HEALTH QUALITY & SAFETY COMMISSION NEW ZEALAND
Kupu Taurangi Hauora o Aotearoa

POMRC
Perioperative Mortality Review Committee

Equity in outcomes following major trauma among hospitalised patients | Te taurite o ngā hua i muri mai i te whētuki nui ki waenga i ngā tūroro hōhipera

Ninth report of the Perioperative Mortality Review Committee | Te pūrongo tuaiwa o te Komiti Arotake Mate Whai Muri mai i te Poka

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Abbreviations | Ngā whakarāpopoto

AIS	Abbreviated Injury Scale
CI	confidence interval
CT	computed tomography
DHB	district health board
GCS	Glasgow Coma Scale
HR	hazard ratio
IAT	Implicit Association Test
IQR	inter-quartile range
ISS	Injury Severity Score
NHI	National Health Index
NZBD	New Zealand Burden of Diseases, Injuries and Risk Factors Study, 2006–2016
NZ-MTR	New Zealand Major Trauma Registry
OR	odds ratio
POMRC	Perioperative Mortality Review Committee
RR	rate ratio
RTC	road traffic crash
sTBI	serious traumatic brain injury
TBI	traumatic brain injury

Definitions | Ngā tautuhi

Comorbidity	A disease or medical condition that is simultaneously present at the time of trauma. This analysis measures it using the Charlson Comorbidity Index (see Appendix 1).
Confidence interval (CI)	A measure of the precision of an estimate. The wider the confidence interval, the less precise the estimate. This report uses 95% confidence intervals, meaning that we can be 95% sure that the true value of the estimate (eg, odds ratio, hazard ratio) lies within the 95% CI.
Definitive care hospital	As defined by the New Zealand Major Trauma Registry, the largest hospital the patient has been managed in. This is usually a tertiary hospital that is able to provide leadership and total care for most aspects of the injury.
Hazard ratio (HR)	A ratio of the hazard (rate) of outcome of one group to those of another (ie, one divided by another) to allow for comparison between groups.
Intubation	The insertion of a tube into a patient's body, especially that of an artificial ventilation tube into the trachea.
Major trauma	Trauma to patients suffering physical injury as a result of energy transfer and not internal pathologic processes, with an Injury Severity Score of 13 or more.
Morbidity	Suffering from a disease or condition.
Multivariable	An analysis that considers three or more variables. It results in an 'adjusted' estimate, so takes into account differences between groups of other factors.
Odds	A statistical term that numerically is usually similar to risk, and can be interpreted as such.
Odds ratio (OR)	A ratio of the odds of one group to those of another (ie, one divided by another) to allow for comparison between groups. For example, the odds ratio for mortality comparing Māori with non-Māori is the odds (risk) of mortality in Māori compared with the odds (risk) of mortality in non-Māori.
Rate ratio (RR)	A ratio of the rate of outcome in one group to those of another (ie, one divided by another) to allow for comparison between groups.
Univariate	The first stage in an analysis, when we describe the association between two variables (eg, ethnicity and mortality rate). It does not take any other variables into account.

Executive summary | Whakarāpopototanga matua

Introduction

Equity in major trauma outcomes is the focus of this ninth Perioperative Mortality Review Committee (POMRC) report. Trauma is a considerable health burden globally: injuries have a substantial impact on health, both as a leading cause of premature death and as a result of disability following a trauma [1, 2]. The importance of injury as a major contributor to death and disability in Aotearoa New Zealand has been increasingly recognised over recent decades with research often putting injury in the top five leading causes of death and hospitalisation [3–6]. Over this time, studies have also highlighted marked inequities in injury burden by ethnicity, leading to calls for the development of interventions aimed at reducing ethnic disparities in the quality of trauma care [4, 7–9].

International evidence indicates that disparities exist across all aspects of trauma care including by race or ethnicity, socioeconomic position and access to emergency services, as well as by age group and gender [10–21]. Additionally, differences based on both socioeconomic position and the epidemiology of traumatic injury appear to contribute to inequities in treatment outcomes among trauma patients [22–26]. Similar evidence of inequities based on ethnicity is emerging in Aotearoa New Zealand [9, 27–29].

The POMRC has prioritised understanding and addressing the persistent inequities for Māori in our health system that have led to poor health outcomes specifically as they relate to perioperative mortality [30]. The equity focus of this work is guided by the articles of Te Tiriti o Waitangi, as described in the Health Quality & Safety Commission's Window on equity [31]. The articles of Te Tiriti o Waitangi affirm Māori rights to collective self-determination, and policy today recognises that those rights include the rights to health care provision and to equitable health outcomes [31, 32].

Consistent with POMRC's previous work on equity in surgical outcomes for Māori [30], we have used Te Pou, the Māori responsiveness rubric developed by Ngā Pou Arawhenua, the Māori members of the mortality review committees [33], to guide the analysis, interpretation and recommendations we present in this report. As part of this work, we:

- considered how our current trauma care system creates and maintains health equity and inequity
- applied a robust equity approach to the analyses
- highlighted systemic factors that impact access to appropriate trauma care
- developed recommendations to address identified inequities that will improve outcomes for Māori and for all New Zealanders
- prioritised Māori expertise and input throughout the process of developing and writing this report and responding to peer review.

Having rapid access to advanced emergency medical and trauma care is critical for services to provide comprehensive care and begin specialised interventions as early as possible to reduce mortality from major trauma and minimise the potential for short- and/or long-term severe disability. Research shows trauma care systems and registries reduce preventable levels of mortality, complications and lifelong disability [34] as well as increasing the cost-effectiveness of services [35]. One of the main functions of the New Zealand Major Trauma

Registry (NZ-MTR), established in 2015, is to record the numbers, treatment and outcomes of major trauma patients admitted to Aotearoa New Zealand hospitals [36, 37] and it publishes this data in its annual reports [38–41]. The NZ-MTR has found the incidence of major trauma for Māori is higher than for non-Māori [38–41]. Although some of the patterns of injury and outcomes appear to be similar for Māori and non-Māori [41], no one has previously conducted a more detailed analysis of potential inequities.

This POMRC report reviews what factors impact on Māori and non-Māori mortality from major trauma based on four years of NZ-MTR data. Its aims are to:

- analyse mortality following major trauma in Māori and non-Māori admitted to hospital
- investigate possible inequities
- identify areas of health care practice or policy that could be improved to address these inequities.

This work will improve understanding of the factors within the trauma care system that impact on equity for Māori and help to identify where health sector performance in terms of major trauma outcomes for Māori can be improved.

Methods

This analysis included data relating to all events of major trauma in the NZ-MTR from 1 July 2015 to 30 June 2019. We also analysed additional data from the National Health Index (NHI), including domicile codes, deprivation decile and ethnicity. We linked this data to the NZ-MTR data using each person's unique NHI number.

The NZ-MTR includes people with an Injury Severity Score (ISS) of 13 or more and people with less severe trauma (ISS of 12 or lower) who die in hospital. The results presented here are based on those people who have experienced major trauma – that is, with an ISS of 13 or more. For the purposes of this report, the main analysis included only the first recorded event for each person.

Statistical methods included tabulating risk factors by ethnicity, calculating Māori to non-Māori mortality hazard ratios (HRs) using Cox regression, and using logistic regression to estimate odds ratios (ORs) for binary outcomes.

Results

The main determinants of 30-day mortality following major trauma were: older age, more comorbidities, more severe injury (based on ISS, Glasgow Coma Scale [GCS] score and requiring intubation) and not having had an index computed tomography (CT) scan. Arriving at a definitive care hospital within an hour of the injury occurring was also associated with a higher risk of mortality, which is likely to be due to the severity of the trauma. The results suggested that non-Māori who experienced trauma within major urban areas had higher mortality than those who experienced trauma in smaller urban or rural areas, which may result from differences in the type of trauma they sustained. Mortality rates were similar in men and women.

The analysis found no evidence of a differential effect of all but one of these variables on mortality for Māori compared with non-Māori. The one exception was not having a CT scan, which had a stronger effect in Māori (HR 4.90, 95% confidence interval [CI] 2.93–8.20) than non-Māori (HR 2.71, 95% CI 2.05–3.59), $p = 0.049$. We found no evidence of inequity between Māori and non-Māori in the timing of CT scan.

Inequity was clear in mortality for Māori youth aged 15–18 years, who were over three times more likely to die in the 30 days following major trauma than non-Māori in the same age group (HR 3.18, 95% CI: 1.21–8.36). This relationship was not explained by differences in sex, time to definitive care, helicopter transfer to hospital, urban or rural location of the injury, receiving index CT scan or presence of serious traumatic brain injury (sTBI). Part, but not all, of the inequity in mortality in these young people was due to trauma severity.

In univariate analyses, Māori had a higher risk of mortality following road traffic crashes (RTC) than non-Māori. The multivariable model, however, showed no difference in mortality following RTC among Māori compared with non-Māori, and measures of severity explained most of the excess.

Māori were more likely than non-Māori to not receive a CT scan. After further adjustment for region, area-level deprivation, injury severity (ISS, GCS score and intubation), mode of transport from scene (which may also be a marker of injury severity) and scene of trauma (urban or rural), Māori remained 37% more likely to not receive a CT scan (OR 1.37, 95% CI: 1.12–1.67).

Being treated at a neurosurgical facility had a beneficial effect for non-Māori (HR 0.79, 95% CI: 0.63–1.00), but not for Māori. This may be because only Māori with the most severe injuries from an sTBI (and for this reason a higher risk of mortality) were transferred. Note that this analysis would ideally also include long-term disability as an outcome.

Māori were 56% more likely than non-Māori to die in the first 30 days following major trauma other than sTBI (HR 1.56, 95% CI 1.02–2.37). None of the potential explanatory variables could fully explain this inequity. Receiving an index CT scan explained part of the inequity in mortality between Māori and non-Māori, but not all of it.

Discussion

The main analysis found no inequities for Māori in overall mortality following major trauma. However, there was a higher risk of mortality among Māori youth, and among people who experienced trauma that did not involve sTBI. Māori were less likely to receive an index CT scan than non-Māori, and less likely to benefit if they were treated at a neurosurgical facility.

The greatest limitation of the data is that anyone who experiences major trauma but dies either at the site of the trauma or on the way to hospital is not included in the NZ-MTR. Previous work has identified inequities by ethnicity in the people who die before arriving at a hospital.

Nevertheless, the analysis points to important areas in which improvements could lead to a reduction in inequities experienced by Māori following major trauma, as the recommendations below reflect.

Recommendations

Higher mortality in Māori youth

Recommendation 1

The POMRC recommends that each district health board (DHB) conducts an in-depth local review in 2021 into all cases of trauma in Māori aged 15–18 years that occurred in 2018–2020, identifying the key points of intervention. The review should focus on whether treatment was optimal and timely, and what systems and processes need to be improved to provide high-quality and equitable care. Improvements could include prioritising trauma cases involving Māori youth aged 15–18 years, so that care pathways aim to prevent inequitable rates of mortality.

Rationale: We identified that more severe injury among Māori does not fully explain higher mortality in Māori youth aged 15–18 years (but not in other age groups). As well as inequity in mortality rates, Māori experience a disproportionate impact from injury because the Māori population has a younger age structure than the non-Māori population so these early deaths have greater potential to represent a greater loss of years of life among Māori.

Māori are more likely to die in the first 30 days following major trauma other than sTBI.

Recommendation 2
The POMRC recommends that each DHB reviews its safe discharge plans to check that they identify whether all aspects of care are addressing inequity to achieve equitable outcomes. We recommend the review team includes a trauma nurse specialist or kaupapa Māori navigation support with a trauma-specific focus.

Rationale: Our findings show a clear inequity in mortality among those who survive up to 14 days: Māori have a higher risk of mortality, which persists over time.

Recommendation 3
The POMRC recommends Te Hononga Whētuki ā-Motu, the National Trauma Network and each DHB review their policies and procedures to ensure they do not include, or allow for, implicit bias and institutional racism at clinician, DHB and policy levels.

Rationale: Beliefs or attitudes held by health practitioners and providers about patients at the individual and group levels have the potential to impact on clinical encounters, in terms of both provider behaviour and patient response to the interaction. This may have implications beyond the acute phase, with ongoing care increasing the potential for discretion in decision-making about treatment and management options. International studies show post-discharge deaths among trauma patients are related to common chronic diseases. Because this connection is particularly relevant given the known barriers to care for Māori, this recommendation should be prioritised as an opportunity for improvement.

Māori are less likely to receive a CT scan

Recommendation 4
The POMRC recommends Te Hononga Whētuki ā-Motu, the National Trauma Network develops a national consensus guideline on prioritising CT scans for trauma cases. The guideline requires timeframe guidance and the assessment of its implementation in each DHB to ensure equitable diagnosis and management.

Rationale: Our results show that Māori are less likely to receive a CT scan. Prompt diagnosis, with the help of a CT scan, plays a key role in the initial management of traumatic injuries and can have an impact on mortality outcomes.

Recommendation 5
The POMRC recommends that DHBs complete an audit of the application of the national consensus guidelines for each Māori trauma patient who did not get a CT scan to see if the guidelines were followed correctly. This analysis should include the role and impact of implicit bias and institutional racism at clinician, DHB and policy levels.

Rationale: Numerous studies identify differences between Māori and non-Māori in the care they receive and the quality of that care. International literature suggests a potential mechanism in the area of trauma care is unconscious bias among providers. Addressing this bias requires linking trauma care to broader, system-wide policies including cultural safety education for health providers and services and improvement strategies that recognise equity as a key dimension of quality.

Neurosurgical facility treatment

Recommendation 6

The POMRC recommends that DHBs review all cases of sTBI who were treated at non-neurosurgical centres, focusing on the appropriateness and effectiveness of decisions made about whether to transfer the patient, and on patient outcomes. DHBs should then change their destination and interhospital transfer policies so that, where safe and feasible, all patients with a significant TBI are transferred to a neuroscience centre.

Rationale: A systematic review of the effectiveness of specialist neurosurgical care in sTBI demonstrated that transferring severe non-surgical TBI patients to specialist neurosurgical centres had a beneficial effect. The United Kingdom National Institute for Health and Care Excellence recommends that transferring all patients with serious head injuries to a neurosurgical unit would benefit them, no matter whether they need neurosurgery or not. Given the reported differences between Māori and non-Māori, we must understand the rationale for treatment at non-neurosurgical centres so that Māori are not disadvantaged.

Recommendation 7

The POMRC recommends DHBs review their protocols on transferring patients with sTBI to neurosurgical centres, with a specific focus on whether these sufficiently address inequity to achieve equitable care and case management. Trauma leads within each DHB should identify training opportunities that will support health care professionals to follow local protocols.

Rationale: Some international evidence suggests that mortality has decreased because health providers are implementing and following guidelines, and that the use of protocol-guided therapy after sTBI improves patient outcomes. Decisions to transfer patients must be explicit and health professionals need to follow them through to ensure unconscious bias or institutional racism do not result in inequitable health outcomes for Māori.

Improved data collection and reporting

Recommendation 8

The POMRC recommends that the Accident Compensation Corporation provides additional data collection resources to enable the NZ-MTR to collect systematic data on outcomes for those people who die before they can be admitted to hospital (pre-hospital outcomes).

Rationale: The data in this report is limited by the lack of information on outcomes for those people who die before being admitted to hospital. Improved information collection in this area would allow more comprehensive reporting in the future to support public health policy development and decision-making.

Introduction | Kupu arataki

Equity in major trauma outcomes is the focus of this ninth Perioperative Mortality Review Committee (POMRC) report. Trauma is a considerable health burden globally: injuries have a substantial impact on health, both as a leading cause of premature death and as a result of disability following a trauma [1, 2]. In Aotearoa New Zealand, trauma is a leading cause of death and disability and the associated social and economic costs are substantial. For the period 2010–2015, injury was the leading cause of death from the age of 5 through to 44 years and more than half of the deaths for those aged 10–34 years were from injury. It was also a significant cause of morbidity, as one of the two main causes of publicly funded hospital treatment for those aged 5–54 years [3, 7].

International evidence indicates that disparities exist across all aspects of trauma care including by race or ethnicity, socioeconomic status, income, insurance status and geographic location as well as by age group [10–21]. Disparities in system-level access to care, including those based on how close a person is geographically to emergency services and/or trauma care, disproportionately impact population groups by race or ethnicity, income and age [10, 19–21]. Additionally, both socioeconomic disparities and differences in the epidemiology of traumatic injury appear to contribute to inequities in treatment outcomes among trauma patients [22–26]. Similar evidence by ethnicity is emerging in Aotearoa New Zealand [9, 27–29].

The POMRC has chosen to examine what factors impact on Māori and non-Māori mortality from major trauma, given this is an important health area that no one has comprehensively reviewed previously. For this report, major trauma is defined as trauma resulting in a patient having an Injury Severity Score (ISS) greater than 12 [42]. This work will contribute to better understanding of the factors in the trauma care system that impact on equity for Māori and contribute to identifying where it is possible to improve health sector performance in terms of major trauma outcomes for Māori.

The equity focus of this work is guided by the articles of Te Tiriti o Waitangi, as the Health Quality & Safety Commission describes in its Window on equity [31]. The articles of Te Tiriti o Waitangi affirm Māori rights to collective self-determination, and policy today recognises that those rights include the rights to health care provision and to equitable health outcomes [31, 32]. As a result of the process of colonisation, the Aotearoa New Zealand health system has generated and continues to reinforce inequities in health outcomes between Māori and non-Māori. Evidence for this impact comes from the documented inequities in life expectancy and mortality and significant morbidity differences, including in surgical outcomes [30, 31, 43–48].

Consistent with POMRC's previous work on equity in surgical outcomes for Māori [30], we have used Te Pou, the Māori responsiveness rubric (tika, manaakitanga, mana and mahi tahi) developed by Ngā Pou Arawhenua, the Māori members of the mortality review committees [33], to guide the analysis, interpretation and recommendations presented in this report. As part of this work, we considered how our current trauma care system creates and maintains health equity and inequity; applied a robust equity approach to the analyses; highlighted systemic factors that impact access to appropriate trauma care; developed recommendations to address identified inequities that will improve outcomes for Māori and for all New Zealanders; and prioritised Māori expertise and input throughout the development, writing and peer review process [49].

The POMRC terms of reference

The POMRC is a statutory committee that reviews and reports on perioperative deaths in Aotearoa New Zealand. Its aim is to reduce complications and death after surgery, and to continually improve surgical health care in Aotearoa New Zealand.

The POMRC defines ‘perioperative death’ as death that occurs:

- during surgery
- within 30 days of surgery
- more than 30 days after surgery, but before discharge from hospital
- while under the care of a surgeon in a hospital, even if surgery was not undertaken.

Health equity

Equity in health has been defined as the absence of socially unjust or unfair health disparities. Braveman and Gruskin note that ‘equity means social justice or fairness; it is an ethical concept, grounded in principles of distributive justice’ (p 254) [50]. Drawing on this explanation of equity, we use the term ‘inequity’ in this report specifically in relation to the notion of ‘unfairness’. Equity and fairness are both ethical concepts related to justice and the distribution of resources in a way that meets everyone’s minimum requirements. Emphasising ‘fairness’ does not translate to equal shares for all but instead recognises that different groups may need different resources to achieve equitable health outcomes.

Health equity is defined as ‘the absence of systematic disparities in health (or in the determinants of health) between different social groups who have different levels of underlying social advantage/disadvantage – that is, different positions in a social hierarchy’ (p 254) [50]. This definition makes explicit that society rather than the individual determines the mechanisms of access to resources, including health services, as well as how those resources are distributed. The words ‘advantage’ and ‘disadvantage’ – that is, whether or not a person has wealth, power or prestige – recognise the need to evaluate the processes that determine how resources are shared and the underlying values of society [31].

The Ministry of Health’s definition of equity states that:

> In Aotearoa New Zealand people have differences in health that are not only avoidable but unfair and unjust. Equity recognises different people with different levels of advantage require different approaches and resources to get equitable health outcomes. (p 5) [51]

Jones identifies three pathways as key contributors to ethnic inequities in health:

1. differential access to the determinants of health or exposures leading to differences in disease incidence
2. differential access to health care
3. differences in the quality of care received [31, 52].

It is well documented that a number of factors that may impact on major trauma outcomes and treatment in important ways are not evenly distributed between Māori and non-Māori. For example, compared with non-Māori, Māori are more likely to live in more socioeconomically deprived areas [4, 53] and experience lower access to health care services [46, 53–55], which may have implications for survival after major trauma. Māori are also more likely than non-Māori to live in rural communities [56], another factor that may affect timely access to high-quality emergency trauma and rehabilitation care. Additionally, Māori experience high rates of chronic health conditions [53]. As international studies show, the presence of such comorbidities, beyond the traumatic injury itself, has a measurable impact on hospitalisation outcomes [57, 58].

Research has also clearly established that institutional and personal racism can influence health care interactions and the quality of care and service delivery in ways that maintain or widen ethnic or racial health inequities [43, 59–65]. Health care provider biases, particularly in doctor–patient relationships, influence clinical decision-making processes and outcomes, including management and treatment decisions; they further impact health care interactions through influencing the quality of communication and experience for patients [63, 66–69].

The purpose of developing cultural safety education [70] was to explicitly identify the causal links between colonisation, institutional racism, power and social justice that are fundamental to understanding and, importantly, taking action to address health inequity [71, 72]. Since 1992, cultural safety has been a core component of all education programmes responsible for training student nurses and midwives in Aotearoa New Zealand [72]. More recently the Medical Council of New Zealand incorporated it into its standards for doctors, which explicitly refer to unequal power in the doctor–patient relationship [73]. The Health and Disability System Review was another to highlight cultural safety; in considering how to strengthen workforce development strategies, it identified cultural safety as one of three basic knowledge requirements for district health board (DHB) members (together with population health and equity) and as a feature that should be part of all health service delivery models [59, 71, 73, 74].

As the above discussion indicates, alongside individual accountability for providing culturally safe care, educational institutions and professional bodies can play a pivotal leadership role in supporting and advocating for cultural safety at the organisational, system and policy levels to achieve equitable health care and health outcomes [73, 75, 76].

Defining major trauma

Drawing on overseas evidence that implementing a national trauma system can improve outcomes, Te Hononga Whētuki ā-Motu, the National Trauma Network was established in 2012,[1] with establishing the New Zealand Major Trauma Registry (NZ-MTR) as one of its main tasks. The NZ-MTR is audited for completeness, logic and accuracy in each region every four months [36]. For the purposes of the current report, the POMRC applies the Network's definition of major trauma.

The national NZ-MTR uses a unique coding system related to physical injury to enable accurate recording of the numbers of major trauma patients admitted to Aotearoa New Zealand hospitals alongside measuring system performance. This approach helps with research and makes trauma care information comparable internationally [37]. The Injury Severity Score (ISS) is used internationally to give a numerical grading for the severity of injury that occurs in different body areas [77]. (See Appendix 1 for details on how it is calculated.) The ISS can be directly correlated with a threat to life and, to a lesser degree, with complications, length of stay, cost and outcome.

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[1] When the Network established, it was known the Major Trauma National Clinical Network. The name later changed to Te Hononga Whētuki ā-Motu, the National Trauma Network.

In line with the Network's focus on major trauma, the NZ-MTR collects data on patients who meet the criterion of an ISS of 13 or more. The ISS ≥ 13 correlates with one severe or critical injury, or two injuries where the Abbreviated Injury Scale (AIS) classifies one injury as major (AIS ≥ 3) and the other as moderate (AIS ≥ 2) [78]. In keeping with this definition, the NZ-MTR includes patients with major trauma defined as an ISS ≥ 13 and includes only those patients suffering physical injury as a result of energy transfer and not internal pathologic processes [39].

Te Hononga Whētuki ā-Motu, the National Trauma Network

While overall the burden of injury globally has improved over the past two decades, trauma continues to be a major health burden. Traumatic injuries have a substantial impact on health both as a leading cause of premature death and as a result of disability following an injury [1, 79–81].

In Aotearoa New Zealand, trauma is a leading cause of death and disability and the associated social and economic costs are substantial. In 2013, injuries were the third most important cause of health loss (measured in disability-adjusted life years) in children and young people, and the fifth most important cause of health loss across all age groups. For the period 2010–2015, injury was the leading cause of death from age 5 through to 44 years and more than half of the deaths for those aged 10–34 years were from injury. Injury is also a significant cause of morbidity: it is one of the two main causes of publicly funded hospital treatment for those aged 5–54 years [3, 7].

About 1,800 New Zealanders die each year from trauma, while a further 2,000 are admitted to hospital with major trauma. The most common cause of these injuries is transport related, followed by falls and assault [40, 41]. Having rapid access to advanced emergency medical and trauma care is critical for services to be able to provide comprehensive care and begin specialised interventions as early as possible to reduce mortality from major trauma and minimise the potential for short- and/or long-term severe disability.

The purpose of developing trauma care systems and registries has been to enable data collection and information systems specific to trauma care for use in hospital settings [36, 82]. Evidence shows comprehensive trauma care systems, including timely pre-hospital emergency care, help to reduce preventable levels of mortality, complications and lifelong disability [34] as well as to increase the cost-effectiveness of services [35]. Trauma registries can also be a source of important information for describing and understanding patterns of trauma and potential points of intervention to improve patient and system outcomes and for highlighting ways of improving the quality of care [36, 83, 84].

Te Hononga Whētuki ā-Motu, the National Trauma Network comprises management and senior clinical leaders from the four regional trauma networks (Northern, Midland, Central and South Island), which represent the 20 DHBs, as well as representatives from ambulance services and other key stakeholder groups including the Accident Compensation Corporation [82, 85]. The initial focus of the Network has been on: establishing a national trauma structure and system; setting up the NZ-MTR (in 2015); and developing consistent guidelines for managing trauma. Aotearoa New Zealand has seven tertiary major trauma hospitals: Auckland City Hospital, Middlemore Hospital, Starship Hospital (paediatric), Waikato Hospital, Wellington Regional Hospital, Christchurch Hospital and Dunedin Hospital [36].

Inequity in trauma outcomes

International literature

Ethnicity

In Australia, the age-standardised rate for indigenous peoples was 2.7 times the rate for non-indigenous Australians for fatal cases and 1.3 times the rate for non-indigenous Australians for serious injuries [11]. Suicide and land transport trauma are the most common causes of injury death among Australian Aboriginal and Torres Strait Islander peoples. While relatively less common, homicide death rates were seven times higher for indigenous compared with other Australian men, and 11 times higher for indigenous compared with non-indigenous Australian women. Although falls contributed to a much lower proportion of injury mortality, indigenous Australian death rates due to falls were 2.5 times higher than those of the general Australian population [11].

In 2008, unintentional injury was the sixth leading cause of death for Canadians of all ages [13]. In 2018, the Public Health Agency of Canada reported unintentional injury was the leading cause of death for children and young people while the mortality rate for the whole population was 30 people per 100,000 [12]. A comprehensive report based on information collected from the First Nations Regional Health Survey in 1997 estimated that, compared with the total Canadian population of children, death rates among aboriginal children from unintentional injury were almost four times greater in infants (17 vs 63 per 100,000 population), more than five times greater in preschoolers (15 vs 83 per 100,000 population) and more than three times greater in teenagers (48 vs 176 per 100,000 population) [86].

More recent data from Canada continues to highlight notable inequities in indigenous peoples who were at greater risk of unintentional injury mortality: First Nations 3.5 times higher, Inuit 3.2 times higher and Métis 2.7 times higher compared with the non-indigenous population [12]. Lower income and education levels were also associated with higher rates of death from unintentional injury. For those in the lowest income bracket, the rate of unintentional injury mortality was 38 per 100,000 compared with 27 per 100,000 in the highest income bracket. Unintentional injury mortality was 1.6 times higher among Canadians living in the most materially deprived areas compared with those living in the least materially deprived areas and was 1.9 times higher in remote areas than in urban centres [12].

A systematic review of 35 studies examining the relationship between trauma and race, insurance, and socioeconomic disparities in the USA found that, independent of socioeconomic status, the mortality rate for black patients was about 20% higher than for white patients. Another study confirmed this finding using data from the US National Trauma Data Bank (2001–2005), based on patients with moderate to severe injuries (ISS ≥ 9); that analysis found an even higher rate for Hispanic patients (about 50% higher than white patients) [10].

Income and poverty

Lower income is a predictor of higher trauma mortality rates. For example, in Canada, people in the poorest income quintile had higher mortality from unintentional injury than those in the richest income quintile (64 vs 38 per 100,000 for males; 35 vs 23 per 100,000 for females) [13]. Similarly, unintentional injury mortality is 1.6 times higher among

Canadians living in the most materially deprived areas compared with those living in the least materially deprived areas.

A USA study of adults hospitalised after injury found that low income levels predicted higher trauma mortality rates [14]. Insurance status, as another measure of socioeconomic status, is strongly associated with trauma outcomes. Haider and colleagues' (2013) meta-analysis found uninsured patients were over twice as likely to die as privately insured patients [10]. Other work highlights increased trauma mortality rates for insured African American and Hispanic patients compared with insured white patients and even stronger effects are evident for uninsured patients across all ethnic groups [87].

In an exception to the general findings in the literature, a large, retrospective analysis of national data of hospital admissions due to injury in England found that for major trauma (defined as an ISS > 15), deprivation did not have an independent relationship with 30-day mortality [15]. Conversely, however, after minor trauma 30-day mortality was significantly higher for people living in more disadvantaged areas [15].

Paediatric trauma studies have identified factors ranging from increased exposure to injuries to unequal access to high-quality emergency trauma and rehabilitation care as factors that may place those in socially disadvantaged groups at increased risk of injury-related disability [22, 23]. For example, one trauma registry-based study in Indiana, USA identified the major reasons why people did not attend follow-up clinics after their hospital discharge were directly linked to the impact of socioeconomic factors. These reasons included that families were experiencing financial difficulties and patients did not have a support person who could help them in getting to the clinic [24].

Age and gender

Internationally, the leading mechanisms of injury are transport-related injuries, self-harm and falls [88, 89]. Men account for the majority (68%) of injury-related deaths. These deaths are highest in the younger age groups: 52% occur in men between the ages of 10 and 24 years [16, 17]. Among youth, motor vehicle crashes account for a substantial proportion of the injury hospitalisation and fatality rates. Lifestyle environment also contributes to differences in injuries between rural and urban youth. Youth aged 10–14 years accounted for the highest number of Australian Aboriginal males injured in transport-related crashes, 40% of whom were pedestrians or cyclists [18].

However, although younger patients still make up the majority of victims, the average age of trauma patients is increasing. The mechanism of injury in trauma deaths also seems to be changing over time as the age of the patient population increases. In particular, studies show an increase in falls as a primary mechanism of injury in trauma-related deaths [90, 91]. Additionally, older populations may be more likely to have comorbidities that may affect traumatic outcomes and thus impact long-term survival. Some studies have investigated whether it would be useful to include comorbidity and polypharmacy data as a way of better predicting the mortality outcomes of elderly trauma patients [57, 92].

Access to care

Timely access to trauma care has a substantial impact on outcomes from major trauma. Several studies examining disparities in system-level access to care, specifically in relation to geographic proximity to and remoteness from emergency services and/or trauma care, have highlighted that access to trauma centres is not the same for all populations [10, 19–21]. Recent work examining the impact of timely access to trauma centre care on pre-hospital death estimates that, over a 10-year period, up to 300,000 trauma deaths in the USA could potentially be prevented if everyone had access to optimal, high-quality trauma care [93].

In another USA study, 1.2 times more deaths occurred pre-hospital than in hospital. The same study found that states with better access to trauma care had lower mortality rates and fewer pre-hospital deaths; and those states with a high pre-hospital death burden had a lower proportion of the population (63%) with access to Level I/II trauma centres within one hour compared with all other states (90%) [21].

A further USA study found that those census tracts (areas) in Chicago and Los Angeles with a majority of black people were more likely than white majority census tracts to be located in a 'trauma desert' (more than 8 km from a trauma centre) [19]. Yet patients may live relatively close geographically to trauma hospitals but still not be able to receive timely care. Highlighting issues related to quality of care, one study reported insured trauma patients received 68% more radiological tests than uninsured patients while another study found variations between insured and uninsured patients in the type and frequency of diagnostic imaging they received for pelvic fractures [25, 94].

Trauma type

Several studies have examined ethnic differences in mortality according to whether the trauma is categorised as blunt or penetrating. Blunt trauma accounts for more than 80% of trauma patients and it mainly results from motor vehicle crashes, falls and pedestrians struck by motor vehicles.

One study of all trauma-related hospital admissions (2006–2014) in the Detroit metropolitan area found that race was associated with trauma mortality and that differences in the mechanism of injury helped to explain this association but did not fully [95]. Compared with white trauma patients, African American trauma patients were 20% more likely to die in hospital and were more likely to have had injuries where the mechanism of trauma was associated with higher risks of death (motor vehicle crashes and gunshot wounds compared with falls) [95].

Traumatic brain injury

Traumatic brain injury (TBI) is a significant public health concern; serious TBI (sTBI) carries a high risk of mortality, and many of those patients that survive are left with permanent and severe disability. In the USA, TBI is a major cause of mortality, contributing to about 30% of all injury-related deaths [98]. From a global perspective, in 2002 the World Health Organization estimated that TBI would become the third leading cause of death and disability worldwide by 2020 [99–101].

TBI is a common injury in the general population of North America, who experience 18 TBI-related deaths per 100,000, yet it is more prevalent among the indigenous population, who experience 27 TBI-related deaths per 100,000 [96, 97]. A study of paediatric TBI patients using the trauma database of Cincinnati Children's Hospital Medical Centre found that African American children had a mortality rate about three times higher than that of white children [102]. In moderately and severely injured paediatric trauma patients, black patients had mortality rates that were 37% higher than white patients, even after controlling for insurance status and injury severity [103]. A further study of children with moderate or severe TBI found no difference in mortality between black and white children; however, black paediatric TBI patients had significantly worse functional outcomes at discharge than white patients [26].

Aotearoa New Zealand literature

The importance of injury as a major contributor to death and disability in Aotearoa New Zealand has been increasingly recognised over a number of decades, with research often putting injury in the top five leading causes of death and hospitalisation [3–6]. Over this time, studies have also highlighted marked inequities in injury burden by ethnicity, leading to calls for the development of interventions aimed at reducing ethnic disparities in the quality of trauma care [4, 7–9].

The New Zealand Burden of Diseases, Injuries and Risk Factors Study 2006–2016 (NZBD) found injury-related health loss in Māori was double that of non-Māori [7]. Marked ethnic inequities in injury mortality and hospitalisation rates are also evident, particularly in younger age groups [4, 7, 8]. In 2010–2012, the unintentional injury mortality rate for Māori children aged 0–14 years was 3.5 times that for non-Māori children and the rate for Māori adults was more than 1.5 times that for non-Māori adults [4]. Hospitalisation rates for unintentional injury (in 2012–2014) were also higher for both Māori children and adults compared with their non-Māori counterparts [4]. In contrast, among those aged 65 years and over, Māori and non-Māori had a similar unintentional injury mortality rate; additionally, Māori females in this age group had significantly lower unintentional injury hospitalisation rates than non-Māori females [4].

In provisional public data on fatal injuries in 2016, Statistics New Zealand reported an age-standardised rate for Māori of 47.7 per 100,000 while for the total population the rate was 37.3 per 100,000 [8]. Provisional figures for all serious non-fatal injuries in 2018 were 231.5 per 100,000 for Māori compared with 218.8 per 100,000 for the total population [8].

Overall, transport and falls, along with self-inflicted injury and assault, make up the majority of causes of injury-related death and morbidity in Aotearoa New Zealand [4, 7, 8, 40]. Research has also documented ethnic differences by mechanism of injury.

- **Transport.** In 2016, the Māori rate of fatal motor-vehicle traffic injuries was 11 per 100,000 compared with 6.8 per 100,000 in the total population. For serious non-fatal motor vehicle traffic injuries, provisional data for 2018 showed the Māori rate was 77.6 per 100,000 compared with the total population rate of 44.7 per 100,000 [8].
- **Assault.** Provisional data for 2016 reported the rate for injuries from serious fatal and non-fatal assault in Māori was 39.4 per 100,000 and in the total population was 13.9 per 100,000 [8].
- **Falls.** The rate for injuries from serious fatal and non-fatal falls (all ages) was 115.9 per 100,000 for the total population and 49.6 per 100,000 in Māori [8].

The leading causes of TBI in Aotearoa New Zealand are transportation injuries, falls and assaults [7, 104]. The NZBD reported Māori experienced over twice the rate of health loss from TBI compared with non-Māori [7]. A one-year (2010–2011) study of all cases of TBI in the Waikato region reported that, compared with New Zealand Europeans, the age-standardised incidence of mild TBI was 35% higher in Māori and of moderate to severe TBI was 23% higher in Māori [105]. Additionally, the incidence of moderate to severe TBI in the rural population was almost two-and-a-half times greater than in the urban population (73 vs 31 per 100,000 person-years respectively) [105]. As we noted in the discussion of the international literature, TBI carries with it a high risk of death compared with other forms of trauma [98]. Estimates indicate that at least a third of all major trauma patients sustain sTBI [41]. Literature suggests care in a neurosurgical hospital leads to better outcomes for sTBI patients, as well as providing timely multidisciplinary input and improving accessibility to rehabilitation services and ongoing support [106].

Since its establishment in 2015, the NZ-MTR has published annual reports that focus on the burden of major trauma (defined as an ISS 13–75) in Aotearoa New Zealand. In each report, the incidence of major trauma has been higher for Māori than for non-Māori (see Table 1).

Table 1: Inequity in incidence of major trauma in Aotearoa New Zealand, 2015–2019

Year	Māori	Non-Māori	Inequity ratio*
2015–2016	69	39	1.77
2016–2017	52	31	1.68
2017–2018	50	43	1.16
2018–2019	56	43	1.30

Note: Incidence is reported per 100,000 population.
*Age-standardised.

A number of factors that may impact on major trauma outcomes and treatment in important ways are not evenly distributed between Māori and non-Māori. Compared with non-Māori, Māori:

- are more likely to live in more socioeconomically deprived areas and experience lower access to health care services, both of which may have implications for survival after major trauma [4, 53, 54, 56]
- are more likely to live in rural communities [56], which may also affect timely access to high-quality emergency trauma and rehabilitation care
- experience high rates of chronic health conditions [53]. This finding is noteworthy because international studies have shown that having comorbidities, beyond the traumatic injury itself, has a measurable impact on hospitalisation outcomes [57, 58].

As noted earlier, differential treatment within the health system contributes to the well-documented inequities in health outcomes between Māori and non-Māori [31, 46, 53–55, 64, 107], including within the area of trauma care [9].

The 2018–2019 NZ-MTR report noted that 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; and time to index CT scan [41]. One area of difference identified in the 2018–2019 report was that Māori were less likely than non-Māori to be directly admitted to their definitive care facility (72% vs 82% respectively) [41].

It is important to note that the majority of deaths from injury occur before the person arrives at a hospital [108]. In a review of trauma-related deaths in Otago and Southland, 65% of those who died did so before reaching hospital, and among this group 45% had injuries that were either survivable (ISS < 25) or potentially survivable (ISS 25–49) [109]. Another study examining pre-hospital transport in the Midland region found 34% of major trauma patients were not directly transported to the closest hospital capable of providing definitive care for their injuries [110]. Analysing pre-hospital injury deaths in Aotearoa New Zealand for a five-year period (2008–2012), Kool and colleagues found that out of the total of 9,430 deaths from all injuries, 6,999 (74%) occurred before the person arrived at a hospital [111, 112].

They also found notable inequities in the rates of these pre-hospital fatalities, with the highest rates in Māori compared with other ethnicities (see Table 2). Importantly, Māori who died had the highest proportion of survivable and potentially survivable injuries (over 35%) out of all ethnic groups [111, 112].

Table 2: Pre-hospital mortality rates following trauma, by ethnicity, 2008–2012

Ethnicity	Rate
Māori	42.1
Pacific peoples	23.1
Asian	16.8
NZ European	33.2

Note: Mortality is reported per 100,000 person-years.

Inequities in pre-hospital deaths by age and sex were also evident for those aged 15–24 years and 65+ years and for males (44.5 per 100,000 person-years) compared with females (20.4 per 100,000 person-years) [113]. A further component of this work examining geographical access to pre-hospital care identified disparities by ethnicity, age and rural location. Lilley and colleagues (2019) estimated 700,000 New Zealanders did not have timely road or air access to emergency medical services that provide advanced-level hospital care; those most affected by these inequities were rural and remote communities, Māori and older adults [27]. Previous studies have highlighted the geographical challenges that Aotearoa New Zealand's unique landscape creates. In particular, mountainous terrain, long travel distances and a relatively small and geographically dispersed population may all reduce the timeliness of physical/transport access to advanced hospital-level care [27, 109, 110].

Data presented in the Ministry of Health's Health and Independence Report 2017 showed injuries were the second highest area of health loss for young people aged 15–24 years in 2016; within this area, self-harm and road transport crashes were the most common causes [114]. Alcohol consumption is a strong contributing factor to injuries and hospitalisations in younger age groups [115]. Since July 2017 it has been mandatory for all DHBs to routinely record whether an emergency department presentation was associated with alcohol. In the seven DHBs that already collected this information in the six months leading up to June 2017, on average 3.9% of emergency department presentations among those aged 20–24 years and 4.1% of those aged 15–19 years were alcohol related. For both age groups, rates were higher for males [114].

One study in elderly (65+ years) trauma patients used the Midland Trauma Registry data for 2012–2014 [116]. The pattern of injuries and outcomes was different to that seen in other studies. Incidence was significantly higher in females than males (608 per 100,000 vs 557 per 100,000) and non-Māori had significantly higher rates of injury than Māori (594 per 100,000 vs 460 per 100,000) [116]. Overall, falls were the leading cause of injuries (65.3%). Transport-related incidents (road traffic crashes, and pedestrian and pedal cycle incidents) were the second leading cause of injury overall (16.0%) but were more prominent among major trauma events (42.8%). In terms of body regions, injuries to the chest were the most common among major trauma patients in this study, closely followed by head and neck injuries. The majority (63%) of older adult trauma admissions were discharged home directly from the acute setting. However, only 32% of major trauma patients were discharged home.

This group was more than twice as likely to go on to a rehabilitation facility compared with those with minor injuries (24% vs 10%) [116].

Further work on the long-term impact and quality of life of those affected by major trauma is an important area for injury research in the future [28, 105, 117–119]. Research to date shows Māori are at increased risk of disability following hospitalisation for injury compared with non-Māori while pre-injury sociodemographic factors alongside health, psychosocial and injury-related characteristics each independently predict disability 24 months after injury among hospitalised and non-hospitalised Māori [29, 120]. These findings have implications for trauma system design in terms of evaluating the effectiveness of trauma care [117] and understanding recovery patterns and timeframes. They can also inform the approach to providing health care, social and disability services, including, particularly in Aotearoa New Zealand, an emphasis on effective and equitable access to health care services for injury [28]. As well as making demonstrated cost savings for the health system, an effective trauma care system that is integrated into wider health and social care systems provides injured patients with improved health outcomes, including lower mortality rates, reduced short- and long-term disability and overall improved quality of life [28, 105, 117, 118].

Summary

International evidence indicates that disparities exist across all aspects of trauma care, including by race or ethnicity, socioeconomic status, income, insurance status and geographic location as well as by age group. Disparities in system-level access to care, including those based on how close people live to emergency services and/or trauma care, disproportionately impact population groups by race or ethnicity, income and age. Additionally, both socioeconomic disparities and differences in the epidemiology of traumatic injury appear to contribute to inequities in treatment outcomes among trauma patients. Similar evidence by ethnicity is emerging in Aotearoa New Zealand.

The aim of this report is therefore to comprehensively analyse mortality following major trauma in Māori and non-Māori, to investigate possible inequities and to identify areas of health care practice or policy that could be improved to address these inequities.

Methods | Ngā tukanga

The results presented in this report come from an analysis of the NZ-MTR data, as provided to Flax Analytics in March 2020. This data is for all events of major trauma that were included in the NZ-MTR from 1 July 2015 to 30 June 2019. Flax Analytics also received data from the National Health Index (NHI), including domicile codes, deprivation decile and ethnicity (see below). We linked that data to the NZ-MTR data using the unique NHI number.

Criteria for including people in the NZ-MTR

Although the criterion for including people in the NZ-MTR is having an ISS of 13 or more, the NZ-MTR also includes people with less severe trauma (ISS of 12 or lower) who die in hospital. Our mortality analyses did not include the latter group, meaning that the results presented in this report are only for those with ISS of 13 or more.

It is also important to note that the NZ-MTR includes only people who are admitted to hospital; it does not include anyone who experiences major trauma but dies either at the trauma site or on the way to the hospital. Because these are likely to be people who have experienced the most serious trauma, the results of these analyses cannot be applied to the whole population, so please bear this limitation in mind when interpreting the results. In particular, as we noted in the Introduction section, there are inequities by ethnicity among the people who die before they arrive at hospital [113].

The NZ-MTR includes all instances of major trauma, which may involve multiple events for one person. For the purposes of this report, we included only the first recorded event for each person in the main analysis due to the assumption of independent samples needed for statistical analysis. For a description of people who experienced more than one major trauma event, see ‘Multiple trauma’ at the end of the Results section.

Ethnicity classification

Health providers in Aotearoa New Zealand collect ethnicity data, which is stored with the NHI data [121]. The Ministry of Health intends this to be self-identified ethnicity [122]. The NHI record can include up to three Level 2 ethnicity codes for each person [123].

In these analyses, where people identified as Māori in any one of three NHI ethnicity variables, we included them as Māori. All analyses compared Māori with non-Māori. This approach allows us to focus on equity while including as much data as possible. For 60 people, the ethnicity data record was ‘not stated/don’t know/refused to answer/response unidentifiable’ and we included them in the non-Māori group. Any resulting bias of this approach will be very small, and could only result in non-differential misclassification bias, which would reduce the inequities we found.

Mortality data

The main outcome throughout the report is 30-day mortality, calculated as the time from the date of trauma to the date of death, as noted in the NHI database. For some analyses, we also present 90-day mortality. In addition, we included in-hospital mortality as an outcome in some subgroup analyses, although it is not a primary outcome. We based this decision on the recording of type of death in the NZ-MTR, as the type of death is only available in the NZ-MTR for deaths that occur in hospital.

Statistical methods

Appendix 1 describes in detail the methods of the statistics used in this report. Briefly, descriptive analyses involved tabulating data and comparing across categories using chi-squared tests and reporting the *p*-values from these. Cox regression was used to determine the associations between exposures and 30- and 90-day mortality. Cox regression estimates the hazard ratio (HR), which compares the mortality risk (technically called a hazard) in one group, in this case Māori, with the risk (hazard) in the other group, in this case non-Māori. The resulting ratio would be 1.0 if the risk in each group was equal. An HR greater than 1.0 indicates that the risk is higher in Māori, and an HR of less than 1.0 indicates that the risk is lower in Māori.

We used logistic regression for binary outcomes other than survival to estimate, for example, the chance of not having an index CT scan. Logistic regression estimates the odds ratio (OR), which compares the risk (technically called the odds) in one group, in this case Māori, with the risk (odds) in the other group, in this case non-Māori. The resulting ratio would be 1.0 if the risk in each group was equal. An OR greater than 1.0 indicates that the risk is higher in Māori, and an OR of less than 1.0 indicates that the risk is lower in Māori.

For all ORs and HRs, we estimated uncertainty using a 95% confidence interval (CI). We interpret this as meaning we can be 95% sure that the true population estimate of the HR lies in the 95% CI. Some people follow the criterion that if a 95% CI for a ratio includes the null value of 1.0, this means there is no association between the exposure and outcome variables. We have not taken this strict interpretation, because the width of the CI not only is related to the strength of the evidence of the association between the two variables, but is also closely related to the sample size. For this reason, we have been more cautious in our interpretation. The corollary of this is that we have not identified *p*-values of < 0.05 as 'statistically significant' and $p > 0.05$ as 'not statistically significant'. Instead we have used the *p*-value as a measure of the strength of the evidence against the null hypothesis that no difference exists between two variables.

For each variable, we conducted an exploratory analysis to determine whether that variable was associated with ethnicity. We then estimated crude associations between the variable and mortality. To investigate equity, we conducted separate analyses for Māori and non-Māori so that we could answer the question 'Are these factors related to mortality in the same way for Māori and non-Māori?' and conducted a statistical test of interaction. We then built statistical models of inequity in mortality between Māori and non-Māori, adjusting for the exposure variable. The results allowed us to answer the question 'Which factors "explain" some of the Māori–non-Māori inequity in mortality?', by investigating confounding. We adjusted these models for age (see Appendix 1) and sex. We finally constructed a multivariable model, including all the variables associated with mortality in the univariate models.

For some variables, it made more sense to restrict the data to certain groups of patients. In these cases, we report our findings as subgroup analyses. For some variables that showed an inequity, we conducted more detailed analyses, which we present in the Results section under 'equity analyses' headings.

Results | Ngā hua

These results are based on data available for injuries that occurred between 1 July 2015 and 30 June 2019. A total of 7,595 people sustained major trauma during that time. Of these, 25 had two major trauma events and 1 person had three events, but we include only the first event for each of these 26 people in this analysis. A total of 143 people had an ISS of under 13 but had been included in the NZ-MTR because they had died in hospital; these were excluded from the main analyses. One person with missing data on sex was excluded. Following this approach, the results we present here include 7,451 people. Of these, 60 people had their ethnicity coded as 'not stated/don't know/refused to answer/response unidentifiable', so we categorised them as non-Māori; in total 1,668 (22.4%) people included in the analysis were Māori. Among the 7,451 people included in the analysis, a total of:

- 682 (9.2%) died within 30 days of injury, including 129 (7.7%) Māori
- 745 (10.0%) died within 90 days of injury, including 141 (8.5%) Māori.

Table 3 sets out descriptive statistics of people admitted with major trauma. The median age (inter-quartile range, IQR) among Māori was 33 years (IQR 21–51 years), and among non-Māori was 50 years (IQR 28–66 years). Among both Māori and non-Māori, there were many more men than women, but this gender difference was more noticeable in Māori. The majority of Māori with trauma lived in the North Island, as we would expect from the distribution of the Māori population more generally.

Among non-Māori, trauma events occurred relatively evenly across all deprivation quintiles. In contrast, among Māori half of the events occurred in the most deprived quintile. The population distribution does not fully explain the disparity; in the 2013 census, 40% of the Māori population lived in the most deprived quintile. The data in Table 3, therefore, suggests an excess of major trauma for Māori in the most deprived areas.

The majority of trauma experienced was blunt trauma (94.9%) (see Table 4). However, Māori were twice as likely to experience burns and penetrating injuries as non-Māori. Although the majority of trauma was unintentional in both Māori and non-Māori, Māori were much more likely to have injuries that others had inflicted.

Table 3: Number (proportion) of people admitted with major trauma in Aotearoa New Zealand, 2015–2019

Sociodemographic factor	Māori (n = 1,668)	Non-Māori (n = 5,783)	*p*-value
Age (years)			
< 15	195 (11.7%)	310 (5.4%)	
15–29	528 (31.7%)	1,240 (21.4%)	
30–44	370 (22.2%)	893 (15.4%)	
45–64	417 (25.0%)	1,775 (30.7%)	
65+	158 (9.5%)	1,565 (27.1%)	< 0.001
Sex			
Female	447 (26.8%)	1,693 (29.3%)	
Male	1,221 (73.2%)	4,090 (70.7%)	0.049
Region			
Northern	553 (33.2%)	1,726 (29.9%)	
Midland	569 (34.1%)	1,136 (19.6%)	
Central	381 (22.8%)	1,258 (21.8%)	
South Island	162 (9.7%)	1,463 (25.3%)	< 0.001
Overseas/unknown	3 (0.2%)	200 (3.5%)	
Deprivation quintile			
Q1	80 (4.8%)	1,139 (19.7%)	
Q2	151 (9.1%)	1,063 (18.4%)	
Q3	217 (13.0%)	1,108 (19.2%)	
Q4	378 (22.7%)	1,174 (20.3%)	
Q5	838 (50.2%)	1,098 (19.0%)	< 0.001
Missing	4 (0.2%)	201 (3.5%)	

Table 4: Description of trauma in Māori and non-Māori admitted patients in Aotearoa New Zealand, 2015–2019

Description	Māori (n = 1,668)	Non-Māori (n = 5,783)	*p*-value
Injury type			
Blunt	1,525 (91.4%)	5,546 (95.9%)	
Penetrating	104 (6.2%)	178 (3.1%)	
Burn	37 (2.2%)	58 (1.0%)	
Unknown	2 (0.1%)	1 (< 0.1%)	< 0.001
Injury intent			
Unintentional	1,357 (81.4%)	5,281 (91.3%)	
By other	249 (14.9%)	355 (6.1%)	
Self-inflicted	43 (2.6%)	118 (2.0%)	
Unknown	19 (1.1%)	29 (0.5%)	< 0.001

Mortality

A total of 682 people (9.2%) died within 30 days of admission to hospital following trauma.

The 30-day mortality risk was 7.7% (129 deaths) among Māori and 9.6% (553 deaths) among non-Māori. This translates to a crude hazard mortality ratio of 0.80 (95% CI: 0.66–0.97), indicating that Māori are 20% less likely than non-Māori to die within 30 days following major trauma. However, after taking age into account, Māori are 14% more likely to die following major trauma than non-Māori (HR 1.14, 95% CI: 0.93–1.40), though this does not reach conventional levels of statistical significance.

Table 5 shows the cause of death. Māori were more likely than non-Māori to die of haemorrhage, and less likely to die of central nervous system injuries, multi-organ failure or medical/other reasons. Māori were also more likely to not have the cause of death coded in the NZ-MTR. Because the NZ-MTR only records cause of death if it occurs in hospital, this higher proportion of ‘missing’ cause of death among Māori implies a higher proportion of deaths among Māori occurs after discharge, compared with non-Māori.

Table 5: Cause of death within 30 days among 682 people who died after admission for major trauma in Aotearoa New Zealand, 2015–2019

Cause of death	Māori (n = 129)	Non-Māori (n = 553)	*p*-value
Central nervous system	56 (43.4%)	274 (49.6%)	
Haemorrhage	21 (16.3%)	56 (10.1%)	
Multi-organ failure	6 (4.7%)	44 (8.0%)	
Medical/other	7 (5.4%)	58 (10.5%)	0.040
Missing	39 (30.2%)	121 (21.9%)	

In the 90 days following trauma, 745 (10%) people died, including 141 (8.5%) Māori. This translates to a crude hazard (mortality) ratio of 0.80 (95% CI: 0.67–0.96), indicating that Māori are 20% less likely than non-Māori to die within 90 days following major trauma. After accounting for age, however, Māori are 19% more likely to die following major trauma than non-Māori (HR 1.19, 95% CI: 0.98–1.44).

Table 6 shows the cause of death and indicates that the patterns for 90-day mortality were similar to those for 30-day mortality. Māori were more likely than non-Māori to die of haemorrhage, and less likely to die of central nervous system injuries, multi-organ failure or medical/other reasons. Māori were also more likely to not have the cause of death coded in the NZ-MTR, indicating they died after discharge, although the difference between Māori and non-Māori was not as marked as it was at 30 days.

Table 6: Cause of death within 90 days among 745 people who died after admission for major trauma in Aotearoa New Zealand, 2015–2019

Cause of death	Māori (n = 141)	Non-Māori (n = 604)	*p*-value
Central nervous system	57 (40.4%)	275 (45.5%)	
Haemorrhage	21 (14.9%)	57 (9.4%)	
Multi-organ failure	7 (5.0%)	46 (7.6%)	
Medical/other	9 (6.4%)	61 (10.1%)	0.090
Missing	47 (33.3%)	165 (27.3%)	

The risk of mortality appeared to increase with increasing age, although this only reached conventional levels of statistical significance among the oldest group, who had three times the risk of mortality compared with those aged 30–44 years (see Table 7). Males appeared to have a lower risk of mortality compared with females admitted with major trauma. No clear patterns for injury year, region or deprivation were associated with 30-day or 90-day mortality following major trauma.

After taking account of sex (Table 8), older age people continued to show increased risk of mortality among both Māori and non-Māori. After adjusting for age, the mortality risk for males was higher than for females, though this only reached conventional levels of statistical significance among non-Māori. Again, no patterns were discernible for injury year or region, but the results suggested a lower mortality risk among non-Māori who live in more affluent areas compared with those in the most deprived areas.

Table 7: Crude associations between sociodemographic factors and 30- and 90-day mortality among 7,451 people admitted with major trauma in Aotearoa New Zealand, 2015–2019

Sociodemographic factor	30-day mortality		90-day mortality	
	HR	95% CI	HR	95% CI
Age (years)				
< 15	0.90	0.59–1.39	0.90	0.59–1.38
15–29	0.93	0.69–1.26	0.92	0.68–1.23
30–44	1*		1*	
45–64	1.05	0.79–1.38	1.08	0.82–1.42
65+	3.37	2.63–4.32	3.74	2.94–4.75
Sex				
Female	1*		1*	
Male	0.86	0.73–1.01	0.82	0.70–0.95
Injury year				
2015	1.06	0.77–1.46	1.15	0.85–1.55
2016	1.11	0.86–1.43	1.1	0.86–1.40
2017	1.19	0.93–1.52	1.17	0.93–1.48
2018	1.11	0.88–1.41	1.09	0.86–1.37
2019	1*		1*	
Region				
Northern	1*		1*	
Midland	0.90	0.73–1.11	0.95	0.78–1.16
Central	1.08	0.88–1.32	1.08	0.89–1.31
South Island	0.93	0.75–1.15	0.95	0.78–1.17
Overseas/unknown	0.73	0.42–1.25	0.68	0.39–1.16
Deprivation quintile				
Q1	0.94	(0.74–1.19)	0.94	(0.75–1.19)
Q2	0.88	(0.69–1.12)	0.91	(0.72–1.15)
Q3	1.08	(0.87–1.36)	1.06	(0.86–1.32)
Q4	1.02	(0.82–1.27)	1.03	(0.84–1.27)
Q5	1*		1*	

Note: CI = confidence interval; HR = hazard ratio.
* Reference category.

Table 8: Age- and sex-adjusted associations between sociodemographic factors and 30-day mortality among 1,668 Māori and 5,783 non-Māori admitted to hospital with major trauma in Aotearoa New Zealand, 2015–2019

Sociodemographic factor	Māori (n = 1,668)		Non-Māori (n = 5,783)	
	HR	95% CI	HR	95% CI
Age (years)				
< 15	0.79	0.39–1.61	0.96	(0.56–1.67)
15–29	0.94	0.56–1.56	0.93	(0.65–1.34)
30–44	1*		1*	
45–64	0.94	0.55–1.61	1.11	(0.80–1.54)
65+	2.72	1.59–4.63	3.68	(2.73–4.96)
Sex				
Female	1*		1*	
Male	1.12	0.75–1.67	1.23	(1.02–1.48)
Injury year				
2015	0.85	0.36–1.97	1.22	(0.86–1.74)
2016	1.14	0.62–2.09	1.14	(0.86–1.52)
2017	1.44	0.81–2.58	1.23	(0.94–1.61)
2018	1.38	0.78–2.44	1.07	(0.82–1.40)
2019	1*		1*	
Region				
Northern	1*		1*	
Midland	0.67	0.43–1.05	0.92	(0.72–1.17)
Central	0.95	0.61–1.48	0.89	(0.71–1.13)
South Island	0.87	0.47–1.64	0.83	(0.66–1.04)
Overseas/unknown	N/A		0.95	(0.55–1.65)
Deprivation quintile				
Q1	1.33	(0.64–2.78)	0.77	(0.59–1.01)
Q2	0.74	(0.37–1.50)	0.74	(0.56–0.98)
Q3	0.80	(0.45–1.42)	0.88	(0.68–1.14)
Q4	1.06	(0.69–1.62)	0.78	(0.60–1.01)
Q5	1*		1*	

Note: CI = confidence interval; HR = hazard ratio. All HRs are adjusted for age and sex (effect of age only adjusted for sex; effect of sex only adjusted for age).
* Reference category.

Underlying health

To estimate comorbidity, we used the five-year Charlson Comorbidity Index, as defined by Quan and colleagues [124]. From the crude data, as Table 9 shows, it appears that Māori were slightly less likely to have comorbidities than non-Māori. However, after accounting for age, Māori were much more likely to have comorbidities than non-Māori (data not shown).

Comorbidity and mortality were strongly related (see Table 10). The effect of comorbidity on 30-day mortality was similar in Māori and non-Māori (see Table 11). We found no evidence of statistical interaction ($p = 0.5$); that is, the effect of comorbidity on 30-day mortality is the same for Māori and non-Māori.

Table 9: Number and proportion of people admitted with major trauma in Aotearoa New Zealand, by Charlson Comorbidity Index, 2015–2019

Comorbidity index	Māori (n = 1,668)	Non-Māori (n = 5,783)	*p*-value
0	1,429 (85.7%)	4,849 (83.9%)	
1	81 (4.9%)	235 (4.1%)	
2	97 (5.8%)	426 (7.4%)	
3	19 (1.1%)	74 (1.3%)	
4	23 (1.4%)	78 (1.4%)	
5+	16 (1.0%)	89 (1.5%)	0.072
Missing	3 (0.2%)	32 (0.6%)	

Table 10: Age- and sex-adjusted association between Charlson Comorbidity Index and 30- and 90-day mortality among 7,416 people admitted with major trauma in Aotearoa New Zealand, 2015–2019

Comorbidity index	30-day mortality		90-day mortality	
	HR	95% CI	HR	95% CI
0	1*		1*	
1	1.29	(0.94–1.77)	1.38	(1.03–1.85)
2	1.60	(1.26–2.01)	1.63	(1.31–2.04)
3	1.85	(1.21–2.83)	2.06	(1.39–3.03)
4	1.99	(1.34–2.96)	2.31	(1.62–3.30)
5+	2.13	(1.46–3.10)	2.30	(1.63–3.26)

Note: CI = confidence interval; HR = hazard ratio.

* Reference category.

Table 11: Age- and sex-adjusted association between Charlson Comorbidity Index and 30-day mortality among Māori and non-Māori, following admission for major trauma in Aotearoa New Zealand, 2015–2019

Comorbidity index	Māori		Non-Māori	
	HR	95% CI	HR	95% CI
0	1*		1*	
1	0.65	(0.23–1.82)	1.43	(1.02–2.00)
2	1.39	(0.73–2.66)	1.62	(1.26–2.08)
3	2.26	(0.79–6.45)	1.8	(1.12–2.89)
4	1.89	(0.66–5.44)	2.08	(1.36–3.20)
5+	3.69	(1.35–10.13)	2.05	(1.36–3.08)

Note: CI = confidence interval; HR = hazard ratio.
* Reference category.

Injury marker 1: Cause of injury

We had four categories for cause of injury (see Appendix 1 for details). The most common cause was a road traffic crash (RTC, 53.6%), followed by falls (26.8%). Assaults accounted for 7.9% of trauma, and the remaining 11.7% of injury was due to another cause. The patterns for cause of trauma were different for Māori and non-Māori: Māori were more likely to suffer major trauma from RTC or assault than non-Māori, and less likely to experience trauma from falls (see Table 12). After adjusting for age and sex, the same patterns remained.

The 30- and 90-day mortality was lower for trauma caused by RTC compared with the other categories, and higher for falls, assaults and other causes of trauma (see Table 13).

Table 14 shows the risk of dying from each type of injury for Māori compared with non-Māori, after adjusting for age and sex. For RTC, Māori had a 25% higher risk of dying than non-Māori, though the results did not reach conventional levels of statistical significance. For falls, assaults and other causes of injuries, the 30-day mortality rate was similar for Māori and non-Māori. Similar patterns were evident for 90-day mortality (Table 15). However, the inequity between Māori and non-Māori mortality was heightened for RTC, which may be partly because Māori experience more severe injury than non-Māori (see 'Injury marker 2: Severity of injury' below).

Table 12: Number and proportion of people admitted with major trauma in Aotearoa New Zealand, by cause of trauma, 2015–2019

Cause	Māori (n = 1,668)	Non-Māori (n = 5,783)	*p*-value
RTC	951 (57.0%)	3,043 (52.6%)	
Fall	301 (18.1%)	1,693 (29.3%)	
Assault	244 (14.6%)	348 (6.0%)	
Other	172 (10.3%)	699 (12.1%)	< 0.001

Note: RTC = road traffic crash.

Table 13: Age- and sex-adjusted association between cause of trauma and 30- and 90-day mortality among 7,451 people admitted with major trauma in Aotearoa New Zealand, 2015–2019

Cause	30-day mortality		90-day mortality	
	HR	95% CI	HR	95% CI
RTC	1*		1*	
Fall	1.17	(0.97–1.42)	1.22	(1.02–1.47)
Assault	1.36	(0.98–1.88)	1.40	(1.02–1.93)
Other	1.70	(1.34–2.16)	1.69	(1.34–2.14)

Note: CI = confidence interval; HR = hazard ratio; RTC = road traffic crash.
* Reference category.

Table 14: Age- and sex-adjusted 30-day mortality among Māori compared with non-Māori, following admission for major trauma from various causes in Aotearoa New Zealand, 2015–2019

Cause	Māori (n = 1,668)	Non-Māori (n = 5,783)
	HR (95% CI)	
RTC	1.25 (0.93–1.68)	1*
Fall	0.97 (0.65–1.44)	1*
Assault#	1.19 (0.66–2.16)	1*
Other#	1.23 (0.71–2.11)	1*

Note: CI = confidence interval; HR = hazard ratio; RTC = road traffic crash.
* Reference category.
# Adjusted for age group, not five-year age bands, due to collinearity in some strata.

Table 15: Age- and sex-adjusted 90-day mortality among Māori compared with non-Māori, following admission for major trauma from various causes in Aotearoa New Zealand, 2015–2019

Cause	Māori (n = 1,668)	Non-Māori (n = 5,783)
	HR (95% CI)	
RTC	1.33 (1.00–1.76)	1*
Fall	1.00 (0.69–1.46)	1*
Assault#	1.18 (0.66–2.10)	1*
Other#	1.26 (0.74–2.14)	1*

Note: CI = confidence interval; HR = hazard ratio; RTC = road traffic crash.
* Reference category.
# Adjusted for age group, not five-year age bands due to collinearity in some strata.

Injury marker 2: Severity of injury

We measured injury severity in three ways, based on:

1. the Injury Severity Score (ISS) – see Appendix 1 for details on calculating the ISS from the Abbreviated Injury Score
2. the Glasgow Coma Scale (GCS) – see Appendix 1 for a description
3. whether the patient was intubated or not.

The analysis of injury severity using ISS showed Māori were more likely to have more serious trauma: 32% of Māori had an ISS of 25 or higher, compared with 27% of non-Māori, $p < 0.001$ (see Table 16). ISS was strongly related to 30- and 90-day mortality (see Table 17). Table 18 shows the 30-day mortality by ISS category for Māori and non-Māori. We found no evidence of statistical interaction ($p = 0.32$); that is, the effect of ISS on 30-day mortality is the same for Māori and non-Māori.

Table 16: Number and proportion of people admitted with major trauma in Aotearoa New Zealand, by Index Severity Score, 2015–2019

ISS	Māori (n = 1,668)	Non-Māori (n = 5,783)	*p*-value
13–15	389 (23.3%)	1,567 (27.1%)	
16–24	743 (44.5%)	2,662 (46.0%)	
25–40	474 (28.4%)	1,361 (23.5%)	
41–75	62 (3.7%)	193 (3.3%)	< 0.001

Note: ISS = Injury Severity Score.

Table 17: Age- and sex-adjusted association between Index Severity Score and 30- and 90-day mortality among 7,451 people admitted with major trauma in Aotearoa New Zealand, 2015–2019

ISS	30-day mortality		90-day mortality	
	HR	95% CI	HR	95% CI
13–15	1*		1*	
16–24	2.09	(1.47–2.97)	1.96	(1.43–2.68)
25–40	11.91	(8.60–16.51)	10.02	(7.48–13.41)
41–75	37.05	(25.66–53.49)	32.00	(22.88–44.77)

Note: CI = confidence interval; HR = hazard ratio; ISS = Injury Severity Score.

* Reference category.

Table 18: Age- and sex-adjusted association between Index Severity Score and 30-day mortality among Māori and non-Māori, following admission for major trauma in Aotearoa New Zealand, 2015–2019

ISS	Māori		Non-Māori	
	HR	**95% CI**	**HR**	**95% CI**
13–15	1*		1*	
16–24	3.05	(1.17–7.95)	1.96	(1.34–2.86)
25–40	14.59	(5.88–36.19)	11.60	(8.17–16.47)
41–75	33.47	(12.32–90.96)	40.13	(26.97–59.70)

Note: CI = confidence interval; HR = hazard ratio; ISS = Injury Severity Score.
* Reference category.

Our second method of investigating the severity of the injury was to use the total GCS score at the time of hospital admission. The scale was classified into mild, moderate and severe head injury, using standard cut-offs [125].

This analysis showed a clear relationship between the two markers ($p < 0.001$) (see Table 19). However, it is noticeable that only 15% of people with severe head injury as coded using the GCS were in the top ISS category, and a small proportion of people with mild symptoms on the GCS had a severe injury according to the ISS categorisation.

Table 19: Number and proportion of people classified according to Glasgow Coma Scale and Injury Severity Score following admission for major trauma in Aotearoa New Zealand, 2015–2019

GCS score		ISS category			
		13–15	**16–24**	**25–40**	**41–75**
13–15 (mild)	n	1,770	2,792	1,122	78
	%	30.7	48.5	19.5	1.4
9–12 (moderate)	n	53	213	146	18
	%	12.3	49.5	34.0	4.2
≤ 8 (severe)	n	49	245	435	136
	%	5.7	28.3	50.3	15.7

Note: GCS = Glasgow Coma Scale; ISS = Injury Severity Score.

Using the GCS, Māori were more likely to have more serious trauma symptoms: 14.5% of Māori had a GCS score of 8 or lower, compared with 10.8% of non-Māori, $p < 0.001$ (see Table 20). GCS score was strongly related to 30- and 90-day mortality, as Table 21 shows.

Table 20: Number and proportion of people admitted with major trauma in Aotearoa New Zealand, by Glasgow Coma Scale score, 2015–2019

GCS score	Māori (n = 1,668)	Non-Māori (n = 5,783)	*p*-value
13–15 (mild)	1,190 (71.3%)	4,572 (79.1%)	
9–12 (moderate)	119 (7.1%)	311 (5.4%)	
≤ 8 (severe)	241 (14.5%)	624 (10.8%)	< 0.001
Missing/NA	118 (7.1%)	276 (4.8%)	

Note: GCS = Glasgow Coma Scale; NA = not available.

Table 21 shows the 30-day mortality by GCS category for Māori and non-Māori. We found no evidence of statistical interaction ($p = 0.52$); that is, the effect of GCS score on 30-day mortality was the same for Māori and non-Māori.

Table 21: Age- and sex-adjusted association between Glasgow Coma Scale score and 30- and 90-day mortality among 7,057 people admitted with major trauma in Aotearoa New Zealand, 2015–2019

GCS score	30-day mortality		90-day mortality	
	HR	95% CI	HR	95% CI
13–15 (mild)	1*		1*	
9–12 (moderate)	4.33	(3.20–5.85)	4.05	(3.04–5.39)
≤ 8 (severe)	22.49	(18.72–27.03)	20.25	(17.01–24.10)

Note: CI = confidence interval; HR = hazard ratio; GCS = Glasgow Coma Scale.
* Reference category.

Table 22: Age- and sex-adjusted association between Glasgow Coma Scale score and 30-day mortality among Māori and non-Māori, following admission for major trauma in Aotearoa New Zealand, 2015–2019

GCS score	Māori		Non-Māori	
	HR	95% CI	HR	95% CI
13–15 (mild)	1*		1*	
9–12 (moderate)	3.35	(1.57–7.16)	4.18	(3.06–5.70)
≤ 8 (severe)	18.74	(12.06–29.13)	21.11	(17.42–25.58)

Note: CI = confidence interval; GCS = Glasgow Coma Scale; HR = hazard ratio.
* Reference category.

Our final measure of severity was whether the patient was intubated[2] or not, either before arriving at hospital or in the hospital. As Table 23 shows, Māori were more likely to be intubated than non-Māori, suggesting they experienced more severe trauma. We found a strong relationship between whether a patient was intubated and both 30-day and 90-day mortality (see Table 24). Those who had been intubated were 10 times more likely to die in the 30 days following trauma than those who had not been intubated.

Table 25 shows the 30-day mortality for Māori and non-Māori according to whether or not they had been intubated. We found no evidence of statistical interaction ($p = 0.56$); that is, the association between whether a patient was intubated and 30-day mortality is the same for Māori and non-Māori.

Table 23: Number and proportion of people admitted with major trauma in Aotearoa New Zealand, according to whether they were intubated or not, 2015–2019

Intubation	Māori (n = 1,668)	Non-Māori (n = 5,783)	*p*-value
Yes	433 (26.0%)	962 (16.6%)	
No	1,235 (74.0%)	4,821 (83.4%)	< 0.001

Table 24: Age- and sex-adjusted association between intubation and 30- and 90-day mortality among 7,451 people admitted with major trauma in Aotearoa New Zealand, 2015–2019

Intubation	30-day mortality		90-day mortality	
	HR	95% CI	HR	95% CI
Yes	10.63	(9.01–12.54)	9.87	(8.43–11.55)
No	1*		1*	

Note: CI = confidence interval; HR = hazard ratio.
* Reference category.

Table 25: Age- and sex-adjusted association between intubation and 30-day mortality among Māori and non-Māori, following admission for major trauma in Aotearoa New Zealand, 2015–2019

Intubation	Māori		Non-Māori	
	HR	95% CI	HR	95% CI
Yes	10.38	(6.90–15.60)	10.84	(9.04–12.99)
No	1*		1*	

Note: CI = confidence interval; HR = hazard ratio.
* Reference category.

[2] Endotracheal intubation is a procedure in which a tube is placed into the windpipe (trachea), usually through the mouth, for respiratory support. Receiving intubation reflects the severity, location and type of injury. Pre-hospital intubation also reflects the skill of the attending pre-hospital care provider(s).

Subgroup: Serious traumatic brain injury

This analysis is based on the definition of serious traumatic brain injury (sTBI) in the NZ-MTR Annual Report 2017–2018: it applies to people with an AIS code of 3 or more in the head and neck region. Based on this definition, we identified a total of 3,141 sTBI cases, accounting for 42.2% of all injuries.

As Table 26 shows, sTBI was more common in Māori, accounting for 45.2% of all major trauma, compared with 41.3% in non-Māori. After adjusting for age and sex, sTBI was associated with over 3.5 times the risk of mortality in the first 30 days and the first 90 days following injury compared with trauma that did not involve sTBI (see Table 27). The effect of sTBI on mortality is similar for Māori and non-Māori (see Table 28), with no evidence of statistical interaction ($p = 0.44$).

Among people who had experienced sTBI, Māori had a 30-day mortality rate that was similar to non-Māori (age- and sex-adjusted HR: 0.94, 95% CI 0.74–1.19). Following adjustment for ISS, the results suggested that Māori had a lower mortality rate (adjusted HR: 0.83, 95% CI 0.66–1.06), although this did not reach conventional levels of statistical significance.

Among people who had experienced trauma that was not classified as sTBI, Māori had a 50% higher 30-day mortality rate than non-Māori (see Table 29). This inequity was stronger after adjusting for ISS (adjusted HR: 1.57, 95% CI 1.06–2.32).

Table 26: Number and proportion of people admitted with major trauma in Aotearoa New Zealand, by serious traumatic brain injury, 2015–2019

sTBI	Māori (n = 1,668)	Non-Māori (n = 5,783)	*p*-value
Yes	754 (45.2%)	2,387 (41.3%)	
No	914 (54.8%)	3,396 (58.7%)	0.004

Note: sTBI = serious traumatic brain injury.

Table 27: Age- and sex-adjusted association between serious traumatic brain injury and 30- and 90-day mortality among 7,452 people admitted with major trauma in Aotearoa New Zealand, 2015–2019

sTBI	30-day mortality		90-day mortality	
	HR	95% CI	HR	95% CI
Yes	3.62	(3.04–4.31)	3.49	(2.96–4.13)
No	1*		1*	

Note: CI = confidence interval; HR = hazard ratio; sTBI = serious traumatic brain injury.

* Reference category.

Table 28: Age- and sex-adjusted association between serious traumatic brain injury and 30-day mortality among Māori and non-Māori, following admission for major trauma in Aotearoa New Zealand, 2015–2019

sTBI	Māori		Non-Māori	
	HR	95% CI	HR	95% CI
Yes	3.19	(2.15–4.72)	3.77	(3.10–4.59)
No	1*		1*	

Note: CI = confidence interval; HR = hazard ratio; sTBI = serious traumatic brain injury.
* Reference category.

Table 29: Comparison of 30-day mortality between Māori and non-Māori, following admission for major trauma in Aotearoa New Zealand, according to serious traumatic brain injury, 2015–2019

sTBI	Māori		Non-Māori
	HR	95% CI	HR
Yes	0.94	(0.74–1.19)	1*
No	1.50	(1.02–2.21)	1*

Note: CI = confidence interval; HR = hazard ratio; sTBI = serious traumatic brain injury. Adjusted for age and sex.
* Reference category.

Process marker 1: Mode of transfer from scene

The way a patient is transferred from the scene of trauma to hospital – by helicopter, ambulance or another means – is partly a marker of the severity of the trauma, and partly due to whether the scene is rural or remote.

The most common mode of transfer from scene of injury was road ambulance, although this was less likely for Māori than non-Māori (65.8% vs 70.3%, $p = 0.002$); Māori were more likely to transfer by helicopter and other modes (see Table 30). Mode of transfer showed an association with 30-day and 90-day mortality, in that helicopter transfers were associated with an increased risk (30-day HR 1.31, 95% CI 1.07–1.60) and other modes were associated with a lower risk (30-day HR 0.45, 95% CI 0.33–0.61) of mortality (see Table 31).

Table 32 shows the patterns of association were the same among Māori and non-Māori for mode of transfer and 30-day mortality. We found no evidence of statistical interaction ($p = 0.81$); that is, the effect of mode of transfer on 30-day mortality was the same for Māori and non-Māori.

Table 30: Number and proportion of people admitted with major trauma in Aotearoa New Zealand, by mode of transfer from scene, 2015–2019

Mode	Māori (n = 1,668)	Non-Māori (n = 5,783)	*p*-value
Road ambulance	1,098 (65.8.%)	4,064 (70.3%)	
Helicopter	297 (17.8%)	931 (16.1%)	
Other	273 (16.4%)	788 (13.6%)	0.002

Table 31: Age- and sex-adjusted association between mode of transfer from scene and 30- and 90-day mortality among 7,451 people admitted with major trauma in Aotearoa New Zealand, 2015–2019

Mode	30-day mortality		90-day mortality	
	HR	95% CI	HR	95% CI
Road ambulance	1*		1*	
Helicopter	1.30	(1.06–1.59)	1.28	(1.05–1.56)
Other	0.45	(0.33–0.61)	0.48	(0.36–0.64)

Note: CI = confidence interval; HR = hazard ratio.
* Reference category.

Table 32: Age- and sex-adjusted association between mode of transfer from scene and 30-day mortality among Māori and non-Māori, following admission for major trauma in Aotearoa New Zealand, 2015–2019

Mode	Māori (n = 1,668)		Non-Māori (n = 5,783)	
	HR	95% CI	HR	95% CI
Road ambulance	1*		1*	
Helicopter	1.40	(0.92–2.13)	1.27	(1.01–1.60)
Other	0.42	(0.21–0.84)	0.46	(0.32–0.65)

Note: CI = confidence interval; HR = hazard ratio.
* Reference category.

Location of scene

For both Māori and non-Māori, the most common scene of injury was within large or major urban areas (defined as population over 30,000), where just under half of all major traumas occurred. Urban areas that are small (population 1,000–10,000) to medium (10,000–30,000), and rural areas (ie, non-urban areas) each accounted for about one-quarter of injuries, while 4–5% of locations were unknown or categorised as ‘other’ (see Table 33). The scene of trauma was associated with 30-day and 90-day mortality, in that smaller urban areas and rural areas had a lower risk of mortality (30-day HR 0.84, 95% CI 0.69–1.01 and HR 0.75, 95% CI 0.60–0.92, respectively) (see Table 34).

Table 35 shows the patterns of association were the same among Māori and non-Māori for scene of trauma and 30-day mortality; however, only non-Māori reached the conventional level of statistical significance. We found no evidence of statistical interaction ($p = 0.81$); that is, the effect of scene location on 30-day mortality was the same for Māori and non-Māori.

Table 33: Number and proportion of people admitted with major trauma in Aotearoa New Zealand, by trauma scene location, 2015–2019

Scene location*	Māori (n = 1,668)	Non-Māori (n = 5,783)	*p*-value
Major urban	752 (45.1%)	2,734 (47.3%)	
Small urban	447 (26.8%)	1,400 (24.2%)	
Rural	400 (24.0%)	1,370 (23.7%)	
Unknown	69 (4.1%)	279 (4.8%)	0.10

* Definition based on Statistics New Zealand Statistical Standard for Geographic Areas, 2018.

Table 34: Age- and sex-adjusted association between scene location and 30- and 90-day mortality among 7,451 people admitted with major trauma in Aotearoa New Zealand, 2015–2019

Scene location	30-day mortality		90-day mortality	
	HR	95% CI	HR	95% CI
Major urban	1*		1*	
Small urban	0.84	(0.69–1.01)	0.85	(0.71–1.02)
Rural	0.75	(0.60–0.92)	0.74	(0.60–0.90)
Unknown	0.82	(0.55–1.24)	0.86	(0.59–1.27)

Note: CI = confidence interval; HR = hazard ratio.
* Reference category.

Table 35: Age- and sex-adjusted association between scene location and 30-day mortality among Māori and non-Māori, following admission for major trauma in Aotearoa New Zealand, 2015–2019

Scene location	Māori (n = 1,668)		Non-Māori (n = 5,783)	
	HR	95% CI	HR	95% CI
Major urban	1*		1*	
Small urban	0.91	(0.60–1.38)	0.80	(0.65–0.99)
Rural	0.71	(0.44–1.14)	0.76	(0.60–0.96)
Unknown	0.70	(0.25–1.94)	0.85	(0.54–1.32)

Note: CI = confidence interval; HR = hazard ratio.
* Reference category.

Process marker 2: Time from injury to arriving at hospital

Of the 7,451 patients in the overall analysis, 503 (6.7%) had missing data on the time of injury (n = 496), time of arrival at hospital (n = 4) or both (n = 3). There was no difference in the degree of missing data between Māori and non-Māori. For a further 34 people (29 Māori, 5 non-Māori), the injury date and time was recorded as being the same as their date and time or arrival at hospital. We therefore excluded the 537 people in all of these categories from the analysis in this section.

The majority of people admitted with major trauma arrived at their first hospital within three hours of their injury (84.2% of Māori and 82.4% of non-Māori) (see Table 36). After taking age and sex into account, the results appeared to show a lower risk of mortality among patients taking longer than one hour to reach the first hospital (see Table 37). The lower risk was not as clear among Māori as it was among non-Māori for the 2–6-hour categories, but was obvious in the group taking over six hours (see Table 38). As with all the data in this report, survivor bias affects the interpretation of the data here; only those people who survived long enough to reach hospital are included in the analysis.

Table 36: Number and proportion of people admitted with major trauma in Aotearoa New Zealand, by time from injury to arriving at first hospital, 2015–2019

Time to hospital	Māori (n = 1,552)	Non-Māori (n = 5,362)	*p*-value
< 1 hr	451 (29.1%)	1,306 (24.4%)	
1 to < 2 hrs	609 (39.2%)	2,228 (41.6%)	
2 to < 3 hrs	247 (15.9%)	884 (16.5%)	
3 to < 6 hrs	126 (8.1%)	476 (8.9%)	
6+ hrs	119 (7.7%)	468 (8.7%)	0.005

Table 37: Age- and sex-adjusted association between time from injury to hospital and 30- and 90-day mortality among 6,914 people admitted with major trauma in Aotearoa New Zealand, 2015–2019

Time to hospital	30-day mortality		90-day mortality	
	HR	95% CI	HR	95% CI
< 1 hr	1*		1*	
1 to < 2 hrs	0.56	(0.47–0.68)	0.58	(0.48–0.70)
2 to < 3 hrs	0.60	(0.47–0.78)	0.61	(0.48–0.78)
3 to < 6 hrs	0.54	(0.39–0.75)	0.58	(0.42–0.79)
6+ hrs	0.46	(0.33–0.63)	0.52	(0.39–0.70)

Note: CI = confidence interval; HR = hazard ratio.
* Reference category.

Table 38: Age- and sex-adjusted association between time from injury to hospital and 30-day mortality among Māori and non-Māori, following admission for major trauma in Aotearoa New Zealand, 2015–2019

Time to hospital	Māori (n = 1,552)		Non-Māori (n = 5,362)	
	HR	95% CI	HR	95% CI
< 1 hr	1*		1*	
1 to < 2 hrs	0.50	(0.32–0.78)	0.58	(0.47–0.72)
2 to < 3 hrs	0.66	(0.39–1.12)	0.59	(0.44–0.78)
3 to < 6 hrs	0.82	(0.44–1.53)	0.47	(0.32–0.69)
6+ hrs	0.13	(0.03–0.53)	0.52	(0.37–0.73)

Note: CI = confidence interval; HR = hazard ratio.
* Reference category.

Process marker 3: Arrival at definitive care hospital

We excluded 507 patients from this analysis because they had missing data on the time of injury, time of arrival at the definitive care hospital or both, and a further 28 people because their injury date and time were recorded as being the same as their date and time of arrival at hospital. The results in this section are therefore based on 6,916 people (1,555 Māori and 5,361 non-Māori).

Overall, 5,468 (79.1%) people with major trauma were taken straight to their hospital of definitive care, whereas the remainder were taken to a different hospital before they were transferred. Māori (70.0%) were much less likely to be taken directly to their hospital of definitive care than non-Māori (81.7%), $p < 0.001$. After accounting for age and sex, Māori were 39% less likely to be taken straight to their definitive care hospital than non-Māori (OR 0.61, 95% CI 0.53–0.70). Given the national implementation of triage and destination policies began in 2017, we explored its effect by recalculating this measure for 2018 and 2019 data only. However, even in these more recent years, Māori were 34% less likely to be taken directly to their definitive care hospital than non-Māori (OR 0.66, 95% CI 0.54–0.80).

Māori were also more likely to take longer to reach their definitive care hospital: 29% of Māori took six hours or longer, compared with 22% of non-Māori (see Table 39). After taking age and sex into account, the results appeared to show a lower mortality rate among patients who took longer than one hour to reach their definitive care hospital compared with those who arrived within an hour of trauma (see Table 40). This association was stronger for non-Māori than Māori (see Table 41).

Table 39: Number and proportion of people admitted with major trauma in Aotearoa New Zealand, by time from injury to arriving at definitive care hospital, 2015–2019

Time to definitive care	Māori (n = 1,555)	Non-Māori (n = 5,361)	*p*-value
< 1 hr	296 (19.0%)	1,027 (19.2%)	
1 to < 2 hrs	436 (28.0%)	1,853 (34.6%)	
2 to < 3 hrs	201 (12.9%)	761 (14.2%)	
3 to < 6 hrs	169 (10.9%)	569 (10.6%)	
6+ hrs	453 (29.1%)	1,151 (21.5%)	< 0.001

Table 40: Age- and sex-adjusted association between time from injury to hospital and 30- and 90-day mortality among 6,916 people admitted with major trauma in Aotearoa New Zealand, 2015–2019

Time to definitive care	30-day mortality		90-day mortality	
	HR	95% CI	HR	95% CI
< 1 hr	1*		1*	
1 to < 2 hrs	0.59	(0.48–0.73)	0.62	(0.51–0.76)
2 to < 3 hrs	0.62	(0.47–0.82)	0.62	(0.48–0.81)
3 to < 6 hrs	0.68	(0.50–0.91)	0.70	(0.53–0.93)
6+ hrs	0.56	(0.44–0.71)	0.59	(0.47–0.74)

Note: CI = confidence interval; HR = hazard ratio.
* Reference category.

Table 41: Age- and sex-adjusted association between time from injury to hospital and 30-day mortality among Māori and non-Māori, following admission for major trauma in Aotearoa New Zealand, 2015–2019

Time to definitive care	Māori (n = 1,555)		Non-Māori (n = 5,361)	
	HR	95% CI	HR	95% CI
< 1 hr	1*		1*	
1 to < 2 hrs	0.67	(0.40–1.13)	0.58	(0.46–0.73)
2 to < 3 hrs	0.86	(0.47–1.56)	0.57	(0.41–0.77)
3 to < 6 hrs	0.97	(0.52–1.83)	0.62	(0.44–0.86)
6+ hrs	0.68	(0.40–1.14)	0.54	(0.41–0.70)

Note: CI = confidence interval; HR = hazard ratio.
* Reference category.

Process marker 4: Treatment of sTBI at a hospital with neurosurgical capability

Ideally, all patients with sTBI would be treated at one of the six hospitals in Aotearoa New Zealand with neurosurgical capability, namely Auckland City Hospital, Christchurch Hospital, Dunedin Hospital, Starship Hospital (paediatric), Waikato Hospital or Wellington Regional Hospital. Records indicate that, among the 3,141 patients with an sTBI, 2,238 (71.3%) had one of these six hospitals as their definitive care facility. Māori were less likely to be treated at one of these hospitals than non-Māori (68.8% vs 72.0%, $p = 0.092$) (see Table 42). After accounting for age and sex, Māori with sTBI were 35% less likely to be treated at a neurosurgical facility than non-Māori (OR 0.65, 95% CI 0.53–0.78).

Having treatment at a neurosurgical facility was not associated with 30- or 90-day mortality in age- and sex-adjusted models (see Table 43). The results suggested that Māori who were treated at a neurosurgical facility had a higher mortality than those who were not, whereas this association did not apply to non-Māori (see Table 44). The *p*-value for statistical interaction was 0.15. This observation, coupled with the finding above that Māori with sTBI were less likely to be treated at a neurosurgical facility, suggests that arrival at a definitive care hospital for Māori with sTBI may be more likely to occur for those with a more serious injury, whereas for non-Māori this did not depend on injury severity.

Table 42: Number and proportion of people admitted with serious traumatic brain injury who are treated at a neurosurgical facility or another facility in Aotearoa New Zealand, 2015–2019

Type of facility	Māori (n = 754)	Non-Māori (n = 2,387)	*p*-value
Neurosurgical facility	519 (68.8%)	1,719 (72.0%)	
Non-neurosurgical facility	235 (31.2%)	668 (28.0%)	0.092

Note: Classification is based on hospital of definitive care.

Table 43: Age- and sex-adjusted association between having treatment at a neurosurgical facility or another facility and 30- and 90-day mortality, among 3,141 admitted patients with serious traumatic brain injury in Aotearoa New Zealand, 2015–2019

Neurosurgical facility	30-day mortality		90-day mortality	
	HR	95% CI	HR	95% CI
Yes	1.05	(0.86–1.27)	1.04	(0.86–1.25)
No	1*		1*	

Note: CI = confidence interval; HR = hazard ratio.
* Reference category.

Table 44: Age- and sex-adjusted association between having treatment at a neurosurgical facility or another facility and 30-day mortality, among 3,141 admitted patients with serious traumatic brain injury in Aotearoa New Zealand, 2015–2019

Neurosurgical facility	Māori (n = 754)		Non-Māori (n = 2,387)	
	HR	95% CI	HR	95% CI
Yes	1.42	(0.88–2.30)	0.98	(0.80–1.22)
No	1*		1*	

Note: CI = confidence interval; HR = hazard ratio.
* Reference category.

Process marker 5: Blood alcohol measurement

Blood alcohol concentration measurements were taken for 59% of Māori and 50% of non-Māori over the five-year period 2015–2019 (see Table 45). Note, however, that this testing increased over this period to the point that in 2019 it was performed for 71% of Māori and 64% of non-Māori patients admitted with major trauma.

After taking age and sex into account, the results indicated no difference in 30-day mortality comparing Māori with non-Māori among those tested for alcohol concentrations (see Table 46). The results suggested an increased mortality risk for Māori compared with non-Māori among those not tested following major trauma (HR 1.23, 95% CI 0.91–1.65), although this did not reach conventional levels of statistical significance. This association was somewhat stronger for 90-day mortality (see Table 47).

Table 45: Number and proportion of people admitted with major trauma in Aotearoa New Zealand, by whether blood alcohol testing was conducted, 2015–2019

Blood alcohol testing	Māori (n = 1,668)	Non-Māori (n = 5,783)	*p*-value
Measurement taken	989 (59.3%)	2,893 (50.0%)	
No measurement	679 (40.7%)	2,890 (50.0%)	< 0.001
(Measured in 2019)	177 (70.5%)	617 (63.8%)	

Table 46: Age- and sex-adjusted 30-day mortality among Māori compared with non-Māori for whether blood alcohol testing was conducted following admission for major trauma in Aotearoa New Zealand, 2015–2019

Blood alcohol testing	Māori (n = 1,668)		Non-Māori (n = 5,783)
	HR	95% CI	
Measurement taken	1.05	(0.80–1.39)	1*
No measurement	1.23	(0.91–1.65)	1*

Note: CI = confidence interval; HR = hazard ratio.
* Reference category.

Table 47: Age- and sex-adjusted 90-day mortality among Māori compared with non-Māori for whether blood alcohol testing was conducted following admission for major trauma in Aotearoa New Zealand, 2015–2019

Blood alcohol testing	Māori (n = 1,668)	Non-Māori (n = 5,783)
	HR (95% CI)	
Measurement taken	1.09 (0.84–1.43)	1*
No measurement	1.29 (0.97–1.70)	1*

Note: CI = confidence interval; HR = hazard ratio.
* Reference category.

Process marker 6: Patients receiving an index CT scan

Among patients admitted with major trauma, 86% of Māori received an index CT scan compared with 90% of non-Māori (see Table 48). After accounting for age and sex, those people who did not receive an index CT scan had twice the risk of mortality as those who received scans (see Table 49). As Table 50 shows, the risk of 30-day mortality among those without CT scans was greater for Māori (HR 2.77, 95% CI 1.87–4.10) than non-Māori (HR 1.85, 95% CI 1.47–2.33), although the test for statistical interaction showed that this could have occurred by chance ($p = 0.14$).

It is important to remember that CT scans are not necessarily appropriate for all types of trauma, in particular penetrating trauma, which is more common among Māori. We address this subject in the multivariable analysis of patients who receive a CT scan (see 'Equity analyses: Patients receiving CT scan' in the Multivariable analysis section).

Table 48: Number and proportion of people admitted with major trauma in Aotearoa New Zealand, by whether they received an index CT scan, 2015–2019

Index CT scan	Māori (n = 1,668)	Non-Māori (n = 5,788)	*p*-value
Yes	1,420 (86.2%)	5,145 (90.4%)	
No	227 (13.8%)	546 (9.6%)	< 0.001
Unknown	21	92	

Table 49: Age- and sex-adjusted association between receiving an index CT scan or not and 30- and 90-day mortality, among 7,338 people admitted with major trauma in Aotearoa New Zealand, 2015–2019

Index CT scan	30-day mortality		90-day mortality	
	HR	95% CI	HR	95% CI
Yes	1*		1*	
No	2.04	(1.68–2.49)	1.95	(1.61–2.36)

Note: CI = confidence interval; HR = hazard ratio.
* Reference category.

Table 50: Age- and sex-adjusted association between receiving an index CT scan or not and 30-day mortality, among 7,338 people admitted with major trauma in Aotearoa New Zealand, 2015–2019

Index CT scan	Māori (n = 1,647)		Non-Māori (n = 5,691)	
	HR	95% CI	HR	95% CI
Yes	1*		1*	
No	2.77	(1.87–4.10)	1.85	(1.47–2.33)

Note: CI = confidence interval; HR = hazard ratio.
* Reference category.

Process marker 7: Time from injury to CT scan

The median time from injury to CT scan was 3 hours (IQR 2.08–4.53). Māori were more likely to receive a CT scan sooner: the median time from injury to CT scan was 2.78 hours for Māori (IQR 1.93–4.12) compared with 3.07 hours for non-Māori (IQR 2.13–4.67). See Table 51 for a more detailed comparison of Māori and non-Māori data.

Table 52 shows the association between time to CT scan and mortality. A decreasing risk of mortality with increasing time to CT scan is evident at 30 and 90 days after trauma. Table 53 compares mortality rates among Māori and non-Māori, indicating a different pattern for these two groups. Māori who had a CT scan in the first hour following injury had a high mortality rate, whereas the mortality rates at all later times from injury to CT were similar. In contrast, for non-Māori, mortality reduced in a continuous linear pattern by increasing time from injury to CT scan. Some statistical evidence supported a true difference in patterns between Māori and non-Māori, *p*(interaction) = 0.06.

When interpreting the above data, it is important to recognise that prioritisation of CT scans is related to the severity of the injury. In urgent cases, CT scans may not occur until after surgery, whereas in those instances where surgery can wait, they may occur before surgery.

Table 51: Number and proportion of people admitted with major trauma in Aotearoa New Zealand, by time from injury to CT scan, 2015–2019

Time to CT scan	Māori (n = 1,668)	Non-Māori (n = 5,783)	*p*-value
< 1 hr	28 (1.7%)	48 (0.8%)	
1 to < 2 hrs	323 (19.4%)	952 (16.5%)	
2 to < 3 hrs	366 (21.9%)	1,312 (22.7%)	
3 to < 6 hrs	412 (24.7%)	1,706 (29.5%)	
6+ hrs	194 (11.6%)	787 (13.6%)	< 0.001
Missing	345 (20.7%)	978 (16.9%)	

Table 52: Age- and sex-adjusted association between time from injury to hospital and 30- and 90-day mortality among 6,129 people admitted with major trauma in Aotearoa New Zealand, 2015–2019

Time to CT scan	30-day mortality		90-day mortality	
	HR	95% CI	HR	95% CI
< 1 hr	4.16	(2.53–6.86)	4.25	(2.61–6.90)
1 to < 2 hrs	1.66	(1.31–2.10)	1.63	(1.29–2.05)
2 to < 3 hrs	1*		1*	
3 to < 6 hrs	0.73	(0.57–0.93)	0.75	(0.60–0.94)
6+ hrs	0.56	(0.41–0.77)	0.68	(0.52–0.91)

Note: CI = confidence interval; HR = hazard ratio.
* Reference category.

Table 53: Age- and sex-adjusted association between time from injury to hospital and 30-day mortality among Māori and non-Māori, following admission for major trauma in Aotearoa New Zealand, 2015–2019

Time to CT scan	Māori (n = 1,324)		Non-Māori (n = 4,805)	
	HR	95% CI	HR	95% CI
< 1 hr	5.14	(2.02–13.05)	3.96	(2.16–7.24)
1 to < 2 hrs	1.29	(0.68–2.43)	1.73	(1.34–2.24)
2 to < 3 hrs	1*		1*	
3 to < 6 hrs	1.20	(0.66–2.16)	0.66	(0.50–0.86)
6+ hrs	0.68	(0.29–1.58)	0.56	(0.40–0.78)

Note: CI = confidence interval; HR = hazard ratio. Excludes people with missing data on time to CT scan.
* Reference category.

Process marker 8: Destination after emergency department

After they arrived at the emergency department, the most common destination for patients admitted with major trauma was directly to a ward. However, this destination did vary by ethnicity: 33% of Māori received ward transfer compared with 44% of non-Māori.

Among those who were not transferred to a ward, Māori were more likely to be transferred to an intensive care unit, operating room or another facility and less likely to be transferred to a high dependency unit, compared with non-Māori (see Table 54). Despite these apparent differences between Māori and non-Māori in their destination after the emergency department, without additional medical details it is not possible to look further into whether such differences were clinically appropriate.

Table 54: Number and proportion of people admitted with major trauma in Aotearoa New Zealand, by destination after the emergency department, 2015–2019

Destination after emergency department	Māori (n = 1,668)	Non-Māori (n = 5,783)	*p*-value
Ward	552 (33.1%)	2,536 (43.9%)	
Intensive care unit	440 (26.4%)	1,201 (20.8%)	
Transferred to another facility	297 (17.8%)	658 (11.4%)	
Operating room	227 (13.7%)	538 (9.3%)	
High dependency unit	126 (7.6%)	712 (12.3%)	
Died in emergency department	18 (1.1%)	69 (1.2%)	
Discharged	1 (0.1%)	7 (0.1%)	< 0.001

Summary of descriptive and equity analysis

Age, sex, comorbidity, injury severity, having an sTBI, helicopter transfer from scene, not having an index CT scan and having a CT scan sooner are strong determinants of mortality in Māori and non-Māori. Each of these determinants had a similar effect on mortality in Māori and non-Māori. Mortality was highest among both Māori and non-Māori who were transferred quickly to hospital. Māori took longer to arrive at the definitive care hospital. Among non-Māori but not among Māori, time to definitive care was associated with mortality. As a result of these observations, we conducted a multivariable model of determinants of 30-day mortality among Māori and non-Māori, which we report on in the following section.

In some subgroups, mortality among Māori was higher than among non-Māori.

- Māori are more likely to have sTBI and are equally likely to die following sTBI, but more likely to die following all other trauma.
- Māori with sTBI are less likely to be treated at a specialist facility.
- Māori have a higher risk of mortality following RTC than non-Māori.

We conducted the following additional subgroup analyses.

- Because the ‘time to CT scan’ was an important variable in the descriptive analyses, we undertook further work on this. As the variable is only available for people who had a CT scan, we ran a separate model based only on people who had a CT scan.

- Given the observation that Māori have a higher risk of mortality following RTC than non-Māori, we performed further multivariable analyses on RTC.
- Based on the literature review in the Introduction section, we performed subgroup analyses by age to investigate whether there were any patterns of inequity between Māori and non-Māori by age.

Multivariable analysis

The first set of multivariable models was based on explanatory variables that were associated with mortality as described above. The variables included were age, sex, comorbidity, injury severity (ISS, GCS and intubation), time to definitive care, mode of transfer from scene, location of scene, and whether the patient had an index CT scan. We ran each of them separately for Māori and non-Māori, and tested interactions between each variable and ethnicity, to determine whether a particular explanatory variable differed in its effect on mortality between Māori and non-Māori. After adjusting for all of these variables, we also ran an equity analysis comparing the risk of mortality in Māori and non-Māori.

Table 55 presents the results of the main multivariable model. Among Māori and non-Māori, determinants of 30-day mortality following major trauma were older age, more comorbidities, more severe injury (ISS, GCS score and intubation) and not receiving an index CT scan. Arriving at a definitive care hospital within an hour of the injury was also associated with a higher risk of mortality, likely reflecting the severity of the trauma. The results suggested that non-Māori who experienced trauma within major urban areas had higher mortality than those who experienced trauma in smaller urban or rural areas, which may reflect differences in the type of trauma sustained. Mortality rates were similar in men and women.

We found no evidence of a differential effect of all but one of these variables on mortality for Māori compared with non-Māori ($p > 0.33$ for each variable tested in a two-way interaction with Māori ethnicity). The exception was for not receiving a CT scan, which was much more likely in Māori than non-Māori ($p = 0.049$). We followed up this finding with a further analysis of the predictors of who does not have a CT scan (for more details, see 'Equity analyses: Patients receiving CT scan').

The equity analysis showed no difference in mortality at 30 days between Māori and non-Māori (HR 0.96, 95% CI: 0.76–1.22).

Please take care when interpreting the results for markers of severity. To precisely understand the effect of severity on mortality, we would not include ISS, GCS and intubation all in the same model, because this is 'adjusting away' the effect (given they are all different markers of injury severity). We have, however, included them all in this analysis to understand the effect of carefully adjusting other variables for severity.

Table 55: Multivariable association between determinants of 30-day mortality among 6,444 people admitted with major trauma in Aotearoa New Zealand, 2015–2019

Variable	Māori (n = 1,427)		Non-Māori (n = 5,017)	
	HR	**95% CI**	**HR**	**95% CI**
Age (years)				
< 15	0.52	(0.21–1.30)	0.96	(0.50–1.84)
15–29	0.82	(0.44–1.54)	0.81	(0.53–1.24)
30–44	1*		1*	
45–64	1.33	(0.68–2.63)	1.63	(1.11–2.39)
65+	10.40	(4.56–23.7)	6.54	(4.56–9.37)
Sex				
Female	1*		1*	
Male	0.95	(0.57–1.56)	1.21	(0.98–1.49)
Comorbidity index				
0	1*		1*	
1	0.73	(0.22–2.44)	1.57	(1.08–2.27)
2	1.08	(0.50–2.33)	1.45	(1.09–1.94)
3	1.29	(0.39–4.31)	1.70	(0.96–2.99)
4	1.22	(0.31–4.79)	2.61	(1.63–4.18)
5+	6.06	(1.82–20.2)	3.58	(2.26–5.65)
ISS				
13–15	1*		1*	
16–24	1.78	(0.64–4.94)	1.35	(0.90–2.03)
25–40	5.19	(1.96–13.73)	5.25	(3.56–7.75)
41–75	6.91	(2.20–21.76)	9.52	(5.99–15.13)
GCS score				
13–15	1*		1*	
9–12	4.54	(1.92–10.75)	2.46	(1.69–3.58)
≤ 8	13.12	(6.91–24.93)	8.19	(6.19–10.84)
Intubation				
Yes	1.87	(1.05–3.33)	1.39	(1.06–1.81)
No	1*		1*	

Time to definitive care				
< 1 hr	1*		1*	
1 to < 2 hrs	0.87	(0.47–1.61)	0.78	(0.60–1.02)
2 to < 3 hrs	0.73	(0.33–1.61)	0.86	(0.59–1.24)
3 to < 6 hrs	0.62	(0.27–1.42)	0.64	(0.43–0.96)
6+ hrs	0.40	(0.21–0.74)	0.56	(0.41–0.77)
Mode				
Road ambulance	1*		1*	
Helicopter	0.81	(0.41–1.61)	1.04	(0.76–1.41)
Other	0.74	(0.25–2.17)	0.65	(0.41–1.04)
Location				
Major urban	1*		1*	
Small urban	0.98	(0.56–1.71)	0.72	(0.55–0.94)
Rural	0.87	(0.45–1.67)	0.80	(0.59–1.08)
Unknown	0.72	(0.2–2.59)	0.66	(0.31–1.42)
Index CT scan				
Yes	1*		1*	
No	4.90	(2.93–8.20)	2.71	(2.05–3.59)

Note: CI = confidence interval; GCS = Glasgow Coma Scale; HR = hazard ratio; ISS = Injury Severity Score.
* Reference category.

Subgroup analyses: Time to CT scan

We ran a multivariable model, based only on people who had a CT scan, to investigate the effect of time from injury to CT scan (see Table 56). The results showed a pattern of higher mortality among those who had their CT scan in the first hour following trauma, which is presumably a marker of injury severity. Mortality risks showed a pattern of lowering mortality with longer time to CT scan for both Māori and non-Māori. As mentioned earlier, a CT scan may be done before or after surgery and its timing depends on the clinical need of the patient. Importantly, we found no evidence of inequity in timing of CT scan between Māori and non-Māori.

Table 56: Multivariable association between determinants of 30-day mortality among 5,795 people admitted with major trauma who had an index CT scan in Aotearoa New Zealand, 2015–2019

Time to CT scan	Māori (n = 1,233)		Non-Māori (n = 4,562)	
	HR	**95% CI**	**HR**	**95% CI**
Under 1 hr	1*		1*	
1–2 hrs	0.24	(0.09–0.66)	0.63	(0.34–1.16)
2–3 hrs	0.13	(0.04–0.41)	0.44	(0.23–0.84)
3–6 hrs	0.19	(0.06–0.60)	0.40	(0.21–0.77)
6+ hrs	0.30	(0.09–1.02)	0.47	(0.24–0.94)

Note: CI = confidence interval; HR = hazard ratio.
All HRs are adjusted for age, sex, comorbidity, ISS, time to definitive care, mode of transport from scene, urban/rural location, GCS category and whether the patient was intubated or not.
* Reference category.

Subgroup analyses: Determinants of mortality by age

The following tables present the results of the main multivariable model for two age groups: children and young people (Table 57) and older adults (Table 58). Determinants of 30-day mortality following major trauma for both subsets showed broadly similar patterns to the full model, with higher mortality among those with more severe injuries and those who reached their definitive care hospital within an hour. Among older people (aged 65 years or above), none of the variables reached conventional levels of statistical significance, probably because the numbers of people and deaths in this group were small.

Table 57: Multivariable association between determinants of 30-day mortality among people aged up to 18 years admitted with major trauma in Aotearoa New Zealand, 2015–2019

Variable	Māori (n = 260)		Non-Māori (n = 488)	
	HR	**95% CI**	**HR**	**95% CI**
Sex				
Female	1*		1*	
Male	0.72	(0.19–2.79)	0.75	(0.24–2.41)
ISS				
13–15	1*		1*	
16–24	0.11	(0.01–2.10)	0.34	(0.02–6.22)
25–40	1.37	(0.14–13.12)	2.95	(0.33–26.31)
41–75	3.15	(0.23–43.28)	4.60	(0.47–45.46)
GCS score†				
9–15	1*		1*	
≤ 8	7.31	(1.53–34.8)	6.29	(1.06–37.27)

Intubation				
Yes	2.45	(0.40–14.94)	10.43	(0.91–119.55)
No	1*		1*	
Time to definitive care				
< 1 hr	1*		1*	
1 to < 3 hrs	0.40	(0.06–2.52)	0.18	(0.04–0.86)
3+ hrs	0.38	(0.08–1.92)	0.22	(0.05–0.87)
Mode				
Road ambulance	1*		1*	
Helicopter	1.09	(0.18–6.79)	1.09	(0.28–4.30)
Other	0.53	(0.06–5.03)	1.19	(0.12–12.1)
Location‡				
Major urban	1*		1*	
Small urban	0.92	(0.21–3.97)	0.51	(0.10–2.58)
Rural	1.99	(0.31–12.91)	1.75	(0.39–7.84)
Index CT scan				
Yes	1*		1*	
No	3.62	(0.96–13.72)	6.23	(1.88–20.62)

Note: CI = confidence interval; GCS = Glasgow Coma Scale; HR = hazard ratio; ISS = Injury Severity Score. Adjusted for all variables in the table.

* Reference category.

† Because this age group had no non-Māori deaths in people with a GCS score of 13–15, the GCS categories were combined into severe (≤ 8) and non-severe (9–15). To allow for comparisons, the same was done in the Māori model.

‡ Unknown location category omitted.

Table 58: Multivariable association between determinants of 30-day mortality among people aged 65 years and older admitted with major trauma in Aotearoa New Zealand, 2015–2019

Variable	Māori (n = 137)		Non-Māori (n = 1,360)	
	HR	95% CI	HR	95% CI
Sex				
Female	1*		1*	
Male	0.91	(0.32–2.60)	1.24	(0.95–1.62)
Comorbidity				
No	1*		1*	
Yes	0.75	(0.27–2.07)	1.71	(1.30–2.25)
ISS				
13–15	1*		1*	
16–24	1.67	(0.37–7.56)	1.21	(0.78–1.89)
25–75	3.83	(0.92–16.00)	3.84	(2.50–5.89)
GCS score				
13–15	1*		1*	
9–12	5.32	(0.88–32.14)	2.39	(1.49–3.82)
≤ 8	3.78	(0.73–19.68)	6.44	(4.43–9.37)
Intubation				
Yes	3.18	(0.91–11.16)	2.00	(1.36–2.93)
No	1*		1*	
Time to definitive care				
< 1 hr	1*		1*	
1 to < 3 hrs	0.64	(0.18–2.32)	0.64	(0.46–0.90)
3+ hrs	0.47	(0.12–1.88)	0.52	(0.35–0.75)
Mode				
Road ambulance/other	1*		1*	
Helicopter	4.22	(0.78–22.77)	1.28	(0.80–2.07)
Location				
Major urban	1*		1*	
Small urban	0.89	(0.35–2.26)	0.81	(0.57–1.15)
Rural	0.14	(0.01–1.31)	0.94	(0.60–1.46)
Unknown	0.30	(0.01–10.06)	0.86	(0.34–2.13)
Index CT scan				
Yes	1*		1*	
No	0.80	(0.14–4.64)	1.62	(1.04–2.52)

Note: CI = confidence interval; GCS = Glasgow Coma Scale; HR = hazard ratio; ISS = Injury Severity Score. Adjusted for age in five-year bands, plus all other variables in the table. Some categories of explanatory variables are combined due to small numbers.
* Reference category.

A more detailed analysis of the results for children and young adults showed a clear inequity in mortality for Māori youth aged 15–18 years, but not for children or young adults (Table 59). Māori aged 15–18 years were over three times more likely to die in the 30-days after trauma than non-Māori in this age group. It is important to note that although highly statistically significant, this result is based on a small number of people. When we investigated confounding (statistical adjustment), we found no effect on the reported inequity on 30-day mortality of: sex, time to definitive care, helicopter transfer to hospital, urban/rural designation of injury, receiving an index CT scan and presence of sTBI. Table 59 does not show adjusted data because the small numbers involved make some models unstable.

Because injury severity has such a strong influence on mortality, we adjusted for each measure (ISS, GCS and intubation) separately. Adjusting for ISS did not affect the inequity between Māori and non-Māori (HR for 30-day mortality 3.20, 95% CI 1.21–8.44). When adjusted for severity using a binary variable derived from the GCS (≤ 8 vs 9 or more total score on admission), part of the inequity was explained (adjusted HR 2.05, 95% CI 0.71–5.94).[3] The adjustment for whether the patient was intubated or not produced similar results (HR 2.12, 95% CI: 0.80–5.62). We conclude that part, but not all, of the inequity in mortality seen in these young people is due to trauma severity.[4]

When we looked at in-hospital mortality rather than 30-day mortality, a greater risk for young Māori compared with non-Māori remained, although the evidence was weaker than when 30-day mortality was used as an outcome (OR 2.25, 95% CI: 0.77–6.57).

It is clear that young Māori are experiencing more serious injuries than young non-Māori, as well as higher mortality rates. To gain a deeper understanding of this issue, we explored the types of injuries involved. The injuries for Māori were more likely to be transport-related (72.1% vs 66.5% for non-Māori) or due to assault (13.9% vs 4.1%) rather than falls (8.2% vs 14.7%). Māori in this age group were also more likely to have penetrating injuries (8.2% vs 1.5%). However, neither the cause nor the type of trauma explained the higher mortality among young Māori. There was no difference between Māori and non-Māori as to whether they were injured in an urban or rural setting.

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[3] Data was missing on the GCS, so this analysis was based on 369 people, of whom 14 died.

[4] The confidence intervals of the results adjusted for GCS and intubation include the null value, and therefore do not reach conventional levels of statistical significance. Nevertheless, in the analysis of potential confounding (ie, looking for explanations for observed associations), what matters is the **change in the magnitude** of the HR, rather than the width of the confidence interval. Adding more variables to a model will always increase the stochastic error, and so the confidence intervals will be wider.

Table 59: Inequity in mortality among young people following admission for major trauma in Aotearoa New Zealand, 2015–2019

Age group (years)			Māori: non-Māori mortality	
	Number of deaths	Number of people	HR	95% CI
0–10	22	344	0.90	0.39–2.11
11–14	6	161	1.25	0.23–6.83
15–18	17	388	3.18	1.21–8.36
19–24	46	793	1.15	0.62–2.12

Note: CI = confidence interval; HR = hazard ratio. Data is not adjusted. See text for details on adjustment. The age groups were chosen to reflect early childhood, early adolescence, later adolescence and early adulthood. Typically, paediatric services treat children up to the age of 14 years, and adult services treat those aged 15 years and over.

Subgroup analyses: Determinants of mortality following road traffic crashes

Road traffic crashes were the most common cause of recorded trauma among Māori (57%) and non-Māori (53%). The multivariable model showed no difference between Māori and non-Māori in mortality following an RTC; the severity of the injury explained most of the excess (HR 1.06, 95% CI 0.74–1.50).

Table 60 shows the determinants of mortality in Māori and non-Māori. Broadly, the patterns of mortality were the same as in the main model: older age, greater injury severity (ISS and GCS, but not intubation), shorter time to definitive care and not receiving a CT scan were all associated with higher mortality. Among non-Māori, comorbidities were also associated with higher mortality, and mortality was higher in men than women. Neither of these patterns was evident for Māori.

As Appendix 2 describes in more detail, patterns of mortality were related to deployment of airbags. However, the data on airbags was limited, with a considerable number of people, especially Māori, in the ‘unknown’ category. Due to the uncertainty about the accuracy of the data, we recommend interpreting the associations between inequity in mortality and airbag deployment with caution.

Throughout this report, but particularly in this section, it is also important to remember that the results presented are based on people included in the NZ-MTR – that is, those who were admitted to a hospital following trauma. Therefore, this analysis does not include people who died at the scene or during transfer to hospital. If trauma severity differs by ethnicity – for example, if Māori are more likely to be involved in an accident and die at the scene – the effect will be to reduce the observed inequity in mortality based on the NZ-MTR results.

Table 60: Multivariable association between determinants of 30-day mortality following road traffic crashes and admission for major trauma in Aotearoa New Zealand, 2015–2019

Variable	Māori (n = 829)		Non-Māori (n = 2,714)	
	HR	95% CI	HR	95% CI
Age (years)				
< 15	0.29	(0.06–1.51)	0.74	(0.31–1.77)
15–29	1.04	(0.44–2.46)	0.77	(0.46–1.30)
30–44	1*		1*	
45–64	1.48	(0.54–4.05)	1.00	(0.57–1.74)
65+	19.21	(4.82–76.51)	5.22	(3.14–8.66)
Sex				
Female	1*		1*	
Male	1.15	(0.53–2.46)	1.39	(0.98–1.96)
Comorbidities				
Yes	0.77	(0.24–2.43)	1.72	(1.17–2.51)
No	1*		1*	
ISS				
13–15	1*		1*	
16–24	2.35	(0.46–11.95)	1.54	(0.76–3.12)
25–40	7.65	(1.58–37.03)	6.01	(3.05–11.86)
41–75	13.15	(2.36–73.28)	9.90	(4.71–20.82)
GCS score				
13–15	1*		1*	
9–12	1.90	(0.22–16.09)	1.26	(0.49–3.26)
≤ 8	32.06	(10.06–102.13)	8.28	(5.02–13.68)
Intubation				
Yes	0.66	(0.23–1.89)	1.34	(0.84–2.13)
No	1*		1*	
Time to definitive care				
< 1 hr	1*		1*	
1 to < 3 hrs	1.23	(0.51–2.96)	0.66	(0.44–1.00)
3+ hrs	0.48	(0.19–1.22)	0.41	(0.25–0.68)
Mode				
Road ambulance	1*		1*	
Helicopter	0.79	(0.32–1.97)	1.20	(0.78–1.84)

Airbags				
Airbags deployed	1*		1*	
No airbags	2.34	(0.54–10.13)	0.73	(0.39–1.37)
Did not deploy	0.51	(0.06–4.28)	0.57	(0.20–1.62)
Unknown	0.75	(0.31–1.78)	0.75	(0.50–1.11)
Index CT scan				
Yes	1*		1*	
No	11.61	(4.72–28.58)	5.22	(3.38–8.05)
Location of trauma				
Major urban	1*		1*	
Small urban	1.54	(0.65–3.61)	0.80	(0.50–1.25)
Rural	1.07	(0.42–2.74)	0.93	(0.60–1.44)
Unknown	n/a		0.62	(0.15–2.55)

Note: CI = confidence interval; GCS = Glasgow Coma Scale; HR = hazard ratio; ISS = Injury Severity Score.
* Reference category.

Equity analyses: Patients receiving CT scan

As shown above, not receiving a CT scan was a strong predictor of 30-day mortality after injury. In age- and sex-adjusted analyses, Māori were 47% more likely to not receive a CT scan (OR 1.47, 95% CI: 1.24–1.74). After further adjustment for region, area-level deprivation, injury severity (ISS, GCS score and intubation), mode of transport from scene (which may also be a marker of severity) and scene of trauma (urban/rural), Māori remained 37% more likely to not receive a CT scan (see Table 61).

Those with serious injuries (ISS 41 or over, or intubated) and those brought to hospital by a means other than helicopter or road ambulance were also more likely to not have a CT scan, possibly because they died before a scan could be performed. Some evidence suggested regional differences, with people in the Northern region more likely to have a CT scan than those in the Midland region. There were clear differences in receiving a CT scan based on the location of the accident: those in major urban areas were more likely to receive a scan than those in smaller urban areas or rural areas.

Table 61: Multivariable determinants of *not* receiving a CT scan among 7,141 people admitted with major trauma in Aotearoa New Zealand, 2015–2019

	OR	95% CI
Ethnicity		
Māori	1.37	(1.12–1.67)
Non-Māori	1*	1*
Age (years)		
< 15	1.31	(0.94–1.83)
15–29	0.85	(0.65–1.1)
30–44	1*	
45–64	0.99	(0.77–1.26)
65+	0.90	(0.69–1.18)
Sex		
Female	1*	
Male	1.12	(0.92–1.35)
ISS		
13–15	1*	
16–24	0.8	(0.66–0.98)
25–40	0.8	(0.63–1.02)
41–75	1.65	(1.07–2.54)
GCS score		
13–15	1*	
9–12	0.56	(0.36–0.87)
≤ 8	1.04	(0.76–1.43)
Intubated		
No	1*	
Yes	1.50	(1.13–1.99)
Region		
Northern	1*	
Midland	1.28	(1.02–1.61)
Central	0.88	(0.69–1.12)
South Island	1.19	(0.93–1.51)

Deprivation quintile		
Q1 (least deprived)	0.78	(0.58–1.03)
Q2	0.77	(0.58–1.02)
Q3	0.87	(0.68–1.13)
Q4	0.99	(0.78–1.25)
Q5 (most deprived)	1*	
Mode		
Road ambulance	1*	
Helicopter	0.39	(0.29–0.52)
Other	2.49	(2.04–3.05)
Location		
Major urban	1*	
Small urban	2.24	(1.84–2.74)
Rural	1.51	(1.20–1.89)
Unknown	1.18	(0.78–1.79)

Note: CI = confidence interval; GCS = Glasgow Coma Scale; ISS = Injury Severity Score; OR = odds ratio.
* Reference category.

To further explore whether an inequity in receiving a CT scan truly exists or whether clinical need explains it, we conducted a number of subgroup analyses. Among people who survived, Māori were 43% more likely to not receive a CT scan (age- and sex-adjusted OR 1.43, 95% CI: 1.18–1.72).

When we restricted the analysis to those who experienced blunt rather than penetrating trauma, evidence remained that Māori had a higher chance of not receiving a CT scan (age- and sex-adjusted OR 1.28, 95% CI: 1.05–1.56). However, among people who were transferred from the emergency department straight to a ward, no inequity in receiving a CT scan was evident (age- and sex-adjusted OR 1.18, 95% CI: 0.83–1.66).

Equity analyses: Treatment at a neurosurgical facility

As we reported for 'Process marker 4: Treatment of sTBI at a hospital with neurosurgical capability', Māori with sTBI were less likely to be treated at a specialist facility. After adjusting for age and sex, the OR of being treated at a neurosurgical facility was 0.65 (95% CI: 0.53–0.78); that is, Māori with sTBI were 35% less likely to be treated at a neurosurgical facility. This effect persisted after adjusting for ISS (OR 0.63, 95% CI: 0.52–0.76), GCS score (OR 0.58, 95% CI: 0.48–0.71) and intubation (OR 0.62, 95% CI: 0.51–0.75).

When we examined the results by ISS category, the inequity in not being treated at a neurosurgical facility was present at all levels, other than the most serious (see Table 62).

When we restricted the data to include only people whose DHB of domicile was coded as one that has a neurosurgical facility, the inequity persisted (OR 0.56, 95% CI: 0.42–0.74). This implies that the higher proportion of Māori living in more remote areas does not explain why Māori are less likely to be treated at a neurosurgical facility.

Table 62: Age- and sex-adjusted ratio for Māori to non-Māori risk of not being treated at a neurosurgical facility among 3,141 admitted patients with serious traumatic brain injury in Aotearoa New Zealand, 2015–2019

	Māori: non-Māori	
	OR	**95% CI**
Adjusted for ISS	0.63	(0.52–0.76)
Stratified by ISS*		
13–15	0.45	(0.27–0.76)
16–24	0.62	(0.47–0.83)
25–40	0.71	(0.50–1.02)
41–75	0.79	(0.37–1.70)
Multivariable model**	0.59	(0.47–0.72)

Note: CI = confidence interval; ISS = Injury Severity Score; OR = odds ratio.
* Adjusted for broader age groups rather than five-year age bands.
** Adjusted for age, sex, ISS, Charlson Comorbidity Index, first hospital is definitive care, time to definitive care, mode of transfer to hospital, scene of injury and receiving index CT scan.

Multivariable analysis showed an association between being treated at a neurosurgical facility and lower 30-day mortality, although this did not reach conventional levels of statistical significance (HR 0.88, 95% CI: 0.69–1.13). For non-Māori, being treated at a neurosurgical facility had a beneficial effect (HR 0.79, 95% CI: 0.63–1.00), but this did not occur for Māori (HR 1.40, 95% CI: 0.82–2.39). This result suggests that Māori treated at a neurosurgical facility had a 40% higher mortality than those not treated at a neurosurgical facility. This higher risk may be because only Māori with the most severe injuries from an sTBI (and so at higher risk of mortality) are being transferred.

Note too that ideally we would also analyse long-term disability as an outcome here.

Equity analyses: Mortality following a trauma that did not involve sTBI

Of the 7,451 incidents of trauma, 4,310 were classified as a trauma that did not involve a serious traumatic brain injury (non-sTBI). As Table 29 has shown, Māori were 50% more likely to die within 30 days following a non-sTBI. To explore possible reasons for this, we examined models of mortality among people who had a non-sTBI, adjusted for potential explanatory variables (see Table 63). This analysis is based on 3,963 people (849 Māori and 3,114 non-Māori) with a non-sTBI injury and no missing data on any of the explanatory variables in the table. The slightly different data set explains the differences between Table 29 and Table 63 in their age- and sex-adjusted data.

The first row of Table 63 shows that Māori were 56% more likely to die in the first 30 days following non-sTBI major trauma. Each of the following rows shows that none of the explanatory variables explains this inequity. Receiving an index CT scan could explain part of the inequity in mortality between Māori and non-Māori, but not all of it.

To investigate whether the pattern of mortality differs with increasing time since injury, we repeated the analysis for differing periods following the trauma, including 7-day, 14-day and 90-day mortality, and compared the results with those for 30-day mortality. As Table 64 shows, the results provided only weak evidence of an inequity in mortality in the first week following trauma. However, by 14 days after trauma, the mortality rate for Māori was over 50% higher than for non-Māori, and this persisted at 30 days and 90 days following the trauma.

The weak evidence for inequity in mortality following trauma at 7 days was confirmed using logistic regression to model the risk of in-hospital mortality. In age- and sex-adjusted models, Māori had a 29% higher mortality risk (OR: 1.29, 95% CI: 0.83–2.00).

Table 63: Possible explanations of inequity in 30-day mortality among 3,963 people following admission for major trauma that did not involve serious traumatic brain injury in Aotearoa New Zealand, 2015–2019

	Māori: non-Māori mortality	
	HR	**95% CI**
Adjusted for		
Age and sex	1.56	(1.02–2.37)
Also adjusted for		
+ ISS	1.55	(1.02–2.37)
+ Charlson Comorbidity Index	1.42	(0.94–2.15)
+ Mode	1.55	(1.02–2.35)
+ Time to definitive care	1.51	(0.99–2.29)
+ Receiving index CT scan	1.31	(0.86–2.01)
+ Urban/rural place of injury	1.58	(1.04–2.41)

Note: CI = confidence interval; HR = hazard ratio; ISS = Injury Severity Score. This table is based on people with complete data for all potential confounders. All models are adjusted for age and sex. Models in the lower half of the table are also adjusted for each additional confounder separately.

Due to small numbers in the < 1-year age group, the data was combined with the data for the group aged 1–5 years.

Table 64: Age- and sex-adjusted Māori/non-Māori inequity in mortality among 4,310 people following admission for major trauma that did not involve serious traumatic brain injury in Aotearoa New Zealand, 2015–2019

Period after trauma	Māori: non-Māori mortality	
	HR	95% CI
7-day mortality	1.38	(0.89–2.14)
14-day mortality	1.53	(1.03–2.28)
30-day mortality	1.52	(1.03–2.24)
90-day mortality	1.59	(1.10–2.29)

Note: CI = confidence interval; HR = hazard ratio. Due to small numbers in the < 1-year age group, the data was combined with that for the group aged 1–5 years.

Sensitivity analysis

As mortality patterns among people who experience major burns can differ from the patterns for people with other causes of trauma, we conducted a sensitivity analysis, removing those people who had suffered burns. This group consisted of a total of 95 people, of whom 27 (28%) died in the first 30 days following trauma. However, excluding burns did not materially change the results of the full multivariable model of mortality among Māori and non-Māori.

Multiple trauma

Twenty-five people had a second (or in one case, a third) episode of multiple trauma. Most of these were male (21 male, 4 female) and non-Māori (2 Māori, 23 non-Māori). The median age at injury was 55 years (range 0–83 years). Almost all injuries were blunt trauma (except for one case of penetrating injury). Given the small numbers, excluding these people from the main analysis presented in this report would have a negligible effect on any of the reported results.

Discussion | He kōrerorero

Summary of results

Results of the main multivariable model show that among Māori and non-Māori, determinants of 30-day mortality following major trauma were older age, more comorbidities and more severe injury (ISS, GCS score and intubation) and not receiving an index CT scan. Arriving at a definitive care hospital within an hour of the injury was also associated with a higher risk of mortality, which is likely to reflect the severity of the trauma. Some results suggested that non-Māori who experienced trauma within major urban areas had higher mortality than those who experienced trauma in smaller urban or rural areas, which may reflect differences in the type of trauma they experienced. Mortality rates were similar in men and women.

Evidence indicated that, for all but one of these variables, the effect on mortality was the same for Māori and non-Māori. The exception was not having a CT scan, which was much more likely in Māori than non-Māori. Importantly, we found no evidence of inequity in the timing of a CT scan between Māori and non-Māori.

Inequity in mortality for Māori youth aged 15–18 years was evident. Our analysis showed that this inequity could not be explained by differences in sex, time to definitive care, helicopter transfer to hospital, urban or rural location of injury, receiving an index CT scan or presence of sTBI. Trauma severity explained part, but not all, of the inequity in mortality for these Māori young people.

In univariate analyses, Māori had a higher risk of mortality than non-Māori following road traffic crashes. The multivariable model, however, showed no difference in mortality; the severity of the injury explained most of the excess.

Māori were less likely to receive a CT scan, which is strongly related to mortality. After adjusting further for region, area-level deprivation, injury severity (ISS, GCS score and intubation), mode of transport from scene (which may also be a marker of severity) and scene of trauma (urban or rural), Māori remained 37% more likely to not receive a CT scan.

For non-Māori, being treated at a neurosurgical facility had a beneficial effect (HR 0.79, 95% CI: 0.63–1.00), which did not occur for Māori. A potential explanation for this higher risk for Māori could be that only Māori with the most severe injuries from an sTBI (and so a higher risk of mortality) are being transferred to a neurosurgical facility. Note that ideally we would also analyse long-term disability as an outcome here.

Māori are 56% more likely to die in the first 30 days following non-sTBI major trauma. None of the possible explanatory variables could fully explain this inequity. Receiving an index CT scan could explain part of the inequity in mortality between Māori and non-Māori, but not all of it.

Limitations of the data

The data collected in the NZ-MTR is generally of high quality, with little missing data. The collection of NHI numbers makes it possible to link data, including on ethnicity and mortality, to national databases. In 2015, the NZ-MTR recorded very few trauma cases from the South Island. In later years, the data has become more complete. Because region was not related to mortality or inequity in mortality (Table 7 and Table 8), we believe that the more limited data in 2015 is unlikely to have biased the results.

The greatest limitation of the data, which will have affected all the results presented here, is that only cases of major trauma who are admitted to hospital are included in the NZ-MTR. This is essentially a form of selection bias because the characteristics of the people who survive to be admitted are different to those of the people who die at the scene.

As previously noted, the majority of deaths from injury occur before people arrive at a hospital and they involve a higher proportion of Māori than non-Māori. In a review of trauma-related deaths in Otago and Southland, 65% of those who died did so before reaching hospital, and among this group 45% had injuries that were either survivable (ISS < 25) or potentially survivable (ISS 25–49) [109]. Another study found that of injuries that resulted in death, 74% of the deaths occurred before the person arrived at a hospital [113]. It also found notable inequities in the rates of these pre-hospital fatalities, with significantly higher rates in Māori compared with non-Māori. Additionally, Māori had the highest proportion of survivable and potentially survivable injuries out of all ethnic groups.

Such findings highlight inequities in survival even before patients arrive at hospital. Please bear these observations in mind when interpreting the data in this report.

Key results and recommendations

Youth

We found a higher mortality in Māori youth aged 15–18 years, but not in other age groups under 25 years. More severe trauma among Māori explained part, but not all, of this inequity.

We are limited in our ability to directly compare these results with those in other published work in Aotearoa New Zealand due to differences in the age range reported. One reasonably close comparison comes from the Child and Youth Mortality Review Committee, which reported a total of 270 deaths in Māori aged 15–19 years during the period 2012–2016 [126]. The leading causes of death were intentional injury (47%), unintentional injury (31%) and medical conditions (21%). In this age group, young Māori had statistically significantly higher mortality rates from unintentional injury compared with non-Māori, non-Pacific young people (rate ratio (RR) 1.71, 95% CI 1.31–2.24).

More generally, however, these results are consistent with ethnic inequities in injury mortality and hospitalisation rates that have previously been reported, particularly in the younger age groups. In 2010–2012, unintentional injury mortality rates for Māori children aged 0–14 years were 3.5 times those of non-Māori children (RR 3.53, CI 2.66–4.70); and the rates for Māori adults (15–64 years) were more than 1.5 times those for non-Māori adults (RR 1.73, CI 1.55–1.94) [4]. Such findings add a further dimension to the disproportionate impact of injury for Māori because the Māori population has a younger age structure than the non-Māori population and so these early deaths have the potential to represent a greater loss of years of life among Māori. In the 2018 census, 32.1% of Māori were aged less than 15 years, compared with 17.2% of non-Māori, and 7.5% of the Māori population was aged 15–18 years, compared with 4.7% of the non-Māori population [127].

Hospitalisation rates for unintentional injury (in 2012–2014) were also higher for Māori children [4]. Less information is available on treatment-related or process indicator factors relating to trauma care, although many publications identify ethnic disparities in the quality of and access to health services for a range of health conditions [44, 46, 53–55]. A small qualitative study explored the experiences of 23 Māori, Pacific and New Zealand European families who had a child (< 15 years) admitted to hospital for an unintentional injury [128]. It identified four key issues relating to engagement with the hospital system:

- inadequate communication and information
- difficulties negotiating an environment the families perceived as foreign
- the stress of conflicting demands placed on families
- issues relating to ethnicity and cultural miscommunication [128].

Māori and Pacific families felt particularly alienated in the hospital setting and did not appear to see themselves as being entitled to high-quality information or services.

In Australia, fatal and non-fatal injuries due to unintentional land transport crashes were reported over a five-year period (2010/11–2014/15). The age-specific fatal injury rate for Australian Aboriginal and Torres Strait Islander males aged 15–19 years was 18.8 cases per 100,000 population, which was 1.7 times higher than the rate for non-indigenous males (11.0 per 100,000) while the rate for indigenous females was 1.8 times higher than for non-indigenous females in this age group (9.3 vs 5.1 per 100,000 population respectively) [11].

In summary, the results in this report relating to youth are consistent with previously published research on Māori youth in Aotearoa New Zealand and with data on indigenous youth in Australia.

Recommendation 1
The POMRC recommends that each DHB conducts an in-depth local review in 2021 into all cases of trauma in Māori aged 15–18 years that occurred in 2018–2020, identifying the key points of intervention. The review should focus on whether treatment was optimal and timely, and what systems and processes need to be improved to provide high-quality and equitable care. Improvements could include prioritising trauma cases involving Māori youth aged 15–18 years, so that care pathways aim to prevent inequitable rates of mortality.

Injuries that do not involve sTBI

Māori were over 50% more likely to die in the first 30 days following major trauma other than sTBI than non-Māori. Little evidence of inequity between Māori and non-Māori was apparent at 7 days, but the inequity was clear by 14 days and remained up to 90 days. It is plausible that, in the acute phase of care for severe injuries, bias has less of an influence on clinical decision-making given the focus is on urgent and immediate trauma management decisions [129]. Our findings show a clear inequity among those who survive up to 14 days and then Māori appear to have a higher risk of mortality that persists over time. Beliefs about patients at the individual and group levels have the potential to impact on clinical encounters, affecting both provider behaviour and patient response to the interaction [60, 129, 130]. In terms of major trauma, these influences may have implications beyond the acute phase, with ongoing care increasing the potential for discretion in decision-making about treatment and management options [60].

Trunkey was first to describe a trimodal trauma mortality model in 1983. The model broadly identified three key periods as:

- immediate death occurring within minutes of the injury
- early deaths occurring usually within 24 hours of arrival to hospital
- late deaths, which include those occurring more than 24 hours after an injury and all other in-hospital deaths [131].

Providers have made significant progress in emergency medical services and developing trauma care systems, as well as in areas related to injury prevention including improved automotive safety. Yet the proportion of deaths occurring immediately after injury has remained largely unchanged over time, at 50–60%, while similarly, the proportion of early deaths has remained relatively constant, at 25–30% of all trauma deaths [132]. Because the most common cause of immediate and early death is brain injury [132–135], earlier mortality due to sTBI may explain our findings.

In contrast, studies have identified that, unlike the first two key periods, the proportion of late deaths has clearly dropped over time. The most likely causes are advances in resuscitation and critical care that have reduced the impact of the most common complications, circulatory collapse, haemorrhage and multi-organ failure, which occur during this period [132]. Gunst and colleagues reported that over a period of one year after the initial injury, about half of all deaths occurred within the first 30 days while the rest occurred later [136]. Although research into causes of death after discharge from hospital is less common, several studies have identified that post-discharge deaths among trauma patients are related to common chronic diseases [137, 138]. Mullins and colleagues evaluated cause-of-death codes reported on death certificates for injured patients who died of non-traumatic causes during their hospital stay and within 30 days after discharge. Of 1,174 post-discharge deaths, over 30% were due to common chronic diseases including cardiovascular disease, ischaemic heart disease and chronic obstructive pulmonary disease [137].

The impact of injuries on the outcome of chronic diseases remains unknown. However, this is a potential area for future research, which could be valuable given research has established that the prevalence of chronic conditions among Māori is high [53] and Māori are at increased risk of disability following hospitalisation from injury [120].

Recommendation 2
The POMRC recommends that each DHB reviews its safe discharge plans to check that they identify whether all aspects of care are addressing inequity to achieve equitable outcomes. We recommend that the review team includes a trauma nurse specialist or kaupapa Māori navigation support with a trauma-specific focus.

Recommendation 3
The POMRC recommends Te Hononga Whētuki ā-Motu, the National Trauma Network and each DHB review their policies and procedures, to ensure they do not include, or allow for, implicit bias and institutional racism at clinician, DHB and policy levels.

Receiving a CT scan

Māori were less likely to receive a CT scan than non-Māori, although there was no evidence of inequity in timing of CT scan between Māori and non-Māori. Because prioritisation of CT scans is related to the severity of the injury, in urgent cases CT scans may not be done until after surgery. In relation to these findings, however, this is more relevant to timing. That is, Māori and non-Māori who were assessed as requiring a scan did not differ in the time to scan. Additionally, no inequity was evident among those who transferred straight from the emergency department to the ward, which would more likely be those with less severe injuries.

Prompt diagnosis, with the help of a CT scan, plays a key role in the initial management of traumatic injuries and can have an impact on mortality outcomes [25, 94, 139]. The international evidence on inequities between ethnic groups related to receiving CT scans is mixed.

An analysis of mild TBI using the US National Hospital Ambulatory Medical Care Survey data (1998–2000) found the proportion of those not receiving a CT scan was higher for Hispanics (63.3%) than non-Hispanics (58.8%) and higher for African Americans (62.6%) than whites (58.9%), but these differences were not statistically significant [140].

A retrospective medical record review of 270 patients presenting with minor head injury to one hospital emergency department in Australia found no statistically significant difference between indigenous and non-indigenous patients in **requests** for CT head scans when clinically indicated. However, the results indicated that indigenous patients were less likely to **receive** a CT head scan when clinically indicated (OR 0.35; 95% CI = 0.07–1.77) [141].

Numerous studies have identified differences between Māori and non-Māori in what care they receive and the quality of that care [46, 53–55]. Discussions in the overseas literature suggest that unconscious bias among providers may help explain this association in the area of trauma care. Work among trauma surgeons and acute care physicians in the USA has demonstrated that a majority of them had an Implicit Association Test (IAT) score demonstrating an unconscious preference toward white people and people of upper social class, although IAT scores were not associated with responses to clinical vignettes [68]. However, another study using clinical vignettes did find implicit racial bias was linked to differences in decision-making for black and white patients among emergency and internal medicine residents [69].

Two localised IATs were developed to compare Māori with New Zealand European ethnic groups [142]. They featured in the first study to examine implicit and explicit racial/ethnic bias in Aotearoa New Zealand, which was conducted with final-year medical students in 2014–2015 [60]. The study demonstrated implicit bias in that the students saw New Zealand European patients as more compliant than Māori patients. Explicit bias was less evident, although it did appear for ethnic preference, relative warmth, and beliefs about the compliance and competence of Māori relative to New Zealand European patients. Additionally, many researchers have described institutional racism in Aotearoa New Zealand as a key factor in a range of inequitable health outcomes [65, 107, 143–147] and it may contribute to trauma care inequities.

The purpose of developing cultural safety education [70] in Aotearoa New Zealand was to explicitly identify the causal links between colonisation, institutional racism, power and social justice that are fundamental to understanding and, importantly, taking action to address health inequity [59, 71, 72]. The significance of cultural safety and its potential to be applied in practice have gained international recognition [148–150]. A culturally safe and clinically skilled workforce was one of six themes that a recent systematic review of 33 studies identified when it examined factors determining the optimal and most productive relationship among indigenous communities, surgeons and providers of surgical services [150]. Drawing on studies documenting the experiences of Māori (n = 2), Aboriginal and Torres Strait Islander peoples (n = 20), North American First Nation (n = 10) and indigenous Latin Americans (n = 1), the review also identified core themes that surgical services for indigenous communities need to successfully address health inequities. These themes were: accessible health services; community participation and governance; continuous quality improvement; flexible approaches to care; and holistic health care.

Health care organisations play a key role in determining the systems and structures that either promote or prevent inequities in health outcomes. For this reason, supporting broader systems-level change requires individual practitioners alongside their various professional bodies to contribute to the development of culturally safe organisations and advocate for public policy changes that will positively impact on health equity [9, 59, 150–154].

Recommendation 4

The POMRC recommends Te Hononga Whētuki ā-Motu, the National Trauma Network develops a national consensus guideline on prioritising CT scans for trauma cases. The guideline requires timeframe guidance and the assessment of its implementation in each DHB to ensure equitable diagnosis and management.

Recommendation 5

The POMRC recommends that DHBs complete an audit of the application of the national consensus guidelines for each Māori trauma patient who did not get a CT scan to see if the guidelines were followed correctly. This analysis should include the role and impact of implicit bias and institutional racism at clinician, DHB and policy levels.

Neurosurgical facility treatment

For non-Māori, being treated at a neurosurgical facility had a beneficial effect, which did not occur for Māori. A potential explanation could be that only Māori with the most severe injuries and at high risk of mortality were transferred to neurosurgical facilities.

There is conflicting literature on whether sTBI should always be treated at specialist facilities. A United Kingdom study on head injury (1996–2003) investigated outcomes for patients treated at non-neurosurgical centres. Treatment at these centres was associated with a mortality rate adjusted for case mix that was over twice as high (OR 2.15, 95% CI: 1.77–2.60) as the rate for patients treated at a neurosurgical centre [155].

Teig and Smith argue that it can never be certain that a patient with sTBI will not require urgent neurosurgical intervention at some stage and delay in providing such treatment is a major preventable cause of morbidity and mortality [106]. The UK National Institute for Health and Care Excellence (NICE) recommends that transferring all patients with serious head injuries (GCS ≤ 8) to a neurosurgical unit would benefit them, whether or not they need neurosurgery [106, 156].

Petsas and Waldmann, on the other hand, argue that a growing body of evidence indicates that use of protocol-guided therapy after TBI improves patient outcome, and that it is unclear whether management within a neurosurgical centre provides any additional benefit [157]. They argue that mortality has decreased because providers are implementing and following guidelines, and that neurosurgical centres should leave beds available for complex patients who require specialist interventions, rather than receiving all head injuries [157].

A systematic review into the effectiveness of specialist neurosurgical care in sTBI found an adjusted odds ratio for mortality favoured secondary transfer for severe non-surgical TBI patients to specialist neurosurgical centres, ranging from 1.92 (95% CI 1.25–2.95) to 2.09 (95% CI 1.59–2.74) [158].

Regardless of the conflicting findings from previous research, what is clear from this report is that Māori received less specialist facility care than non-Māori.

Recommendation 6
The POMRC recommends that DHBs review all cases of sTBI who were treated at non-neurosurgical centres, focusing on the appropriateness and effectiveness of decisions made about whether to transfer the patient, and on patient outcomes. DHBs should then change their destination and interhospital transfer policies so that, where safe and feasible, all patients with a significant TBI are transferred to a neuroscience centre.

Recommendation 7
The POMRC recommends DHBs review their protocols on transferring patients with sTBI to neurosurgical centres, with a specific focus on whether these sufficiently address inequity to achieve equitable care and case management. Trauma leads within each DHB should identify training opportunities that will support health care professionals to follow local protocols.

General

Māori are more likely to die after major trauma, and process markers indicate that they are not receiving the same treatment and quality of care as non-Māori.

Prevention and pre-hospital care

The majority of deaths from injury occur before people arrive at a hospital. Previous research has found notable inequities in the rates of these pre-hospital fatalities, with the highest rates in Māori compared with other ethnicities. Māori also have the highest proportion of survivable and potentially survivable injuries (over 35%) out of all ethnic groups. Prevention of trauma is therefore a key part of addressing inequity.

Recommendation 8
The POMRC recommends that the Accident Compensation Corporation provides additional data collection resources to enable the NZ-MTR to collect systematic data on outcomes for those people who die before they can be admitted to hospital (pre-hospital outcomes).

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Appendix 1: Statistical methods | Āpitihanga 1: Ngā tukanga tauanga

Data management

The date of CT scan for one individual was changed because a data entry error had clearly occurred – all other events related to the case occurred in April, but the CT scan was recorded as having taken place in May.

The date of death for one person was changed because it was recorded as the day before the injury. He died in the emergency department, with date of 'discharge' on the same day as injury, so the date of death was recoded to that day.

Each variable was categorised using standard categories, or those used in NZ-MTR annual reports. Each variable was tabulated for Māori and non-Māori, and the proportion of missing data was documented. Chi-squared tests, omitting the missing data, were used to investigate differences between groups; the resulting *p* values are reported.

Calculating the Injury Severity Score

To calculate the ISS, each injury is given a grade as described in the Abbreviated Injury Scale (AIS) [78] between 1 (minor) and 6 (maximal), The ISS sums the squared AIS scores for each of the three most severely injured body regions. That is, $ISS = a^2 + b^2 + c^2$ where a, b and c are the AIS scores of the three regions with the highest AIS score.

An ISS of 13 or more implies a serious injury in one body region and/or less severe injuries in two or more body parts [36].

Calculating the Glasgow Coma Scale

The Centers for Disease Control and Prevention has published a description of how GCS is determined, and definitions of its categories [125]. Briefly, the GCS classifies patients according to their eye opening, verbal and motor responses to various stimuli.

Intubation

For 150 people in this analysis, it was unknown whether they had been intubated or not, so these were coded as 'not intubated'. Any resulting misclassification would have been minimal.

Charlson Comorbidity Index

The Charlson Comorbidity Index is a method of categorising comorbidities of patients based on the International Classification of Diseases (ICD) diagnosis codes found in administrative data, such as hospital admission data. Each comorbidity category has an associated weight, based on the adjusted risk of mortality. All hospital admissions in the five years before the index admission are considered. The sum of all the weights in the five-year period results in a single comorbidity score at the time of the index admission. The index has been validated in a variety of clinical settings and has been recently updated so that it can be used with ICD10 administrative data in Aotearoa New Zealand [124].

Cause of trauma

Table 65 shows the mapping used to classify the ICD10 trauma codes into the categories used for analysis. The NZ-MTR provided this information.

Table 65: Mapping used to classify ICD codes into categories of cause of trauma

Cause of trauma	ICD10 code
Assault	X85–X99; Y00–Y09
Fall	W00–W19
Transport	V00–V79; V86–V89; X82
Other	V80–V85; V90–V99; W20–W99; X00–X19; X30–X81; X83, X84; Y10–Y35

Note that in the NZ-MTR, road transport crashes include all trauma associated with the crash, including people in cars (both drivers and passengers), people on motorbikes, bicycles, off-road quadbikes and pedestrians.

DHBs with a neurosurgical facility

The following DHBs were coded as having a neurosurgical facility: Auckland, Waitematā, Counties Manukau, Waikato, Capital & Coast, Hutt Valley, Canterbury and Southern.

In-hospital mortality

In-hospital mortality was defined as the presence of a cause of death coded in the NZ-MTR, because the NZ-MTR only codes in-hospital deaths. For the analyses of in-hospital mortality, logistic regression rather than Cox regression was used. It is unlikely that this will make any material difference to the results.

Statistical models

Cox regression was used to estimate mortality (hazard) ratios, comparing one category of an exposure variable with a chosen baseline category and, in separate models, comparing Māori with non-Māori. For the Cox models, the start date of entry to the study was the date of trauma. The end date was the date of death for people who died within 30 days of trauma; those who did not die in this timeframe were censored (ie, the period of observation was closed) 30 days following the date of trauma. This was repeated using 90 days for 90-day mortality. The measure of uncertainty (precision) was the 95% CI.

Logistic regression was used for determinants of binary outcomes other than mortality, such as receiving a CT scan. This method calculates odds ratios and associated 95% CIs.

For ordered categorical outcomes, that is, the Charlson Comorbidity Index category, ordered logistic regression was used. This estimates an OR per extra category of the Charlson index.

Age adjustment

To account for differences in the age-structures of the Māori and non-Māori populations, many models were adjusted for age. The age-adjusted results can be interpreted as the effect of a variable on mortality, after taking age into account. For these age-adjusted analyses, age was categorised as < 1 year and then in five-year bands to age 90 until 90+. In some instances, the amount of data available was insufficient to allow for such finegrained age bands. In these cases, broader age groups (0–14 years; 15–29 years; 30–44 years; 45–64 years; 65 years and over) were used for adjustment. Where this was done, we state this in the footnote to the relevant table.

Appendix 2: Effect of airbag deployment on inequity in mortality | Āpitihanga 2: Te pānga o te whakamahi pēkehau mō te taurite kore o te mate

Note: Given the level of missing data ('unknown') in the NZ-MTR, and the lack of any further information on the nature of the vehicle(s) involved or other details of the crash, we are uncertain of the reliability of the data presented in this section.

Table 66 presents whether, among 1,987 patients involved in road traffic crashes, airbags were deployed in the crash. The results show significant differences among Māori and non-Māori. They suggest that Māori were less likely to have 'no airbags' recorded, but more likely to have unknown data on airbags.

The mortality analysis shows that in RTCs where the airbags did not deploy, patients appeared to have a lower risk of 30-day mortality when compared with those in crashes where the airbags did deploy. This may reflect the level of impact from the crash. The analysis also indicated that where the RTC involved no airbags, the level of mortality was lower, and clear evidence showed that where the data was unknown, mortality risk was high (see Table 67). The mortality patterns appeared to differ between Māori and non-Māori, according to deployment of airbags (p(interaction) = 0.079) (see Table 68). Among Māori, no discernible associations were evident, whereas among non-Māori, the mortality risk was clearly higher for those with unknown data on airbags.

Table 69 shows potential inequities in mortality between Māori and non-Māori. In instances where airbags deployed or did not deploy, or where it was unknown, mortality did not differ between Māori and non-Māori. However, in crashes where no airbags were involved, Māori had a higher mortality than non-Māori.

The lack of reliability of the data means that these results should be interpreted with caution.

Table 66: Number and proportion of 1,987 people admitted with major trauma following a road traffic crash in Aotearoa New Zealand, by airbag deployment, 2015–2019

Airbags	Māori (n = 484)	Non-Māori (n = 1,503)	*p*-value
Deployed	177 (36.6%)	687 (45.7%)	
Did not deploy	73 (15.1%)	118 (7.9%)	
No airbags	74 (15.3%)	406 (27.0%)	
Unknown	160 (33.1%)	292 (19.4%)	< 0.001

Table 67: Age- and sex-adjusted association between airbag deployment and 30- and 90-day mortality among 1,987 people admitted with major trauma following a road traffic crash in Aotearoa New Zealand, 2015–2019

Airbags	30-day mortality		90-day mortality	
	HR	**95% CI**	**HR**	**95% CI**
Deployed	1*		1*	
Did not deploy	0.45	(0.20–1.06)	0.64	(0.32–1.30)
No airbags	0.71	(0.41–1.20)	0.70	(0.41–1.17)
Unknown	2.07	(1.39–3.08)	2.01	(1.36–2.97)

Note: CI = confidence interval; HR = hazard ratio.
* Reference category.

Table 68: Age- and sex-adjusted association between airbag deployment and 30-day mortality among Māori and non-Māori, following admission for major trauma from road traffic crashes in Aotearoa New Zealand, 2015–2019

Airbags	Māori (n = 484)		Non-Māori (n = 1,503)	
	HR	**95% CI**	**HR**	**95% CI**
Deployed	1*		1*	
Did not deploy	0.18	(0.02–1.38)	0.60	(0.24–1.51)
No airbags	0.80	(0.25–2.57)	0.66	(0.36–1.20)
Unknown	1.15	(0.54–2.45)	2.37	(1.50–3.73)

Note: CI = confidence interval; HR = hazard ratio. Age was adjusted for in age groups, not five-year age bands, due to smaller numbers in this analysis.
* Reference category.

Table 69: Inequity in mortality among 3,740 patients admitted following a road traffic crash in Aotearoa New Zealand, 2015–2019

All RTCs	Māori: non-Māori mortality	
	HR	**95% CI**
	1.10	(0.81–1.49)
Airbags deployed	1.73	(0.89–3.37)
No airbags	4.09	(0.88–19.09)
Did not deploy	1.30	(0.06–29.59)
Unknown	0.96	(0.67–1.37)

Note: CI = confidence interval; HR = hazard ratio; RTC = road traffic crash. Age is included in categories, not five-year age bands. Also adjusted for sex, comorbidities, injury severity, time to definitive care, mode to transport to hospital and receiving index CT scan.