subdural h'ge inj + open intracran wnd+LOC unspec duration
S624.	Epidural haematoma following injury
S6240	Extradural h'ge inj no open intracranial wnd + unspec consc
S6241	Extradural h'ge inj no open intracranial wnd + no loss consc
S6242	Extradural h'ge inj no open intracranial wnd+<1hr loss consc
S6243	Extradural h'ge inj no open intracran wnd+1-24hr loss consc
S6244	Extradural h'ge inj no open intracran wnd+>24hr LOC+recovery
S6245	Extradural h'ge inj no open intracran wnd+>24hr LOC-restored
S6246	Extradural h'ge inj no open intracra wnd+LOC unspec duration
S625.	Open traumatic extradural haemorrhage
S6250	Extradural h'ge inj + open intracranial wnd + unspec consc
S6251	Extradural h'ge inj + open intracranial wound+no loss consc
S6252	Extradural h'ge inj + open intracranial wnd+<1hr loss consc
S6253	Extradural h'ge inj + open intracran wnd+1-24hr loss consc
S6254	Extradural h'ge inj + open intracran wnd+>24hr LOC+recovery
S6255	Extradural h'ge inj + open intracran wnd+>24hr LOC -restored
S6256	Extradural h'ge inj + open intracran wnd+LOC unspec duration
S626.	Epidural haemorrhage
S627.	Traumatic subarachnoid haemorrhage
S628.	Traumatic subdural haemorrhage
S63..	Other cerebral haemorrhage following injury
S630.	Other cerebral h'ge after injury no open intracranial wound
S6300	Oth cerebral h'ge inj no open intracran wnd+unspec consc
S6301	Oth cerebral h'ge inj no open intracranial wnd+no loss consc
S6302	Oth cerebral h'ge inj no open intracran wnd+<1hr loss consc
S6303	Oth cerebral h'ge inj no open intracran wnd+1-24hr LOC
S6304	Oth cereb h'ge inj no open intracran wnd+>24hr LOC +recovery
S6305	Oth cereb h'ge inj no open intracran wnd+>24hr LOC -restored
S6306	Oth cereb h'ge inj no open intracran wnd+LOC unspec duration
S631.	Other cerebral h'ge after injury + open intracranial wound
S6310	Oth cerebral h'ge inj + open intracran wnd + unspec consc
S6311	Oth cerebral h'ge inj + open intracranial wnd+no loss consc
S6312	Oth cerebral h'ge inj + open intracran wnd+<1hr loss consc
S6313	Oth cerebral h'ge inj + open intracran wnd+1-24hr loss consc
S6314	Oth cereb h'ge inj + open intracran wnd+>24hr LOC + recovery
S6315	Oth cereb h'ge inj + open intracran wnd+>24hr LOC -restored
S64..	Intracranial injury NOS
S640.	Intracranial injury NOS no open intracranial wound
S6400	Intracranial inj NOS no open intracran wnd + unspec consc
S6401	Minor head injury
S6402	Intracranial inj NOS no open intracran wnd+<1hr loss consc
S6403	Intracranial inj NOS no open intracran wnd+1-24hr loss consc
S6404	Intracranial inj NOS no open intracran wnd+>24hr LOC+recover
S6405	Intracran inj NOS no open intracran wnd+>24hr LOC -restored
S6406	Intracran inj NOS no open intracran wnd+LOC unspec duration
S641.	Intracranial injury NOS + open intracranial wound
S6410	Intracranial inj NOS + open intracranial wnd + unspec consc
S6411	Intracranial inj NOS + open intracranial wound+no loss consc
S6412	Intracranial inj NOS + open intracranial wnd+<1hr loss consc
S6413	Intracranial inj NOS + open intracranial wnd + 1-24hr LOC
S6414	Intracranial inj NOS + open intracran wnd+>24hr LOC+recovery
S6415	Intracran inj NOS + open intracran wnd+>24hr LOC -restored
S6416	Intracran inj NOS + open intracran wnd+LOC unspec duration
S642.	Traumatic cerebral oedema
S643.	Diffuse brain injury
S644.	Focal brain injury
S645.	Intracranial injury with prolonged coma
S830.	Open wound of scalp
SE09.	Contusion, scalp
SF03.	Crushing injury of skull
SH1..	Head burns
SP101	Cerebral anoxia complication

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
800.91	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	Fracture of Base of Skull; Anterior; Middle; Posterior; Occiput Bone; Orbital Roof; Ethmoid; Frontal; Sphenoid Bone; Temporal Bone, Closed, without Mention of Intracranial Injury
801.00	Fracture of Base of Skull; Anterior; Middle; Posterior; Occiput Bone; Orbital Roof; Ethmoid; Frontal; Sphenoid Bone; Temporal Bone, Closed, without Mention of Intracranial Injury, Unspecified State of Consciousness
801.02	Fracture of Base of Skull; Anterior; Middle; Posterior; Occiput Bone; Orbital Roof; Ethmoid; Frontal; Sphenoid Bone; Temporal Bone, Closed, without Mention of Intracranial Injury, with Brief [Less than One Hour] Loss of Consciousness
801.09	Fracture of Base of Skull; Anterior; Middle; Posterior; Occiput Bone; Orbital Roof; Ethmoid; Frontal; Sphenoid Bone; Temporal Bone, Closed, without Mention of Intracranial Injury, with Unspecified Concussion
801.1	Fracture of Base of Skull; Anterior; Middle; Posterior; Occiput Bone; Orbital Roof; Ethmoid; Frontal; Sphenoid Bone; Temporal Bone, Closed, with Cerebral Laceration and Contusion
801.2	Fracture of Base of Skull; Anterior; Middle; Posterior; Occiput Bone; Orbital Roof; Ethmoid; Frontal; Sphenoid Bone; Temporal Bone, Closed, with Subarachnoid, Subdural, and Extradural Hemorrhage
801.91	Fracture of Base of Skull; Anterior; Middle; Posterior; Occiput Bone; Orbital Roof; Ethmoid; Frontal; Sphenoid Bone; Temporal Bone, Open with Intracranial Injury of Other and Unspecified Nature, with No Loss of Consciousness
803	Other and Unqualified Skull Fractures
803.0	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
804.0	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
850.1	Concussion with Brief 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
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 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 1 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
852.20	Subdural Hemorrhage Following Injury, without Mention of Open Intracranial Wound, Unspecified State of Consciousness, Unspecified Loss of Consciousness
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, without Mention of 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, Other and Unspecified
853.02	Intracranial Hemorrhage Following Injury without Mention of Open Intracranial Wound, with Brief (Less than 1 Hour) Loss of Consciousness, Other and Unspecified
853.06	Intracranial Hemorrhage Following Injury without Mention of Open Intracranial Wound, with Loss of Consciousness of 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

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

ICD-10 code	Description
310.2	Postconcussion Syndrome
854.1	Intracranial Injury of Other and Unspecified Nature with Ope
F072	Postconcussional syndrome
Q200.	Subdural and cerebral haemorrhage due to birth trauma
Q208.	Cerebral oedema due to birth injury
Q2121	Liveborn with prelabour hypoxia
Q4111	Intraventric (nontraumatic) haemorhage grade 2 fet newborn
Q4113	Intraventricular haemorrhage due to birth injury
Q412.	Perinatal subarachnoid haemorrhage
S001.	Closed fracture vault of skull with intracranial injury
S0030	Open #skull vlt + intracranial injury, unspec state of consc
S0031	Open #skull vlt + intracranial injury, no loss of consc
S0032	Open #skull vlt + intracranial injury, <1hr loss of consc
S0033	Open #skull vlt + intracranial injury, 1-24hr loss of consc
S0034	Open #skull vlt + intracranial injury, >24hr LOC + recovery
S0035	Open #skull vlt + intracranial inj, >24hr LOC not restored
S010	Open wound of scalp
S011.	Closed fracture base of skull with intracranial injury
S0130	Open #skull bse + intracranial injury, unspec state of consc
S0131	Open #skull bse + intracranial injury, no loss of consc
S0133	Open #skull bse + intracranial injury, 1-24hr loss of consc
S0134	Open #skull bse + intracranial injury, >24hr LOC + recovery
S0135	Open #skull bse + intracranial inj, >24hr LOC not restored
S0136	Open #skull bse + intracranial injury, LOC unspec 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.	Mult #skull/face+other bones, closed + intracranial injury
S043.	Mult #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

S0630	Focal cerebral and cerebellar injury, unspecified
S0631	Focal cerebral contusion
S0633	Focal cerebral haematoma
S064	Epidural haemorrhage
S065	Traumatic subdural haemorrhage
S066	Traumatic subarachnoid haemorrhage
S068	Other intracranial injuries
S069	Intracranial injury, unspecified
S080	Avulsion of scalp
S099	Unspecified injury of head
S620.	Closed traumatic subarachnoid haemorrhage
S621.	Open traumatic subarachnoid haemorrhage
S6210	Subarachnoid h'ge inj + open intracran wound + unspec consc
S6211	Subarachnoid h'ge inj + open intracranial wound + no LOC
S6212	Subarachnoid h'ge inj + open intracran wound+<1hr loss consc
S6213	Subarachnoid h'ge inj + open intracran wnd+1-24hr loss consc
S6214	Subarach h'ge inj + open intracran wnd +>24hr LOC + recovery
S6215	Subarach h'ge inj + open intracran wnd+>24hr LOC -restored
S6216	Subarach h'ge inj + open intracran wnd+LOC unspec duration
S6220	Subdural haemorrage injury no open intracranial wnd + 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 intracran wnd+1-24hr loss consc
S6224	Subdural h'ge inj no open intracranial wnd+>24 LOC +recovery
S6230	Subdural h'ge inj + open intracranial wound + unspec consc
S6231	Subdural h'ge inj + open intracranial wound+no loss consc
S6232	Subdural h'ge inj + open intracranial wound+<1hr loss consc
S6233	Subdural h'ge inj + open intracranial wnd+1-24hr loss consc
S6234	Subdural h'ge inj + open intracran wound+>24hr LOC +recovery
S624.	Closed traumatic extradural haemorrhage
S6250	Extradural h'ge inj + open intracranial wnd + unspec consc
S6251	Extradural h'ge inj + open intracranial wound+no loss consc
S6252	Extradural h'ge inj + open intracranial wnd+<1hr loss consc
S627.	Traumatic subarachnoid haemorrhage
S628.	Traumatic subdural haemorrhage
S6300	Oth cerebral h'ge inj no open intracran wnd+unspec consc
S6301	Oth cerebral h'ge inj no open intracranial wnd+no loss consc
S6302	Oth cerebral h'ge inj no open intracran wnd+<1hr loss consc
S6303	Oth cerebral h'ge inj no open intracran wnd+1-24hr LOC
S6304	Oth cereb h'ge inj no open intracran wnd+>24hr LOC +recovery
S6305	Oth cereb h'ge inj no open intracran wnd+>24hr LOC -restored
S6310	Oth cerebral h'ge inj + open intracran wnd + unspec consc
S6311	Oth cerebral h'ge inj + open intracranial wnd+no loss consc
S6312	Oth cerebral h'ge inj + open intracran wnd+<1hr loss consc
S640.	Intracranial injury NOS no open intracranial wound
S641.	Intracranial injury NOS + open intracranial wound
S642.	Traumatic cerebral oedema
S643.	Diffuse brain injury
S644.	Focal brain injury

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

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

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

	General population[46]	**Police:** People proceeded against	**Courts:** People charged	**Corrections:** People starting community sentence	**Corrections:** People remanded in custody	**Corrections:** People starting prison sentence
Definition 1	13%	34%	36%	40%	47%	46%
Definition 2	12%	31%	32%	36%	41%	41%

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] w/out 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

[46] 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 C1: Prevalence of prior recorded TBI for selected victims in 2015

	General population	Police: People victimised
Whether had prior recorded traumatic brain injury	13%	22%

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