New Zealand Major Trauma Registry
& National Trauma Network

Annual Report
2018-2019

Te Hononga Whētuki ā-Motu
National Trauma Network

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Te Hononga Whētuki ā-Motu
National Trauma Network

Foreword

This is the fourth annual report from the National Trauma Network. It provides a comprehensive picture of the incidence, process of care and outcomes following major trauma in New Zealand. Additionally, it presents the progress made on key initiatives with respect to the Network's 5-year strategic plan.

This year the Accident Compensation Corporation (ACC) funded a new 5-year partnership that resources a quality improvement programme in areas of trauma rehabilitation, severe traumatic brain injury and the management of critical haemorrhage. As more data has been collected, the trauma registry has developed into an integral resource in fostering local research in trauma prevention and care. The Network has also introduced a rebranding to reflect our commitment to Te Tiriti o Waitangi.

The work reflected in this report is the result of the immense efforts of staff delivering care in each of the DHBs, prehospital providers, central health governance and our funding agencies. Specific acknowledgement is made of the sponsors of the Network, ACC, and the Ministry of Health (MoH). Without the guidance, commitment of resources, and ongoing support of DHB staff, ambulance, and our sponsors, the outcomes described in this report would not have been possible.

There has been great progress made in our understanding of the quality of trauma care in New Zealand. As the Network continues to develop, we anticipate further opportunities to inform policy strategies and improve trauma care outcomes for New Zealand patients.

Ian Civil

National Clinical Lead
National Trauma Network

Siobhan Isles

National Programme Manager
National Trauma Network

14 February 2020

Executive Summary

This has been an important year for the National Trauma Network. The funding of the Network's business case by ACC enables us to work to a sustainable programme over the next five years and to implement the key features of the best performing trauma systems internationally. We have partnered with a new agency, the Health Quality and Safety Commission (the "Commission"), to be the delivery partner for key aspects of our future work.

The intent of the Network is to reduce death from injury, reduce the level of disability for those that survive, and achieve an efficient trauma system. We do this by collecting data on everyone who has major trauma, transform that data into information, and use that information to support quality improvement initiatives.

In previous years we have seen substantial variation in the processes of care and outcomes for major trauma patients. This variation has been observed by geographic location of injury and by the size of hospital.

As variation is the enemy of quality, it is enormously pleasing to show in this annual report that not only have the process and outcome markers improved overall, there is more consistency across the country. This is a fantastic result and a credit to the clinicians and managers across the country who have worked hard to support quality improvements in trauma care at all levels of the system.

Highlights from the New Zealand Major Trauma Registry

Improved outcomes and processes of care for major trauma patients for major trauma patients from last year.

Case Fatality Rate

8.4%

down 0.6%

Compared to the national rate for risk-adjusted mortality,

no hospital has a significantly elevated rate, and two hospitals have significantly lower mortality rates.

Cause of death from haemorrhage

12.6%

A good outcome would be a reduction in the proportion of deaths from haemorrhage, and this will be a focus of work next year.

Recording of blood alcohol concentration

62%

up from 49%

Time to index CT

< 2 hours 72%

down 1%
(although it has improved for patients with impaired consciousness)

Direct from scene to definitive care

80%

up from 79%

Median time from scene to definitive care

between 1.2 – 1.7 hours

for those not transferred and managed definitively in the first hospital

between 6.9 and 10.6 hours

for those transferred from one or more hospitals

While positive changes have been made, there remain further opportunities for improvement. These include:

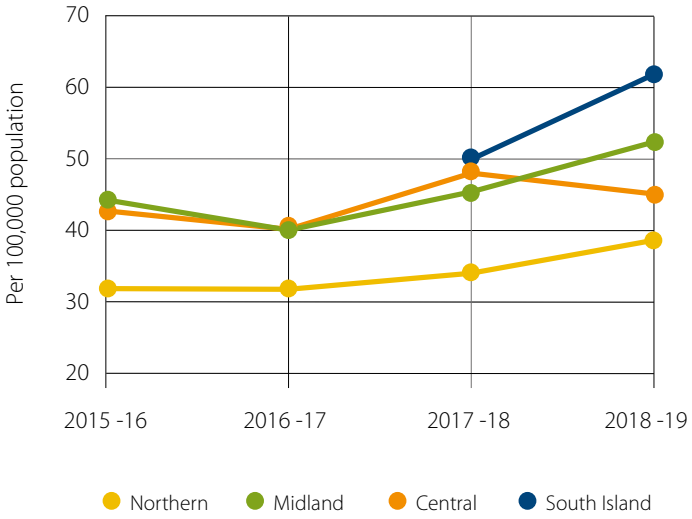
- Understanding how we can reduce deaths from haemorrhage and consequent multi-organ failure, some of which might be avoidable.
- For patients who need transfer to another hospital for definitive care, the time to transfer is variable, and in some cases delays may be detrimental to outcome. Further work to understand the barriers to faster transfer is urgently needed.
- Ensuring patients with severe traumatic brain injury (sTBI) are transferred to hospitals with neuroscience capability. Care in a neuroscience hospital is associated with better outcomes for sTBI patients, as well as providing timely multidisciplinary support and long-term rehabilitation.

Patterns of injury

The Network has little influence over the incidence of trauma. Nevertheless, NZ-MTR data provides useful information on the patterns of injury over time and should be used to indicate where resources are located to manage demand and for injury prevention

Major trauma case volumes have increased 14% from last year with a general upward trend over the past few years in most regions. Some of the increase might be attributed to better data collection, however we believe a true increase in incidence is the primary driver because the pattern is consistent in areas where data collection has been in place for a long time. Further work is needed to inform which factors are contributing to the increase.

Trauma incidence per 100,000 population



Incidence

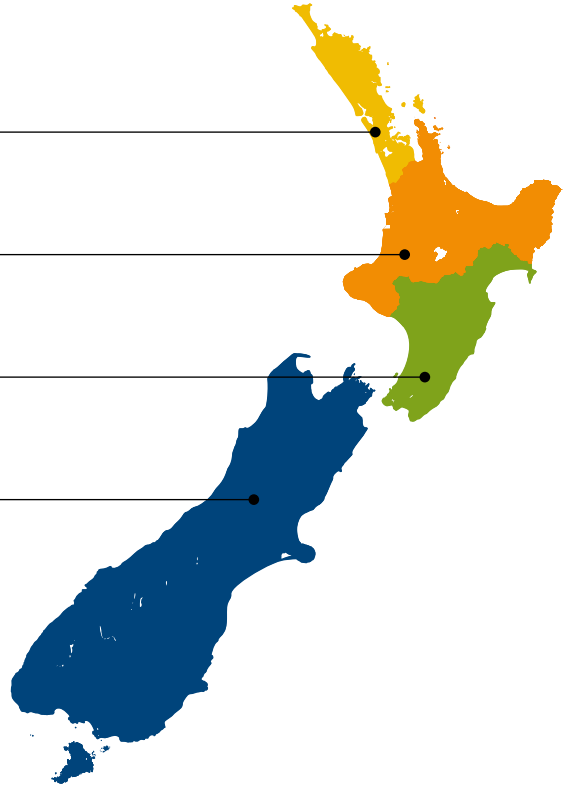
National Incidence
48/100,000 (2,355)

Northern Region
38/100,000 (727)

Midland Region
53/100,000 (501)

Central Region
45/100,000 (414)

South Island
62/100,000 (713)



New information by linking with other datasets

This year we have linked the New Zealand Major Trauma Registry (NZ-MTR) data with other datasets, including the Ministry of Health. Analysis of this data shows:

Statistically significant higher risk of transport and other trauma in rural populations compared to those living in urban areas.

The acute unplanned readmission rate within 30 days of discharge is 11% and increases with severity of injury and with age. Acute unplanned readmission to hospital for care related to the original injury is a detrimental outcome for patients.

There were 39 deaths that occurred within 90 days after discharge from hospital. The number of deaths post-discharge increased substantially with age from 65 years onwards.

Linking the NZ-MTR data with other datasets is proving enormously informative yet we are only beginning to explore the full opportunity this presents. We will be continuing to actively look for ways to link with other datasets.

Highlights from the National Trauma Network across the four areas of focus

NATIONAL TRAUMA NETWORK

1 Governance

- Health Quality and Safety Commission (the Commission) was contracted to deliver key aspects of the 5-year work programme.
- A review of the NZ trauma system by the Royal Australasian College of Surgeons resulted in 69 recommendations of which over 50 are incorporated into the workplan.
- Regional trauma networks continue to mature with work to undertake clinical audits; research on topics such as cost of care, patterns of injury, and patient outcomes; and quality improvement activities.

2 Service excellence

- The first audit of the pre-hospital destination policy showed good overall compliance with the destination policy, except in metropolitan Auckland where there is more choice of hospitals.
- Priorities for the Commission's quality improvement programme were identified: critical haemorrhage, rehabilitation, and serious traumatic brain injury.

3 Enablers

Workforce

- Continued improvements in workforce sustainability and capacity, with the specialist trauma nursing workforce increasing from 15 to 30 over the past three years. A small number of hospitals continue to be seriously under-resourced.
- Trauma education continues to grow supported by the ACC Incentive fund paid pro rata for data uploaded to the NZ-MTR.
- Trauma team training simulation has been successfully piloted.
- Professional development framework for trauma nurses developed and published.

Registry

- The NZ Major Trauma Registry now holds records for more than 7500 major trauma patients.
- Procurement of a new fit-for-purpose registry has started.

4 Research and analytics

- Research programme has been launched led by Professor Belinda Gabbe.
- The Study of Road Trauma Evidence and Data (SORTED) was completed, linking data from seven databases and five agencies
- The NZ Major Trauma Registry Governance Group approved 21 proposals to use data held in the registry for internal and external research.
- A subset of the seven large trauma hospitals has been included into the Australia New Zealand Trauma Registry.

Events in the trauma system

This year the terrorist attacks on two mosques in Christchurch had a profound effect on New Zealand's Muslim community. It resulted in the loss of 51 lives and a further 118 injured, many seriously and who are struggling with the consequences to this day. We commemorate those who lost their lives, those whose acts of courage saved others, and the staff at Christchurch Hospital (and Burwood and Auckland Starship Hospitals) who worked tirelessly on more than a hundred wounded people to minimise any further loss of life.

The tragic death of Dr Peter Hicks was felt by many who knew him as an Intensivist at Wellington Regional Hospital and the clinical lead of the Central Region Trauma Network. Peter's legacy includes the work he did to bring the clinicians in the central region together to begin the trauma network under his inspiring leadership.

Waikato DHB achieved Level 1 trauma verification from the Royal Australasian College of Surgeons.

Dr Ian Civil was awarded two prestigious international prizes; Prize of the "Société Internationale de Chirurgie" at the 48th Annual World Congress of Surgery, and an Honorary Fellowship from The American College of Surgeons.

Matt Sawyer was accepted into the Faculty of Association for the Advancement of Automotive Medicine to become New Zealand's first Abbreviated Injury Scale trainer.

Two members of the trauma network received honours from the Order of St John for their services: Dr James Moore was appointed Commander and Bridget Dicker Officer of the Order of St John.

Pre 2012
Trauma systems in some hospitals and two regions.

2012-2017
Foundation work
Formal trauma structure
NZ-MTR
Consistent policies and guidelines

2017-2022
Service excellence
Enablers
Research
System governance

2011
Minister for Health approved the establishment of the Major Trauma National Clinical Network

2012
Major Trauma National Clinical Network formed

2013
Formal national and regional structures established

2014
National Minimum Dataset developed

2015
Hospital capability study
NZ-MTR established
All DHBs required to collect data

2016
Inaugural Annual Report

2017
Out-of-Hospital triage policy, destination policy, and staging guidelines

2018
National Trauma Network 5-year Strategic Plan
Business case approved
RACS review of the NZ trauma system
Trauma Team Training simulation pilots

2019
Commission contract for QI, research and business intelligence
Key Performance Indicators agreed
New website and rebranded
Binational benchmarking with Australia

2022

Introduction

He aha te mea nui o te ao. He tāngata, he tāngata, he tāngata.

What is the most important thing in the world? It is people, it is people, it is people.

– Māori proverb

This year's report is in two parts: the analysis from the New Zealand Major Trauma Registry (NZ-MTR), and the report from the National Trauma Network.

The NZ-MTR analysis focuses on many of the same key areas that have been identified as priority areas for the Network, while expanding on others. We examine patterns in serious traumatic brain injury, we look at trauma in Māori, we examine outcomes, and we report on the key performance indicators.

For the first time, we have included additional information from the Ministry of Health national collections and Statistics New Zealand which allows us to examine rurality, readmission rates, and post-discharge death.

The National Trauma Network report summarises the progress made against the key workstreams: service excellence, enablers, research, and governance.

This report is structured into the following sections:

The appendices cover summary notes on the methodology, the RACS Key Performance Indicators, and the publications of research into injury in New Zealand.

Report of the New Zealand Major Trauma Registry (NZ-MTR)

The NZ-MTR is a population-based registry which contains information on the most seriously injured people admitted to hospital.

The threshold for inclusion into the NZ-MTR is described in the national minimum dataset for major trauma. Put simply, it includes those patients with a serious injury to one body part, or moderate to severe injury to more than one body part, or who die from their injury regardless of the severity of injury. We use the Abbreviated Injury Scale (AIS) (version 2008) and the Injury Severity Score (ISS) which are used in trauma systems globally as a recognised standard.

In this report we have amended some of the results from last year. These are:

- Updated total due to an extract error from the NZ-MTR which resulted in around 200 cases missing
- Updated results for sTBI
- New methodology used for the standardised mortality ratio to provide a more refined approach
- Exclusion of deaths where the ISS was under 13, except where specifically noted.

We have noted where these amendments have resulted in substantial differences.

Incidence per 100,000 by region of definitive care

Nationally, major trauma case volumes have increased by 14% from last year. This increase has occurred unevenly across the country. The reasons for the increase are likely to be multi-causal and further work is signalled to understand what is driving the increase.

Patterns of major trauma

Incidence

National Incidence
48/100,000 (2,355)

Northern Region
38/100,000 (727)

Midland Region
53/100,000 (501)

Central Region
45/100,000 (414)

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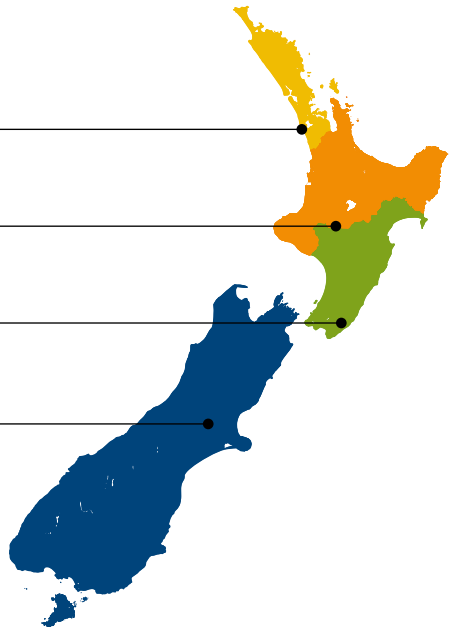
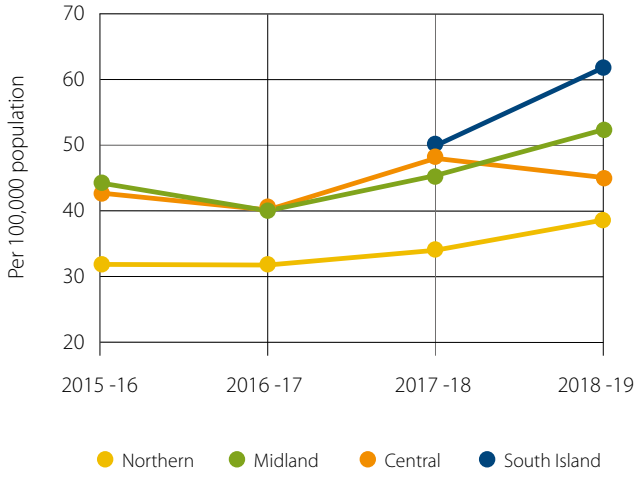
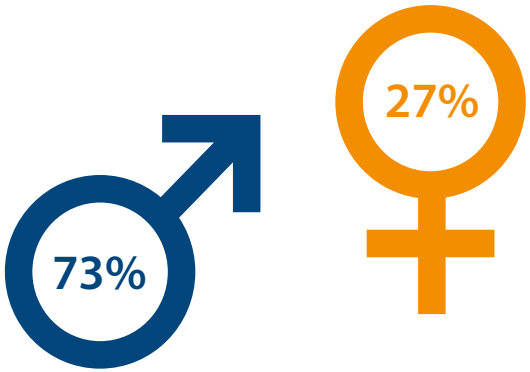




Sex

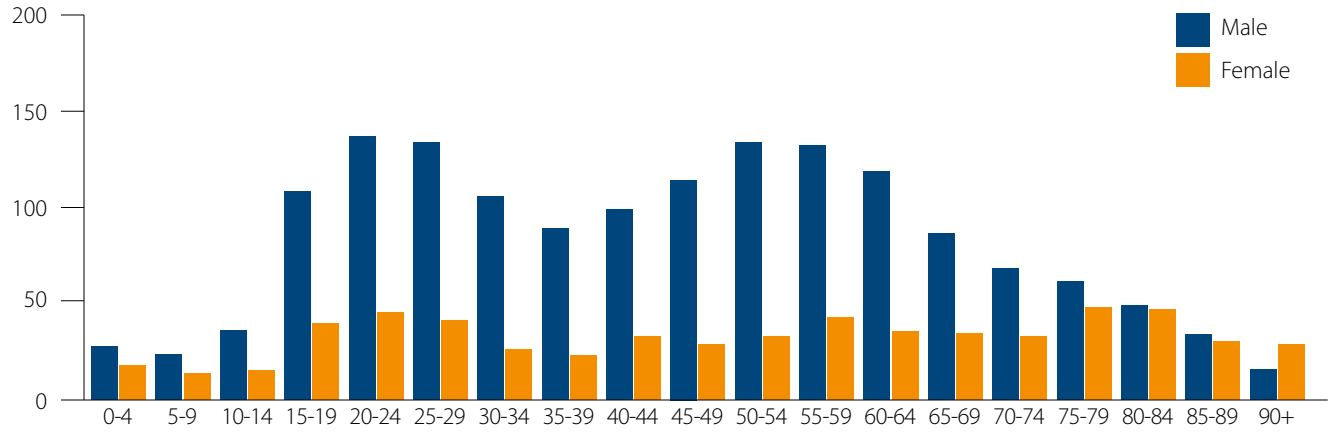


Trauma caseload is higher in males and are higher at every age except in those over 90. Males between the ages of 30 and 54 years have four times the rate for females of the same age.

When we look at the number of cases, there are two age peaks: one centred in the 20s, and one centred in the 50s. These patterns are most distinct in males – the distribution is flatter in females.

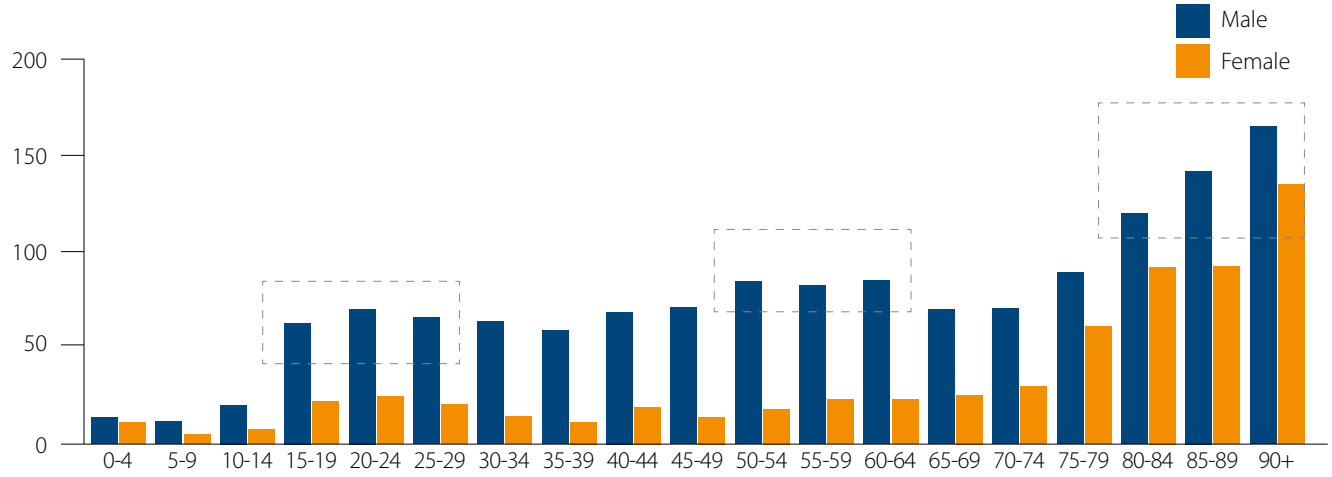
When we look at incidence, the rate is low until the later teen years when a sharp increase occurs. Then the three peaks observed in previous years continues. Rates for both males and females increase rapidly from age 75 and above. This peak is not seen in case volumes because of the relatively small population aged over 75 years.

Average major trauma cases per annum by sex in 5-year age groups



Date range: 2017-18 FY & 2018-19 FY

Major trauma incidence per 100,000 per annum by sex in 5-year age groups



Date range: 2017-18 FY & 2018-19 FY

Injury type

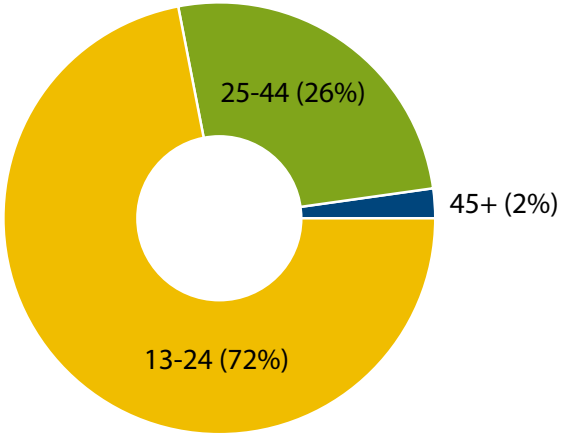
2018-19 cause of injury by region. Percentage of regional total (case volume).

	Fall	Assault	Other	Transport: All Transport	Transport: Car	Transport: Motorcycle	Transport: Pedestrian	Transport: Pedal cycle	Transport: Quad bike/other
Northern	28% (207)	9% (66)	10% (71)	53% (383)	25% (182)	13% (93)	6% (43)	7% (49)	2% (16)
Midland	21% (103)	7% (34)	11% (55)	62% (309)	33% (163)	14% (70)	5% (27)	7% (34)	3% (15)
Central	30% (124)	9% (38)	9% (38)	52% (214)	25% (104)	11% (44)	5% (21)	8% (33)	3% (12)
South Island	29% (205)	6% (46)	12% (86)	53% (376)	23% (163)	10% (70)	5% (38)	12% (82)	3% (23)
National	**27% (639)**	**8% (184)**	**11% (250)**	**54% (1282)**	**26% (612)**	**9% (277)**	**5% (129)**	**8% (198)**	**3% (66)**

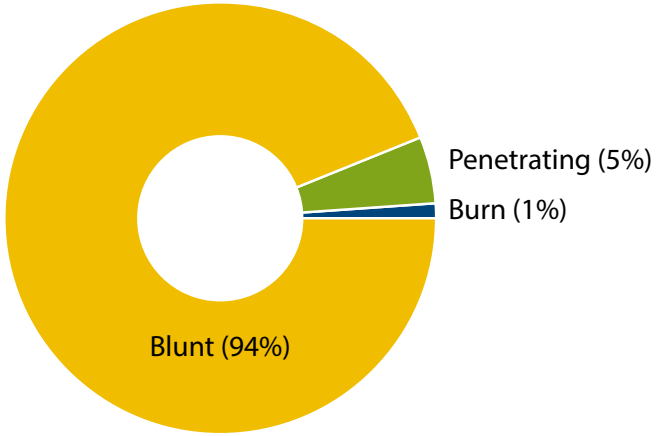
Date range: 2018-19 FY

Transport-related trauma continues to contribute to over 50% of the caseload (this includes on-road and off-road). Increased numbers of pedestrians and cyclists were seriously injured up 40 and 62 cases respectively from last year and that increase is seen across all regions. We will continue to monitor this trend particularly as transport modes change. It is noteworthy that approximately half of the assaults in the South Island are from people hospitalised from the mosque shootings in Christchurch.

Injury severity



Injury type

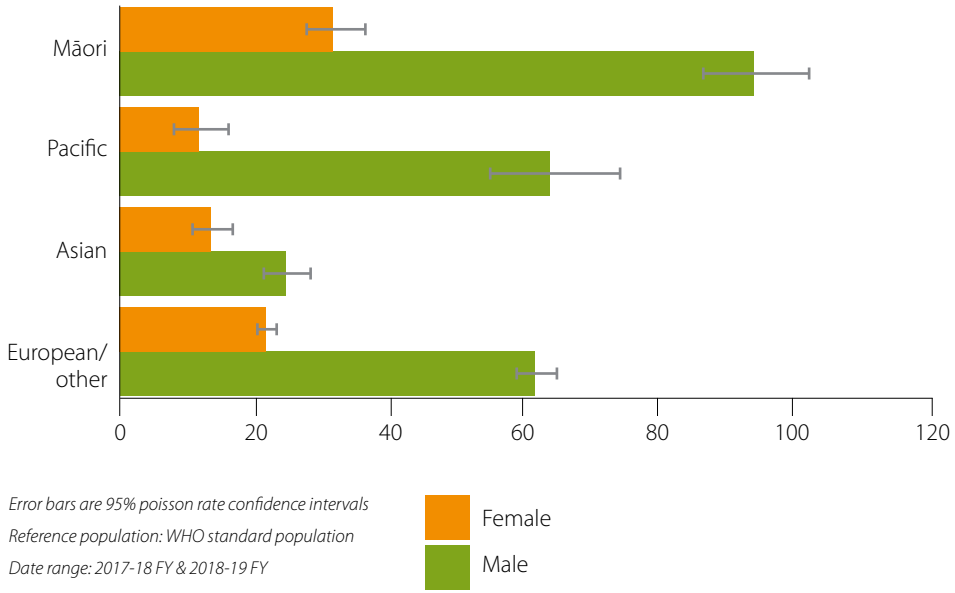


The proportion of penetrating injury has increased as a result of the Christchurch mosque shootings, but still remains similar to the rates seen in Australia. Other jurisdictions such as in in the United States and United Kingdom have higher rates of penetrating trauma.

Māori

The incidence of major trauma is 30% higher in Māori than in non-Māori (56 per 100,000 versus 43 per 100,000).

Age-standardised rates of major trauma by ethnicity and sex per 100,000



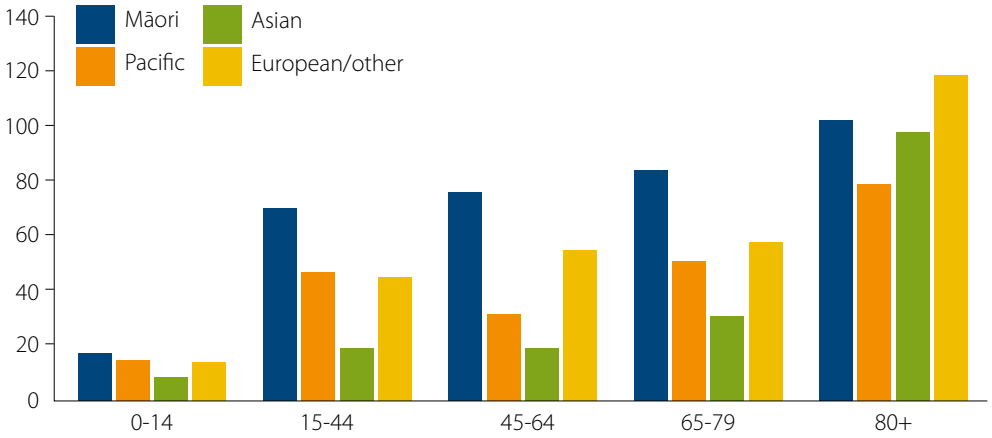
Error bars are 95% poisson rate confidence intervals
Reference population: WHO standard population
Date range: 2017-18 FY & 2018-19 FY

A primary challenge in working towards a collective national approach to trauma is ensuring that the right voices guide the discussions. Because of both the Treaty of Waitangi and the greater burden of trauma that falls on Māori, it is essential that a Māori voice is prominent in the work of the Network. To date, this has not been consistently the case and making sure we do better is an objective we are working to achieve.

We acknowledge that this current annual report focuses on the problem areas for Māori – the places where a deficit lies between Māori and non-Māori. While such deficits must be understood if we are to close the gaps that exist, we also know that a deficit view is both negative and largely informed by a Pākehā understanding of health. We wish to include a more compelling and complete view from Te Ao Māori in our future work.

Starting at a young age and continuing until through all age groups until 80 years, the burden for Māori is greater than the burden for other ethnic groups.

Annual major trauma incidence by ethnicity and age per 100,000



Date range: 2017-18 FY & 2018-19 FY

Although incidence of major trauma is higher for Māori, many of the patterns of injury and outcomes are similar for Māori and non-Māori including:

- Injury severity
- Cause of death and case fatality rate
- Time from injury to hospital
- Time to index CT

One area of difference is that non-Māori are directly admitted to their definitive care facility 82% of the time, compared to 72% for Māori.

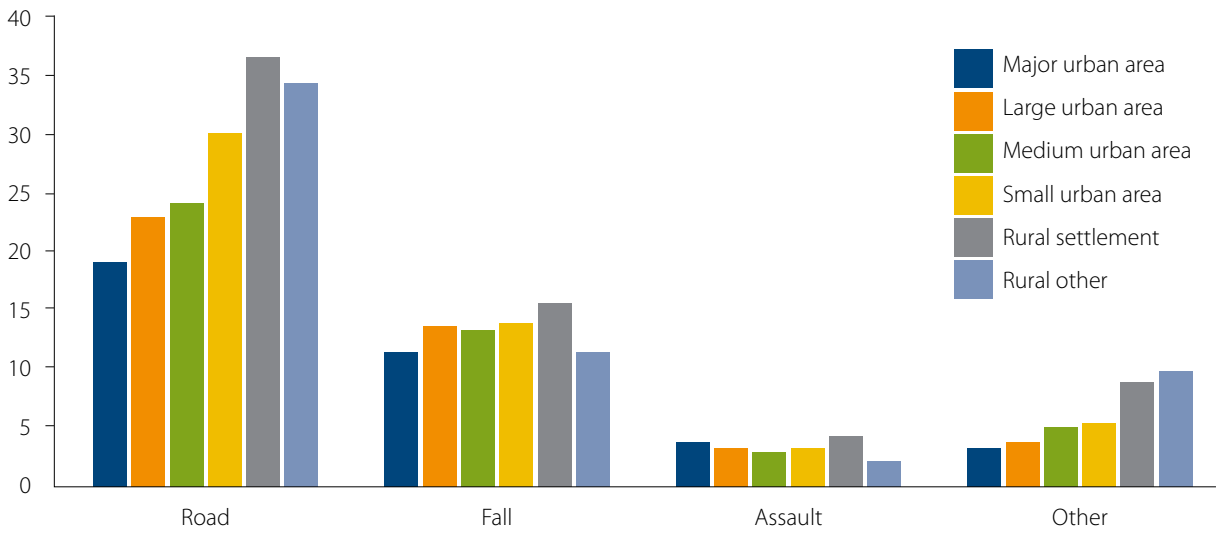
Future work for the Network will examine key aspects of trauma care with a greater focus on Māori perspectives on trauma and trauma care. Engagement with Māori is prioritised.

Urban and rural trauma

Urban and rural major trauma rates were examined on the basis of the domicile code where patients reside. This reflects where the person injured lived, and not necessarily where the injury occurred.

Residents of rural areas have substantially higher rates of transport trauma than urban residents. Similarly, "other" trauma (such as burns) occurs at a higher rate in rural dwellers.

Annual incidence of major trauma per 100,000 by urban/rural descriptor of patient domicile



DHB of service, and DHB of domicile

While our primary analyses of trauma rates designate trauma to the region of 'service' where definitive care was given, this does not necessarily relate to where patients reside. Specifically, injuries may occur while visiting other regions, and some injuries happen to people domiciled outside of New Zealand. When region of definitive care differs from region of domicile, the case can be considered exported by the region of domicile, and imported by the region of definitive care.

Regional 'import' and 'export' of major trauma cases by patient domicile

	Northern	Midland	Central	South Island	Unknown/outside NZ
Import	198	147	104	165	-
Export	116	170	128	70	130
Net	82	-23	-24	95	-130

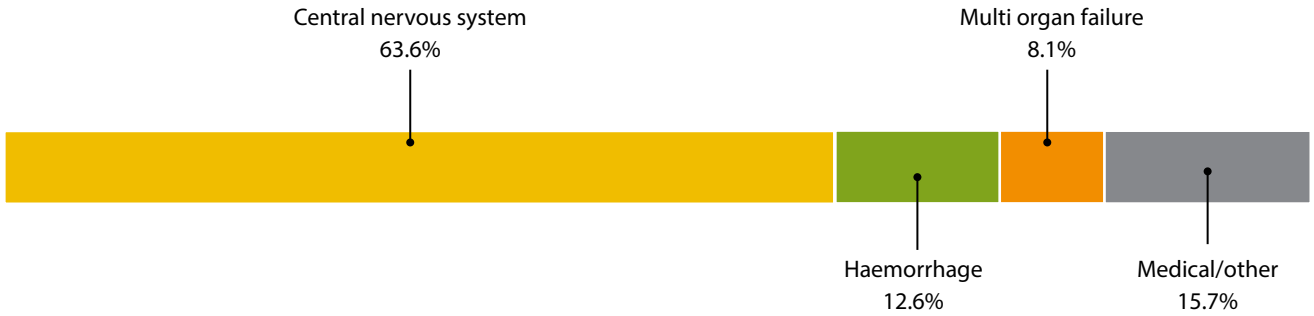
Both the Northern Region and South Island are net importers of major trauma, treating substantial volumes out-of-region trauma. This may have cost implications for the net importers if the cost of trauma care is greater than the cost reimbursed.

Patient outcomes

Cause of death

Death from haemorrhage and consequent multi-organ failure is potentially avoidable.

This year 12.6% of deaths were attributed to haemorrhage and while this is down from 15% seen in previous years, haemorrhage is identified as an area where future improvements may be possible.



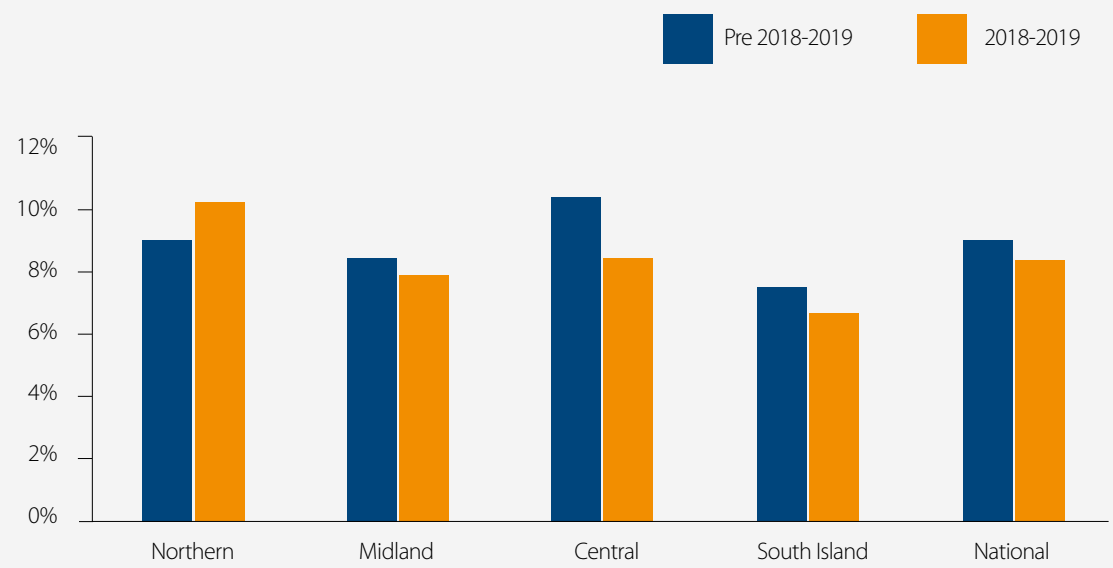
Case fatality rate

The case fatality rate (CFR) is the proportion of definitive care cases where the patient died in hospital. It is an unadjusted value, meaning it does not account for variation in case acuity, or patient factors such as age. This year there were 198 deaths across 2355 cases – a national CFR of 8.4%. This rate is nominally lower than the rate prior to 2018-19 (9.0%), although the difference is not statistically significant (two-proportion test, P = 0.488).

The NZ-MTR also records deaths in patients that do not meet the threshold by anatomical injury for major trauma (ISS < 13) but who died in hospital. Of the 82 patients with an ISS under 13, half were aged 80+ years, and three-quarters had medical/other as cause of death.

These results suggest there are few deaths with a low severity of injury and many of those that do die are likely to have age-related conditions which contributed to the death.

Regional case fatality rate



Standardised mortality ratio (SMR)

Many factors increase a trauma patient's risk of death, and contribute to the CFR, but are out of the control of the acute care setting. The standardised mortality ratio (SMR) adjusts for these risk factors and therefore improves comparisons.

The SMR is a model that predicts a risk of death using a patient's age, injury severity, vital signs on first arrival at hospital, comorbidities recorded on their admission, and injury type (see Appendix A). The SMR is calculated as the hospital's actual deaths divided by the number of deaths predicted by the model. An SMR of 1 means the actual number of deaths equals the number of deaths predicted by the model.

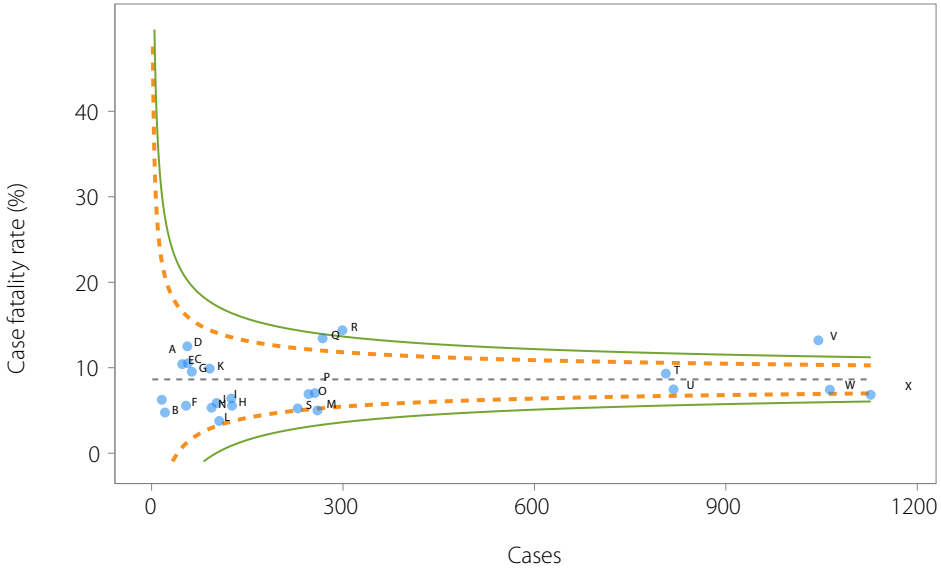
Hospital CFRs and SMRs are displayed on funnel plots, where sites are ordered by their volumes of major trauma cases. The letters denote the anonymised codes for individual hospitals.

The SMR represents a whole-of-system measure and cannot be used in isolation as a metric of hospital quality. For example, a hospital located in easy transport distance of many of its cases could receive more patients who would have died at scene or in transit if their injury event was more remote —increasing the SMR if they then die in hospital. Notwithstanding these caveats, the SMR is a more informative metric than the unadjusted CFR.

The unadjusted CFR funnel plot shows some hospitals have higher mortality rates which are outside of the normal range. The adjusted SMR funnel plot shows the same sites fall within the normal range. This means that no hospitals have a statistically significant higher fatality rate, and two hospitals have a statistically significant lower fatality rate.

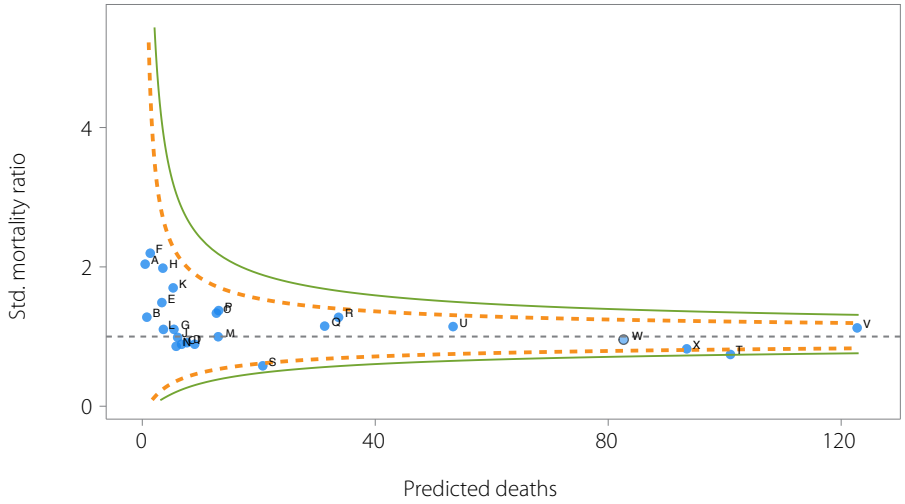
For consistency with previous reports, we also display the SMR as a bar chart on the next page

Case fatality rate (unadjusted)



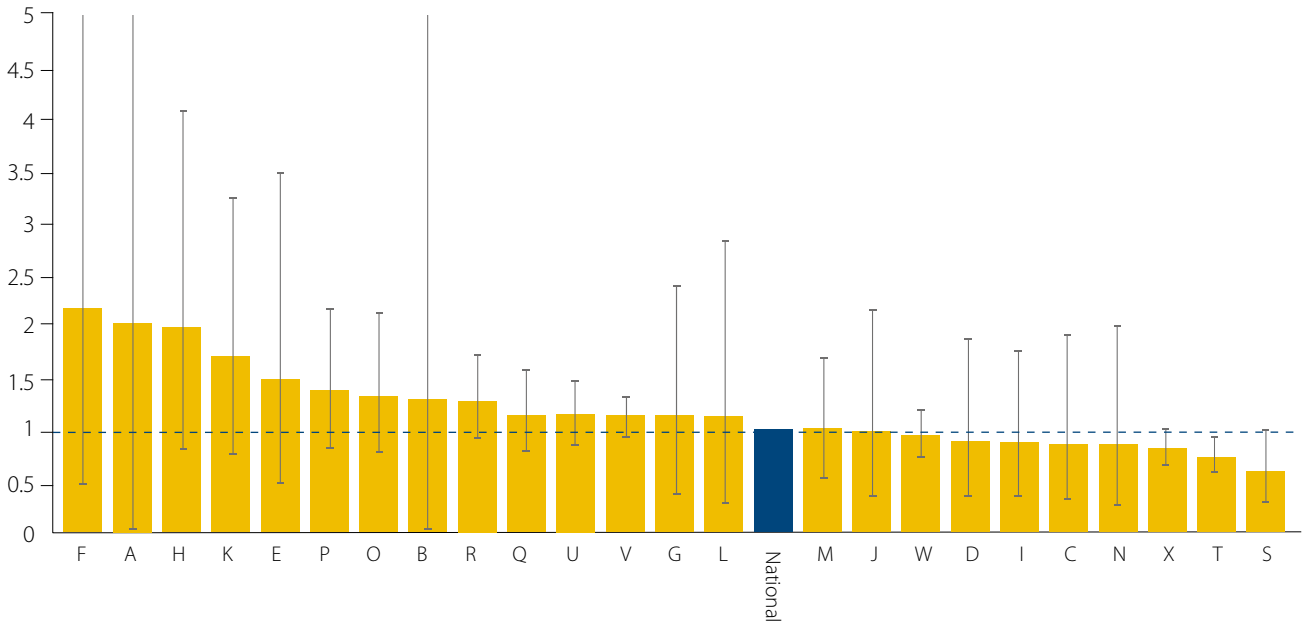
Date range: 2015-16 FY to 2018-19 FY

Standardised mortality ratio



Date range: 2015-16 FY to 2018-19 FY

Standardised mortality ratio by hospital



Date range: 2015-16 FY to 2018-19 FY

No hospitals have statistically significantly elevated standardised higher mortality ratios. There are two hospitals ('S' and 'T') that have SMRs that are statistically significantly lower than 1 (poisson test, P=0.049, P=0.002 respectively).

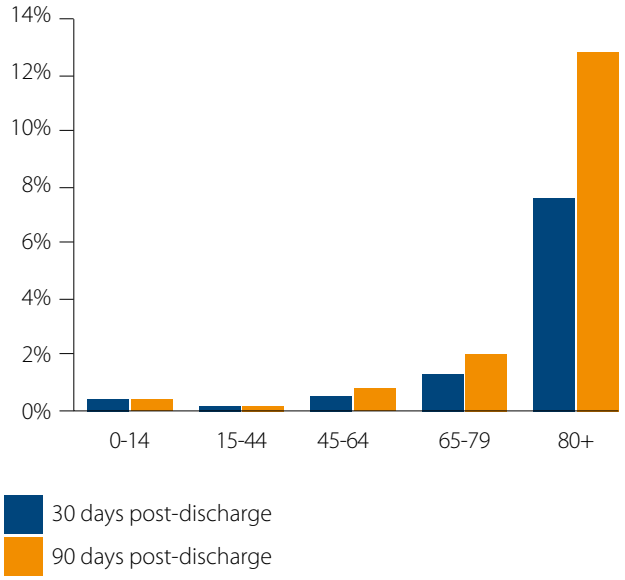
CFR by hospital size (Small <50 cases; medium 50-150 cases, large >150 cases)

	Small	Medium	Large
2018-2019	5.3%	8.6%	9.0%
Pre 2018-2019	8.0%	9.5%	9.0%

While there was evidence that the CFR was higher in medium-sized hospitals in the previous year, this year no statistically significant variation is apparent between medium and large hospitals.

Deaths after discharge

Patients with major trauma are at an elevated risk of death after discharge from hospital. We examined two time points: 30 days and 90 days after discharge, and split the patient cohort by age. Eleven people died at 30-days and 28 people died at 90 days post discharge. This number of deaths increases substantially with age from 65 years onwards.

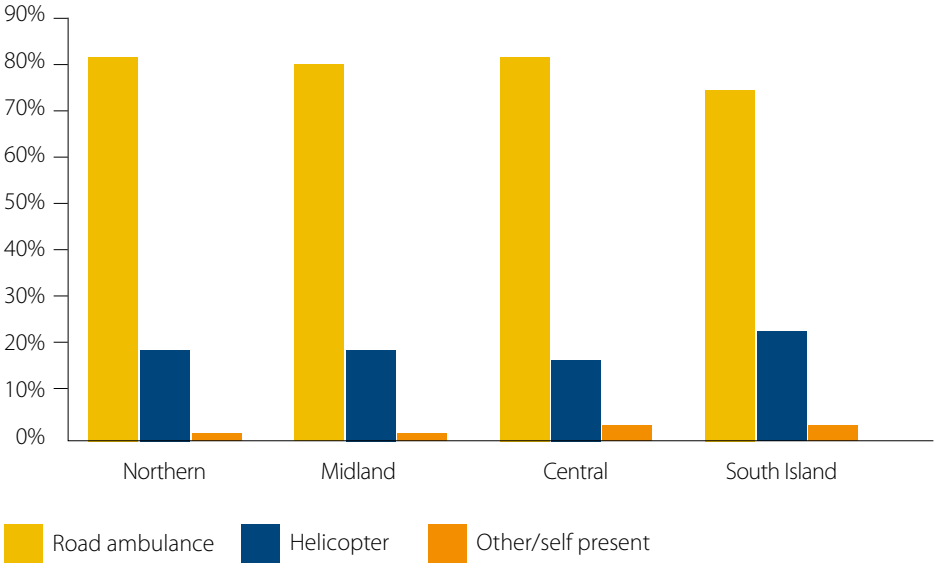


Processes of care

Mode of transport to hospital

The majority of major trauma patients arrive at hospital by road or air ambulance. A small number reach hospital by other means, such as private transportation or by police/prison transport.

Mode of transport to first care hospital



Date range: 2017-18 FY & 2018-19 FY

Patients in South Island were more often transported by helicopter than patients in other regions, although the difference is small (23% vs 18%, 2-proportion test, P = 0.001).

Transfers to definitive care

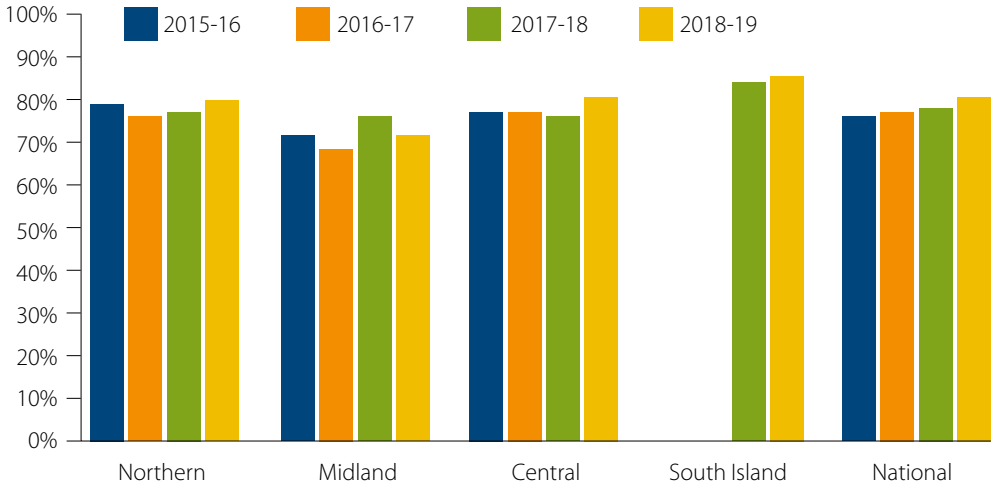
The pre-hospital major trauma triage guideline and destination hospital policy was introduced in the ambulance services in March 2017.

The rate of direct admission from scene to definitive care has improved from 79% the previous year to 81% this year although the difference is not statistically significant (two-proportion test, P = 0.141). However, regional differences are noted.

Fewer patients transported by helicopter from scene were subsequently transferred to an additional facility for definitive care than those transported by road ambulance.

These results suggest we are heading in the right direction towards achieving an effective trauma system where as many patients as possible are transported from scene to the most appropriate hospital that can provide definitive care.

Patients who were transported directly to definitive care facility

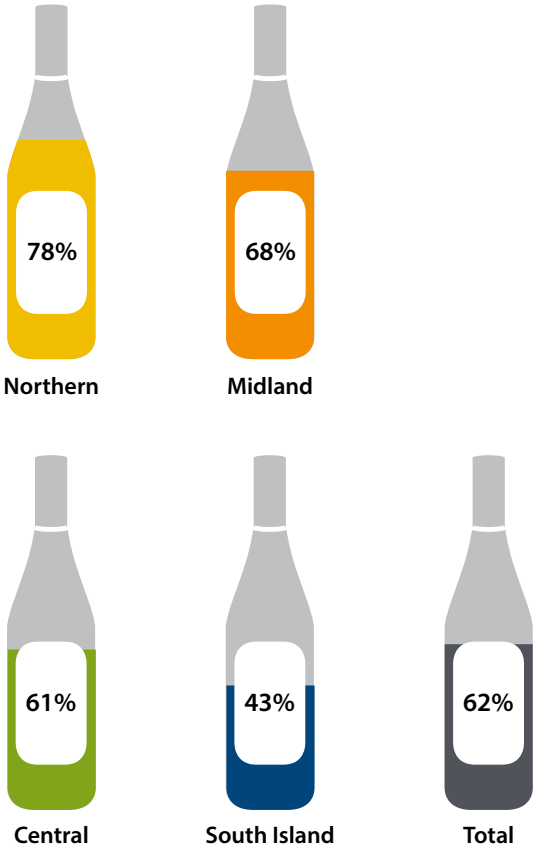


Date range: 2015-16 FY - 2018-19 FY

Blood alcohol concentration collection rates

Rates of recording blood alcohol concentration (BAC) varies substantially between regions. The Northern Region has a significantly higher rate of BAC collection than the national rate (2-proportion test, $P < 0.001$), while the South Island has a significant lower rate of BAC collection (2-proportion test, $P < 0.001$). The collection rate has increased 14% from last year.

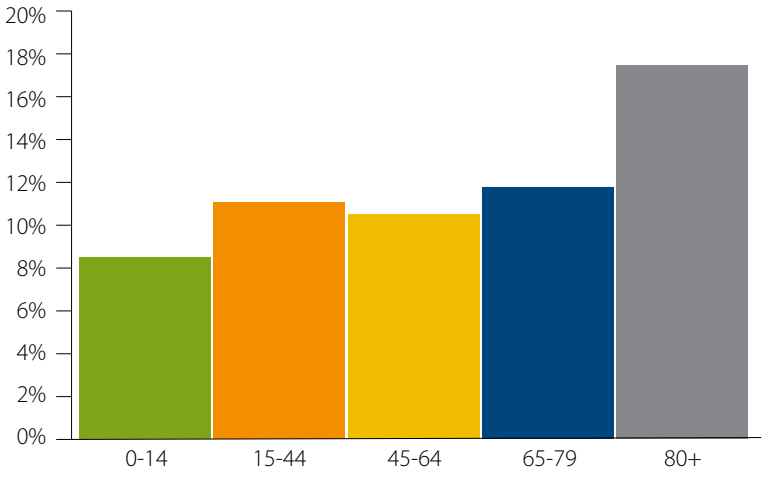
Percentage of major trauma patients whose blood alcohol concentration was recorded.



Readmissions within 30 days of discharge

An acute, unplanned readmission is not a good outcome for the patient or for the hospital. Although not necessarily related to the original hospitalisation, readmission can imply, amongst other possibilities, that the initial discharge from hospital was premature, and/or the appropriate support was not in place to support care post-discharge from hospital.

30-day acute unplanned readmission rate by age



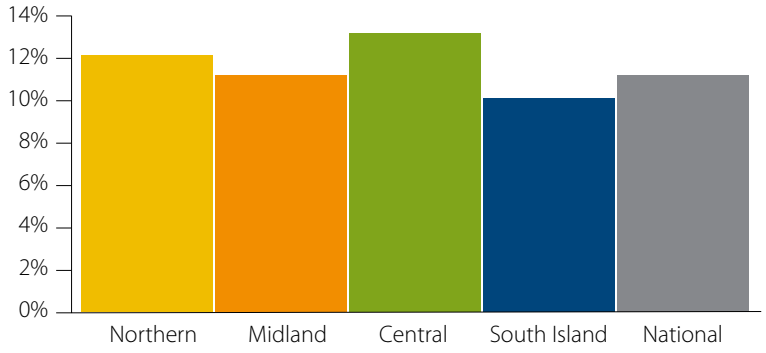
Date range: 2017-18 FY & 2018-19 FY

The average readmission rate is 11%, however patients with a higher injury severity (ISS >45) have an 18% risk of acute readmission compared to 10% in the ISS 13-24 category.

Readmission rates varied modestly between regions, and these small differences were not statistically significant. Perhaps not surprisingly, the risk of readmission increases with severity of injury and with age. Further work is needed to understand the drivers of the readmission rate to see if it can be reduced.

There is a clear association between unplanned acute readmission and high ISS and older age groups. This is important to understand so patients at-risk of readmission can be identified and managed.

30-day acute unplanned readmission by region of definitive care



Date range: 2017-18 FY & 2018-19 FY

Focus areas

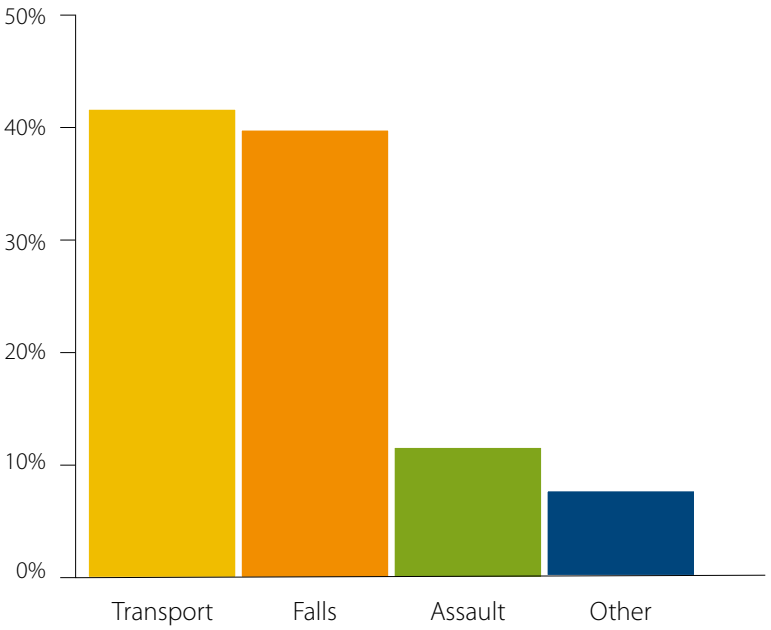
We explore serious traumatic brain injury and the impact of the Christchurch mosque shootings.

Serious traumatic brain injury

Serious traumatic brain injury (sTBI) is identified as an injury to the head graded with a severity of 3 or higher on the Abbreviated Injury Scale (AIS), an international measure of anatomical injury.

More than a third of all major trauma patients sustain sTBIs (35%). Patients with sTBI have a higher risk of death than other major trauma patients. While not all sTBI patients require surgical intervention, multi-disciplinary care and the ability to react quickly are important to improve outcomes for patients with sTBI.

Percentage of sTBI caseload by cause of injury



Date range: 2017-18 FY & 2018-19 FY

Falls and transport injuries are most strongly associated with sTBI.

Complex sTBI, which means the patient has both a significant head injury and an injury to another body part, occurs more commonly in transport trauma and in the 15- to 44-year-old age group. Falls frequently result in isolated head injuries.

Corrina's Story

It's been two weeks since I arrived at ABI, and six weeks since my crash. I was driving on my way to work, and the next thing I knew I woke up in hospital. People started telling me about how my car flipped going 100kmph down the road, how a tree had crushed my side, how no air bags went off and how I had been in a coma for 4 days. I had no memory of the crash, I was just terrified because all I knew was, I was meant to be at work and now I'm in the hospital.

The crash caused a head injury, broken arm, multiple fractures to my spine, pelvis, hip and ribs so I couldn't walk. After staying at Wellington Hospital in bed for 13 days and after being transferred to Hutt Hospital I was bored and luckily an opportunity came up to move to ABI. So, I took up the chance to be in a new environment.

This wasn't my first brain injury, I have had two concussions from soccer before this, so it was like an old injury had gone worse. People don't notice it; it's silent and not everyone can see the effects of it. As I'm recovering, I can really tell how much of a difference the injury had made to how I normally am. I can tell my brain is getting better because at first I couldn't think of the exact words I wanted to say, and instead I would use other words to replace them. I was also sensitive to light and had double vision so I couldn't make out faces properly. That's getting better now.

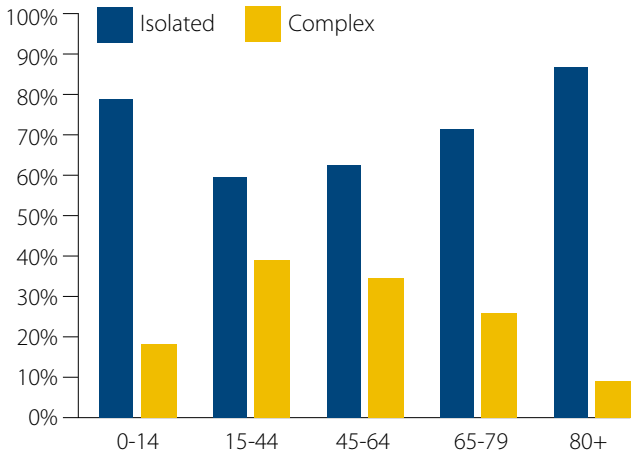
I'm thankful for the strong support I have, helping me come to terms with what had happened. I'm a fit person, I always have been. I was an outside kid, and that's how I've approached my rehabilitation. I don't overwork myself, I eat my vegetables and just do what is good for me. Here they teach you, you are important, and you come first. When it came to my recovery, I really had to learn to care for myself first but it's hard because usually I'm looking after everyone else.

I leave in a month's time. I'm looking forward to being close to my family again. I'm making choices that remove stress from my life, especially so I can spend more time with my son and partner. My son is only four years old and I'm not sure if he really understands what has happened or how he feels since he saw me in hospital. I want to recover well for myself and for him.

I want to thank everyone who has been supportive of me and my partner through the times I was in hospital, and also ABI for helping me through my recovery. They have been awesome.

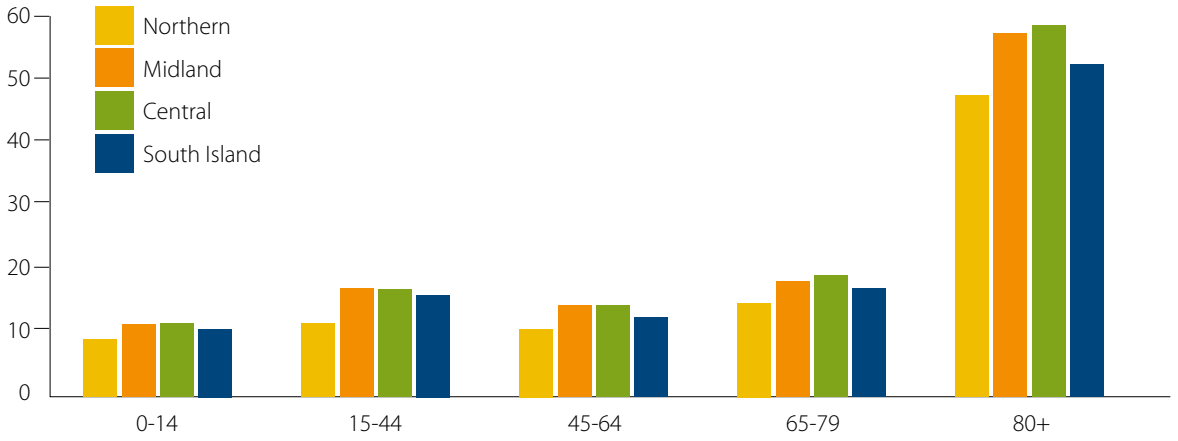
ABI: Acquired Brain Injury (ABI) Rehabilitation.

Complex and isolated sTBI by age



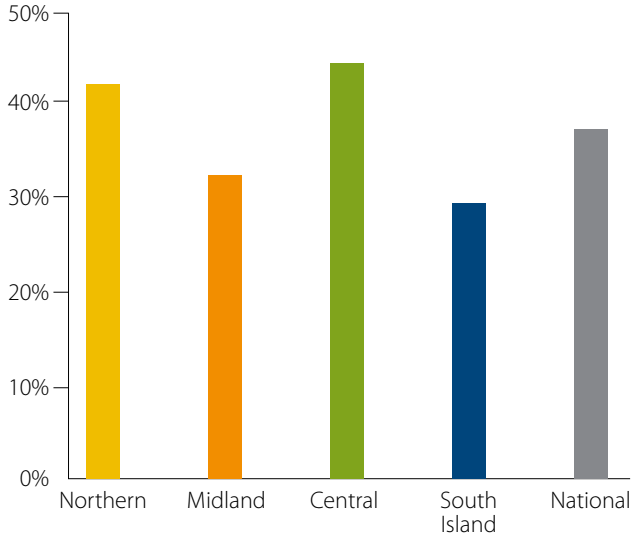
Date range: 2017-18 FY & 2018-19 FY

Incidence of sTBI per 100,000 by age and region of domicile



Date range: 2017-18 FY & 2018-19 FY

Regional variation in the proportion of major trauma patients with sTBI



Date range: 2015-16 FY & 2018-19 FY

The Midland and Central regions have higher domiciled incidences of sTBI in all age groups. There is some variation in sTBI rates between age groups, with substantially elevated rates in the 80+ age group.

	Isolated sTBI	Complex sTBI
2018-19 sTBI, n = 822	**% (n)**	**% (n)**
As proportion of all sTBI	69% (567)	31% (255)
As proportion of all major trauma	24%	11%
sTBI patient subset with GCS ≤9 at scene	22% (122)	41% (104)
Of GCS <9, intubated prior to hospital	37% (45)	52% (54)
Time to CT under 2 hours All major trauma = 71% All sTBI patients = 76%	National: 72% (303) Northern: 80% Midland: 79% Central: 68% South Island: 60%	National: 85% (179) Northern: 85% Midland: 93% Central: 78% South Island: 84%
Case fatality rate All major trauma = 8% All sTBI patients = 17%	14% (78)	24% (61)

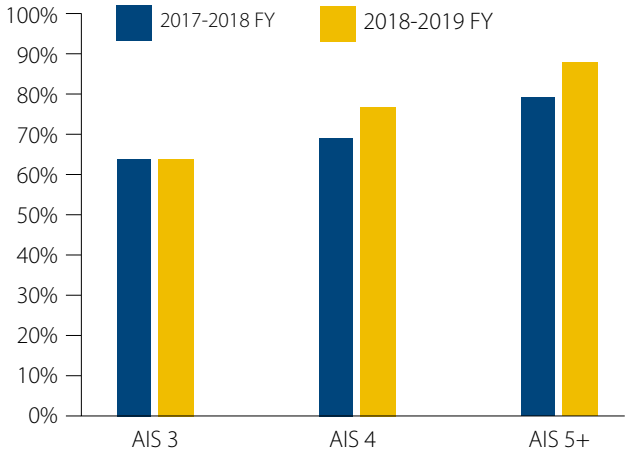
**GCS: Glasgow Coma Scale; GCS < 9 is indicative of a serious head injury*

Date range: 2018-19 FY

The number of patients intubated at the scene has increased from 67 to 99, which could reflect the increased numbers of paramedics trained in Rapid Sequence Intubation.

The time of arrival at first hospital to first CT is important as CT is the primary diagnostic imaging tool to confirm an sTBI. Ideally almost all sTBI patients would receive a CT under two hours. It is pleasing to see the percentage of patients with sTBI who had a CT increased from 52% to 76% which should result in faster diagnosis (but only in those regions which have improving time to CT).

Proportion of sTBI patients given definitive care at neuroscience hospital by head injury severity



Date range: 2017-18 FY & 2018-19 FY

The percentage of sTBI patients who receive definitive care at a centre with neuroscience capability has increased overall from 75% to 77%, and the increase is mainly in the more severely injured AIS 4 and 5 groups.

Proportion of sTBI patients given definitive care at a hospital with neuroscience capability

	Yes		No
Region	**Direct from scene**	**After transfer**	
Northern	50%	26%	24%
Midland	50%	26%	24%
Central	39%	23%	38%
South Island	75%	9%	16%

Date range: 2017-18 FY & 2018-19 FY

This table shows there is substantial variation in care of sTBI depending on what region a person was injured in. Those in the South Island have the greatest chance of being managed in a neuroscience hospital, while those in the Central Region have the least.

Time from injury to definitive care hospital for sTBI patients differs marginally between regions and could likely be explained by geographical distance.

Median time from injury to definitive care (hrs)

Region	**Direct from scene**	**Transferred for definitive care**
Northern	1.2	6.9
Midland	1.4	9.3
Central	1.4	10.6
South Island	1.7	9.7

Date range: 2017-18 FY & 2018-19 FY

For the patients with sTBI who required transfer from a first hospital to definitive care hospital, the median time from injury to definitive care is 6.8 hours. For 17% of those transferred patients, the time from injury to definitive care is 24 hours or longer.

These results imply there is ample opportunity to improve the identification of sTBI and to transfer much faster than is currently done.

Christchurch: the story in data

On March 15, 2019, terrorist mass shootings were perpetrated against the Christchurch Muslim community at two mosques. On that day, 49 people died from their injuries before reaching hospital. Many more injured were able to reach the nearby Christchurch Hospital where 118 people were treated, of whom 45 were hospitalised. Just over half (24) of those hospitalised were major trauma patients (ISS ≥ 13), two of whom were subsequently transferred to Auckland.

To put this day in perspective, Christchurch Hospital has an average of one major trauma case admitted per day. On this day 24 major trauma patients arrived in rapid succession within 45 minutes, along with nearly 100 less severely injured patients. The mechanism of injury for wounds caused by caused by firearms is a relatively unusual occurrence in New Zealand.

We acknowledge the tragic deaths of two patients who died in hospital, along with the 49 others who died in the peaceful practice of their faith at the mosques. It is a testament to the remarkable care of the Christchurch Hospital that 43 of the 45 people who were admitted survived their injuries, in the midst of ongoing security concerns. The efforts of Burwood Hospital and Auckland / Starship Hospital are also credited.

Major trauma cohort

ED length of stay ranged from 14-44 minutes

Average length of stay: 24 days (total bed days: 545)

Average ICU stay: 5.5 days (total ICU bed days: 127)

Average ISS: 25 (range:13-75)

Photo: Stuff Ltd

Adeeb's story

On Friday 15th March I dropped off my daughter at a cafe and went to Friday prayers at Al Noor Mosque. The Imam had just started his speech before Friday prayer when we heard a popping sound and I took the first bullet in my hip. I shouted when I saw my son Ali dialling 111 asking for help, I asked him to switch off the phone and lay down as I could hear the shooting going on outside. I hugged him and we pretended that we were dead when the gunman came back and started shooting everybody around me. I got the second bullet in my shoulder and I lost my friend who was praying next to me who was shot and lay dead on the floor beside me. After the first round of shooting some of us started calling to God loudly in Arabic and the gunman came back and shot them one by one after noticing that they were alive.

After the gunman left a second time I saw Ali stand up and I was so happy he was not hurt. Ali started giving me first aid by removing my jacket and putting pressure on the holes to stop the bleeding.

When the SWAT team came, I first thought the shooter had come back for a third time because they were wearing the same guise. They took Ali away and I asked to go to hospital but had to wait as SWAT started with men in worse condition than me. I noticed others were calling for help but there was no first aid inside the mosque. In the emergency area at Christchurch Hospital they asked me what my name and date of birth was. All I can remember is no one touched me until I got to hospital, and after that I have no memory until I woke up in Intensive Care.

I still have fragments of bullets in my body. The first bullet shattered my pelvis and exploded and damaged my kidneys and stomach. I have had four operations now and mostly healed.

I have some experience of this from Iraq where we had car bombings in Baghdad, and during the Iran-Iraq war we came under fire for 6 hours and many people died, however the view on this day was so painful and cannot be erased from my memory, seeing my friends killed in this horrible way will not leave me forever. Although I am alive and have made new friends and a new life which will help me to heal in a proper way, I did not expect to come to New Zealand to see more shooting.

I consider that the main thing which helped me to go back to normal life is that I went back to work as soon as I could because trying not to think about what happened will be the main treatment that will help me to recover. I'm 90% back to normal but of course have a lot of pain related to the fracture of the pelvic area and the wounds in large parts of my body.


Life Flight

National Trauma Network Report

Highlights of the year

A critical milestone was reached with the approval from the ACC to fund a 5-year partnership. This funding will enable a more sustainable approach to the national trauma network and support efforts to improve outcomes for trauma patients.

Here are the highlights across the four priority areas.

1

Governance

ACC entered into a contract with Health Quality and Safety Commission (the 'Commission') in early March 2019 to deliver key aspects of the business case:

- Quality improvement
- Research, including the long-term outcomes of major trauma patients
- Analytics and data science

The Commission was selected as a key partner because of its focus on healthcare quality improvement, its Māori engagement, consumer engagement, and business intelligence expertise. It is an important and independent part of the health system. Detailed planning for the next four years work was commenced.

A review of the NZ trauma system by the Royal Australasian College of Surgeons resulted in 69 recommendations of which over 50 were incorporated into the workplan.

Regional trauma networks have continued to evolve with a range of interesting work underway such as clinical audits, reviews of deaths, and research on topics such as cost of care, patterns of injury, and patient outcomes. The resourcing of regional networks is variable and a constraint to progress particularly in the Central and South Island regions.

Rebranding of the Network has simplified the name and has been translated into Te Reo Māori to reflect our bicultural focus and commitment to Te Tiriti o Waitangi.

2

Service excellence

The first audit of the pre-hospital destination audit was undertaken and found reasonable compliance to the policy in most areas of the country. Compliance was lower in metropolitan Auckland possibly because there is more choice of hospitals.

Around 80 clinicians were trained in trauma performance improvement (the TOPIC course) by two eminent US trauma clinicians.

The Commission's quality improvement priorities were identified: critical haemorrhage, rehabilitation, and serious traumatic brain injury. Work is underway to plan the programme of work in more detail and build the case for change.

NATIONAL TRAUMA NETWORK

3

Enablers

Workforce

There have been continuing improvements in workforce sustainability. The specialist trauma nurse workforce has doubled over three years from 15 to 30, and more nurses are in permanent roles. More medical time is given to developing trauma services, and DHB executives are strengthening their priority on trauma despite competing pressures. Notwithstanding these gains, serious resource constraints persist in a small number of hospitals which puts considerable strain on the trauma teams.

Trauma education and training opportunities continue to increase, and are supported by the ACC Incentive Fund, paid pro rata for data input to the NZ-MTR.

A pilot of trauma team training was started using a high fidelity NetworkZ operating theatre simulation adapted for Capitilist Emergency Departments. This pilot has received overwhelmingly positive feedback and resulted in tangible changes to team communication and processes in the resuscitation of trauma patients.

A professional development framework for trauma nurses has been developed and published.

Early work has begun on trauma care after resuscitation to improve the capability of nurses and Allied Health staff in the care of trauma patients in hospital wards.

Registry

The NZ Major Trauma Registry now has records for more than 7500 major trauma incidents. The registry holds a full national collection for two years and full regional collection for an additional two years across three trauma regions. Ongoing data collection is undertaken by data collectors who are trained in the Abbreviated Injury Scale, the international standard for trauma coding. This coding allows us to benchmark injury type and severity with other jurisdictions. This population-based clinical quality registry is a key asset to the trauma system as it provides the data which we can transfer into information to inform change.

The Registry is currently hosted by Waikato DHB and has performed well, however there is work underway to procure a new solution to take us into the future.

4

Research and analytics

We are fortunate to have recruited Professor Belinda Gabbe to lead the research programme at the Commission. Belinda heads the Prehospital, Emergency and Trauma Research Unit at Monash University. Her publication record is a testament to her forward-thinking research programme, and she is held in high esteem internationally.

While our research programme is in the embryonic stage, some research has been undertaken. The Study of Road Trauma Evidence and Data (SORTED) collaboration links data held in seven databases by five agencies to provide, for the first time, an objective and quantifiable view of road trauma in New Zealand. The study was presented at the Australasian Road Safety Conference in Adelaide in September.

The NZ Major Trauma Registry Governance Group approved 21 proposals to use data held in the registry for internal and external research. The research includes:

- data sharing agreements between agencies,
- the burden of trauma for Māori
- pre-hospital mortality
- geospatial analysis of trauma across New Zealand
- benchmarking outcomes for trauma between New Zealand and Australia

A subset of the Registry comprising the seven large trauma hospitals has been included into the Australian (New Zealand) Trauma Registry. This enables us to benchmark key indicators across a much larger jurisdiction.

Broader developments in the trauma system

The air ambulance strategy has been progressively implemented across the country to enable a more consolidated pre-hospital transport system. The fleet has improved with larger helicopters that have greater range, and a more coordinated approach to dispatch with the introduction of a centralised Air Desk.

The inter-hospital transfer system is evolving and work is underway to understand where issues lie, such as delays in transfer from first hospital to a definitive care hospital and inconsistent patient run forms..

There is missing information on location of injury and other information electronically recorded due to the strike action that affected some ambulance services in the first six months of 2019.

A collaboration of rehabilitation providers in the northern region has formed a group to identify areas where they can work together to improve outcomes for rehabilitation clients.

ACC has developed the Escalated Care Pathway project which is a new system of purchasing integrated surgical and rehabilitation services, transitioning away from the current siloed inputs-based purchasing to a whole-of-system outcomes-based approach.

ACC has also developed the new generation claims management system which is expected to result in more support for seriously injured clients.

Plans for 2019-20

The priority areas of focus for 2019-20 are on:

- Embedding the partnership with the Commission as a key delivery partner
- Implementing the new Registry
- Implementing the quality improvement programme focussing on:
  - critical haemorrhage to achieve an aspirational goal of zero haemorrhage deaths
  - rehabilitation to identify the opportunities to ensure trauma patients are supported to reach optimal recovery and re-enablement
  - serious traumatic brain injury
- Building the research programme by collaborating with academic researchers across NZ universities, 'internal' programme research, and developing the next generation of researchers
- Business intelligence to continue development of a trauma dashboard tool for DHBs and inform the research and quality improvement programmes
- Consumer and Māori engagement and co-design particularly within the rehabilitation workstream

Awards and recognition

- Royal Australasian College of Surgeons verified Waikato Hospital as a Level 1 trauma centre.
- Dr Ian Civil, Clinical lead of the trauma network, has received two prestigious honours:
  - Prize of the "Société Internationale de Chirurgie" at the 48th Annual World Congress of Surgery,
  - Honorary Fellowship from The American College of Surgeons.
- Matt Sawyer has been accepted into the Faculty of AAAM to become New Zealand's first Abbreviated Injury Scale trainer.
- Two members of the trauma network received honours from the Order of St John for their services: Dr James Moore was appointed Commander and Bridget Dicker Officer of the Order of St John.
- Paul McBride and Alaina Campbell were awarded for Best Data Presentation and Best Clinical presentation at the Trauma Nursing & Data Management Forum held at Trauma 2019 in Sydney.

Regional trauma network reports

Northern Region Trauma Network (NRTN)

A new clinical lead has been appointed for NRTN with continuing support by the Northern Regional Alliance for project management.

A significant focus over the last year has been on nurse education and up-skilling both Emergency Department and inpatient ward nursing care. NRTN sponsored a Trauma Nursing Critical Care (TNCC) course in Northland that was attended by 21 nurses from around the Northern Region. Four more nurses from the region were also sponsored to attend another TNCC course and another two nurses attended the Emergency Management of Severe Burns (EMSB) course.

NRTN has researched what inpatient trauma nurse and allied health education is currently available nationally and internationally. A workstream has been created to identify what education is required to upskill our current multidisciplinary workforce.

Two very successful trauma education evenings have been sponsored by NRTN. St John Ambulance hosted the first with well over 100 attending and live streaming. The second was hosted by Starship Hospital with approximately 460 attendees and live streaming. The Northern Regional Trauma Network website www.northerntrauma.co.nz has the videos of all presentations.

Along with up skilling the trauma nurse workforce and education evenings the ACC Incentive Fund has also sponsored attendance at the AIS course, eight nurses attended Injury 2018 conference and a nurse attended the Trauma, Critical Care and Emergency Surgery Conference (SWAN) 2018.

The Northern Region's retrieval guidelines and inter-hospital transfer guidelines implemented the previous year have been very successful. Regular clinical case audit reviews have occurred over the last year to monitor and support the on-going refinement and adherence to the transfer guidelines.
The guidelines are published on the website.

Midland Trauma System (MTS)

The MTS team continues to provide clinical support services in all the Midland DHBs, backed by a comprehensive regional trauma registry that captures patient data on all age groups and injury severities admitted. We documented over 7200 admissions to Midland hospitals in the last year involving 27,882 bed days at a cost to our hospitals of over $47 million.

Māori in our region are on average 20% more likely to be hospitalised due to an injury and the numbers are increasing. This is especially prominent in the 15-34 age group. Older person trauma is also on the rise and we are revealing inequities in both the incidence of injury and delivery of care. Falls continue to be the greatest cause of injury and will be the topic of more focused research over the next year.

This regional data provides a robust platform for evidence-based system analysis and forms the backbone of our Trauma Quality Improvement Programme (TQIP). Components of the programme this year include:

- Formal verification by the Royal Australasian College of Surgeons was given to the region with Waikato Hospital gaining Level 1 status; the highest level possible and a first for New Zealand.
- Integrated regional work plans have been developed across the five Midland DHB trauma services to ensure integration and collaboration of work. The work plans incorporate regional priorities, local DHB work and recommendations from the RACS verification reviews. This framework enables us to learn from each other, share resources and understand how pieces of work contribute to the overall health goals of our region.
- A region-wide trauma education and training needs assessment was completed for Midland clinical staff. A regional working group is finalising recommendations for a 5-year plan to promote and provide access to consistent best practice trauma education and training
- Hosting of the third regional trauma symposium attended by 140 of our regional and national colleagues who represented all stages of the trauma system response.

Jennifer Dorrian, Waikato DHB trauma nurse, retired in 2019 after 40 years. "Keeping the patient and whanau/families informed is very important and keeps everyone on the same page. I was especially pleased to be part of the team to achieve Trauma verification for Waikato Hospital. "

Read the full story here.

Photo: Dominico Zapata/Stuff

The Midland Research Trauma Centre (MTRC) has produced a number of published peer-reviewed papers in the last 12 months describing patterns of trauma in our communities and revealing opportunities for system improvement and injury prevention. Our goal is to turn data into information. Several papers have incurred national interest sparking conversation and debate.

A recent paper on cycling injuries reviewed policy direction and cycling injury admissions to Midland Hospitals. It gained national public interest resulting in wide media exposure and statements from the Minister of Transport regarding policy direction.

This type of work aligns well with the MTRC strategic plan 2019-2022 which recognises the high social, economic and medical burden of trauma to patients, their whanau, communities and the health system, and therefore focuses its attention on a systems approach to reducing trauma.

MTS intends to grow its work and community-based linkages over the next few years to maximise the use of its staff and information systems for the benefit of Midland communities.

The Incentive funds have been used this year to support:

- AIS course attendance
- AISC-B Coding Exam
- 4 regional TNCC trainings
- Support for regional DHB clinical staff to attend the regional MTS symposium
- Support of the paediatric education evening in each DHB


BEDS
Westpac
Life Flight
PAKnSAVE
SELLAR
SELLAR
RESC
Life Flight

Dr Peter Hicks, Intensivist and first clinical lead of the Central Region Trauma Network. Peter's drive and passion for trauma care and his inspiring leadership has left a legacy of excellence in trauma care in the region and nationally.

Photo: Dominico Zapata/Stuff

Central Region Trauma Network (CRTN)

It has been a somewhat challenging year for the Central Region. October 2018 sadly saw the death of Dr Peter Hicks following a medical event on Mt Cook. Peter was instrumental in setting up the Network and was clinical leader from 2015 to 2017. Peter was an intensive care specialist at Wellington Hospital and had worked in Palmerston North early in his career. He had been involved in trauma care throughout his career, including acting as an ambulance service medical director, an EMST instructor, and he was integral to the medical response to the 1995 Ansett Flight 703 crash. Between 2014-17, Peter was head of trauma at Wellington Hospital, and he was vital to ensuring the Central Region's data contributions to the national registry.

The Central Region Trauma Symposium was again a highlight of the year with a sell-out audience of trauma clinicians from around the country descending upon Kilbirnie to update themselves on topics such as mass casualty incidents, workforce development, maxillofacial trauma and making the most of audit and registry data.

The network is progressing several regional projects including standardisation of guidelines between DHBs, implementation of tertiary survey policies, and developing new regional pathways for complex pelvic trauma.

Ensuring adequate and sustainable staffing for trauma is a critical issue facing the region. It is clear that the trauma nursing staffing is not currently sufficient, and we are developing a business case to address this with the Central Region DHBs. We are pleased with the appointment of Dale Oliff of Wairarapa DHB as the lead Chief Executive for trauma in the region. Dale has a good knowledge of trauma systems and having previously been involved in the establishment of the Midland Network, is well placed to help guide the work currently facing us.

We wish to thank all of the trauma clinicians within the region for their work, and especially we acknowledge the nursing & medical leads for their contribution to the network.

South Island Trauma Workstream

The South Island region continues to build and strengthen its commitment to the care of trauma patients. The regional network, as part of the South Island Alliance, is working to and meeting its requirements in the Alliance's Regional Services Plan.

The regional network values the support of the National Trauma Network and acknowledges the work and initiatives that are happening nationally in education, information gathering and quality improvement. In particular, the South Island is encouraged by the development of a new national database and appreciates that South Island representatives have been included in the various stages of this work.

The Trauma Nurse Coordinators (TNCs) maintain their own regional network and keep each other and associates well informed of trauma practices and training opportunities. Two of the TNCs are members of the regional network and provide much of the 'on the floor' knowledge.

TNCs have been responsible for providing training in hospitals and for helping present the acclaimed preventative Right Track programme in Southern communities.

The ACC incentive payments are kept in a regional fund and are drawn upon by DHBs to reimburse costs associated with staff attending trauma education. Despite many training and education opportunities being taken up, the fund has grown to the extent that it may assist with other opportunities, for example summer studentships and small research projects.

Of current interest to explore further is that of ageing and frailty in association with injury severity scoring.

St John Ambulance and the regional network continue to work closely together to ensure destination policies are understood and appropriate considering the South Island's diverse geographic area.

The region hosted a very successful Trauma South conference thanks largely to the efforts of the Southern based folk. During the two days in Dunedin, 130 conference presenters and participants focussed on learning from the Christchurch tragedies and considering preparedness by other centres.

Appendix A: Appendix

Methods and notes

Data

NZ-MTR data was extracted on September 10, 2019 and included all cases with an injury date between 1 July 2015 and 30 June 2019. Those injured between 1 July 2018 and 30 June 2019 were used in the analysis of this report , unless otherwise specified. It is possible that a small number of cases may not be included if the patient had not yet been discharged from their definitive care facility or if the record had otherwise not been submitted to the registry prior to the extraction date.

Population estimates for each DHB by ethnicity, age, and sex are custom projections produced by Statistics New Zealand specifically for the Ministry of Health from the 2013 census projected to 2019, as updated in 2017. The projections are based on prioritised ethnicity, and take into account DHB-specific rates of fertility, mortality, migration and inter-ethnic mobility.

Case fatality rate

The RACS definition of the case fatality rate is the total number of deaths in the Registry (i.e., including ISS < 13) divided by the total number of major trauma cases in the Registry (ISS ≥ 13). This is problematic because the inclusion of ISS < 13 deaths in the numerator without the inclusion of ISS < 13 cases in the denominator implies these are treated as 'never events'. However, the majority of such cases are medical deaths in patients aged 65 years and over, and as such other factors complicate their inclusion. We define the case fatality rate as the total number of major trauma deaths in the Registry (ISS ≥ 13) divided by the total number of major trauma cases in the Registry (ISS ≥ 13). We discuss ISS < 13 deaths separately.

Population-based rates

Population-based rates are produced by dividing a number of events by the estimated population size for the area of interest, presented on a per 100,000 usually resident people per annum basis. Unless otherwise specified, the numerator of all such rates is defined by the location of definitive care, not by patient domicile. The interpretation of such rates is the annual number of major trauma patients given definitive care per 100,000 residents and does not imply patients are from the resident population.

Standardised mortality ratio

The estimation of a standardised mortality ratio (SMR) requires a model to be built to take account of variation in mortality that is explained by factors that are external to the trauma system. There is a vast body of literature demonstrating that mortality varies with injury severity and type, patient age, and other patient health factors such as presenting co-morbidities.

For this purpose, a generalised additive model (GAM) was built, predicting death at definitive care facility from:

- New Injury Severity Score
- Polytrauma (number of body regions with AIS ≥ 3 injuries)
- Pulse & systolic BP on arrival at definitive care facility
- GCS on arrival at definitive care facility
- Age
- Maximum head AIS score
- Maximum vessels AIS score
- Charlson Comorbidity Index
- Acute hospital admissions within the previous 6 months
- Injury type (blunt, penetrating, burn)

Missing data was handled through multiple imputation, with 20 imputed datasets. Models were compared using Akaike Information Criterion (AIC), and more complex models only retained if preferred by AIC. Other factors were considered, including patient ethnicity, sex, and self-presentation to hospital, however they were not significant predictors of mortality, and/or did not reduce model AIC.

The final GAM was used to predict probability of death for each case in the dataset for ISS ≥ 13. The summed probabilities of death were used as an expected death count for contrast with observed deaths at each site.

Appendix B: RACS key performance indicators

The Royal Australasian College of Surgeons (RACS) Trauma Quality Improvement Committee has developed a set of KPIs for use in the binational trauma system as process markers in trauma care. Some RACS markers are similar to what we have already presented. Differences in methodology are noted.

Case fatality rate (ISS ≥ 13)

	Northern	Midland	Central	South Island	National
2018-19	10.3%	8.0%	8.5%	6.7%	8.4%

Note: We have excluded ISS<13 deaths from because we cannot denominate for it.

Pre-hospital transport times (ISS ≥ 13)

Median time in hours from injury to arrival at first hospital.

	Northern	Midland	Central	South Island	National
2018-19	1.3	1.5	1.4	1.8	1.5

Note: We have used median time not mean to account for outliers who do not present to hospital for several days

Discharge destination (ISS ≥ 13)

Proportion of cases to each destination for patients who were not discharged deceased. 2017-18 and 2018-19 data included.

	Northern	Midland	Central	South Island	National
Acute Care Facility	6%	13%	19%	3%	9%
Convalescence	7%	3%	2%	5%	5%
Home	59%	61%	57%	64%	61%
International Medical Facility	0%	0%	0%	1%	0%
Left Against Medical Advice	1%	3%	2%	0%	1%
Rehabilitation	23%	16%	16%	19%	19%
Residential Care	2%	2%	3%	2%	2%
Special Accommodation	0%	1%	1%	1%	0%
Other	2%	1%	1%	4%	2%

Time in hours to CT for patients with impaired consciousness

Median time hospital to CT for GCS <13

	Northern	Midland	Central	South Island	National
2018-19	0.7	0.8	1.1	0.8	0.8

Blood alcohol concentration

Percentage of major trauma patients whose blood alcohol concentration was recorded.

	Northern	Midland	Central	South Island	National
2018-19	78%	68%	61%	43%	62%

Time in first facility for patients transferred to a definitive care facility (iss ≥ 13)

Median time in hours from arrival to discharge in first care facility if subsequently transferred to another facility for definitive care

	Northern	Midland	Central	South Island	National
2018-19	4.6	5.5	9.6	8.6	6.2

Time in ED (ISS ≥ 13)

Median time in hours in Emergency Department at hospital of first care, excluding patients who died in ED.

	Northern	Midland	Central	South Island	National
2018-19	5.5	4.9	5.2	5.2	5.2

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