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Mortality following severe liver trauma is declining at Auckland City Hospital: a 14-year experience, 2006–2020
Nicholas J Fischer
Over the last 14 years, the number of patients with severe liver injuries admitted to Auckland City Hospital has remained stable, but there seems to have been a reduction in the number of patients who die of bleeding from the liver over time. The reasons behind this reduction in death from bleeding is currently unknown and speculative but is probably related to multiple improvements in the way that severely injured patients are managed.

The societal cost of unintentional childhood injuries in Aotearoa
Michael Young, Tom Love, Melissa Wilson, Moses Alatini, Michael Shepherd
We used information from ACC claims and hospitalisation events to look at the rate and impact of unintended injuries for children aged 0 to 14. We estimated the cost of health care to treat injuries, and the costs in productivity loss caused by managing unintended injuries for children. We found that the overall cost of unintended childhood injury in Aotearoa was nearly $400 million every year. Māori children, and those in low-income households, tended to have more serious injuries, with higher rates of hospitalisation for each injury sustained. The impact of an injury, for example in taking time off work to attend health care appointments, is disproportionately high for Māori, Pacific and low-income families.

Outcomes in patients with fractured ribs: middle aged at same risk of complications as the elderly
Matthew J McGuinness, Liam Ryan Ferguson, Imogen Watt, Christopher Harmston
Adverse events in patients with rib fractures start at a younger age than much of the current literature suggests.

A comparison of major trauma admissions to Christchurch Hospital during and after COVID-19 lockdown in New Zealand
Dali Fan, Hannah Scowcroft, Andrew McCombie, Ruth Duncan, Christopher Wakeman
The study looked at the pattern of major trauma injuries in the Canterbury region during and after COVID-19 lockdown. The purpose of this study was to observe what types of injuries were occurring more frequently during lockdown and immediately after lockdown—both completely new situations for New Zealand (and elsewhere in the world) until last year. This would then hopefully allow us to better prepare ourselves if we were to encounter further waves of the virus, with particular focus on injury prevention strategies to reduce avoidable stressors on precious hospital resources.

Nail gun injuries: not just an occupational hazard
Matthew J McGuinness, Gabrielle Thompson, Samuel Haysom, Ian Civil
Between 1994 and 2019, 45 patients were admitted to Auckland City Hospital with a nail gun injury. Two subgroups were identified: 31% with an intentional injury; 69% with an unintentional injury. Patients with an intentional injury had a higher mortality rate (21.4% vs 9.5%), Injury Severity Scores (24.2 vs 3.4) and intensive care unit admission rate (50% vs 3%) and required more intensive post-injury care when compared to unintentional injuries. There is currently no legislation in New Zealand specifically governing the use of nail guns. Only powder-actuated nail guns require certification.
Variation in resources and impact on performance: results of the emergency department benchmarking survey

Peter Jones, Sophia Faure, Andrew Munro

We surveyed New Zealand emergency departments to find out what the staffing, workload and capacity to cope with acute demand was. We found much variation across the country. When hospitals had relatively fewer staff and less space in the face of high workloads, performance appeared to be worse.

Tertiary survey by trauma nurse specialist at a paediatric trauma centre

Matt Sawyer, Bridget Kool, James K Hamill

When someone is critically injured and brought to hospital, all life threatening injuries are detected and treated through a thorough assessment process. Some more minor injuries aren’t always picked up during this time. Tertiary surveys are done after a few days in hospital to pick up these injuries. This paper shows that nurses are as good as doctors at detecting these if given additional training.

Rethinking resuscitation: moving the goals

Alex Psirides, David G Tripp, Tammy J Pegg

If you are sick enough in hospital that your heart stops, you will receive CPR (cardiopulmonary resuscitation). If your heart stops because of other medical problems, the chances you will die despite this, or survive with other injuries (including brain damage), is high. Unless you tell doctors that you don’t want this to happen, treatment will be provided that may prolong your suffering. Having conversations with doctors and nurses around what you would find acceptable, and how much you would be prepared to go through to get there, will ensure that no decision is made about you without you.
What can we learn from our 2021 respiratory syncytial virus experience?
Cameron C Grant, Q Sue Huang, Adrian Trenholme, Susan Taylor, Tim Wood

Respiratory syncytial virus (RSV), named for it causing multinucleated cells (syncytia) to form in cell culture, is the leading cause of acute lower respiratory infections (ALRIs) during early childhood. Globally in 2015, among children <5 years old, there were an estimated 33.1 million episodes of RSV-ALRI, with 3.2 million RSV-ALRI hospital admissions and 59,600 RSV-ALRI in-hospital deaths. In 2015, while >80% of RSV-associated ALRIs occurred in children ≥6 months old, 45% of the hospital admissions and in-hospital deaths were in children <6 months old.

In New Zealand, based upon the active surveillance study, SHIVERS (Southern Hemisphere Influenza and Vaccine Effectiveness Research and Surveillance), conducted at Starship Children’s, Kidz First Children’s, Auckland and Middlemore hospitals in Auckland from 2012 to 2015, the RSV-ALRI hospitalisation rate was 6.1/1,000 children 0–4 years old during the 22-week surveillance periods (May–September inclusive each year). The year-to-year variance in RSV-ALRI hospitalisation rate was 24% (5.5/1,000 children in 2013 to 6.8/1,000 children in 2012). Consistent with global data, 48% of the preschool age group RSV-ALRI hospitalisations were in children <6 months old.

Hospital admissions of young children represent only a proportion of acute respiratory infection (ARI) healthcare visits caused by RSV. Based upon SHIVERS’ data collected at Kidz First Children’s Hospital, 3,585 (66%) of 5,412 infant ARI emergency department (ED) presentations from May to September 2014–2016 did not result in hospital admission. Of the respiratory viruses tested (RSV, rhinovirus, adenovirus, influenza and human metapneumovirus), RSV was associated with the highest ARI ED-only (34.4/1,000 children) and hospitalisation rates (24.6/1,000 children). The SHIVERS surveillance project also showed the considerable amount of RSV disease resulting in hospital admissions of adults in New Zealand.

The year-to-year variability in RSV-ALRI hospitalisation rates among children 0–4 years old that occurs in New Zealand is considerably smaller than the variability between groups of children in New Zealand defined by ethnicity (470% variability) (European/other 2.9/1,000, Asian 2.7/1,000, Māori 9.3/1,000, Pacific 12.8/1,000) or area-level deprivation (290% variability) (least deprived quintile 2.9/1,000 versus most deprived quintile 8.4/1,000).

What happened to respiratory syncytial virus disease burden in New Zealand in 2020?
In association with New Zealand’s stringent nonpharmaceutical interventions in response to the coronavirus disease 2019 (COVID-19) pandemic, the circulation in New Zealand during 2020 of RSV and most other respiratory viruses was interrupted. This COVID-19 elimination strategy included a nationwide lockdown from 25 March to 27 April 2020.

In the post-lockdown period (28 April to 27 September 2020), in comparison with the 2015–2019 reference period, large reductions occurred in nation-wide identifications of all tested respiratory viruses. These reductions, from largest to smallest, were in influenza (99.9%), RSV (98.0%), human metapneumovirus (92.2%), enterovirus (82.2%), adenovirus (81.4%), parainfluenza virus (80.1%) and rhinovirus (74.6%).
Community and sentinel general practice influenza-like illness and hospital severe acute respiratory infection surveillance all showed very low rates of disease in comparison with the rates observed in 2018–2019. Early childhood ARI-related hospital admissions decreased dramatically in the post-lockdown period. For example, at Kidz First Children’s Hospital, the number of ALRI hospital admissions in children <2 years old from 1 March to 31 August each year from 2015 to 2019 ranged between 1,486 and 2,046, with PCR testing of respiratory samples being positive for RSV in between 252 and 495 samples per year. In comparison, in 2020 there were 159 ALRI hospital admissions from 1 March to 31 August among children <2 years old, with RSV identified from two respiratory samples. Several factors contributed to these dramatic reductions in RSV infections and acute illnesses. The international border controls, including mandatory 14-day isolation of arriving international travellers, will have limited the normal seasonal introduction of RSV into New Zealand. Physical distancing and hygiene measures are also likely to have contributed. Handwashing damages the lipid layer that surrounds RSV, thus reducing its capacity for person-to-person transmission and infection. Rhinovirus, which is a non-enveloped virus that may therefore be less susceptible to the effects of handwashing, continued to be isolated from respiratory samples collected from children admitted to Kidz First Children’s Hospital with ALRI during 2020 in similar numbers to preceding years.

Similar RSV-related observations were reported in Australia following the closure of their international border to non-residents on 20 March 2020. In Western Australia, where the border with other states was also closed on 6 April 2020, RSV detections from April to August 2020 were 98% lower than annual average RSV detections during these same winter months from 2012 to 2019. In the Sydney Children's Hospitals Network, RSV detections (94% decrease), ARI emergency department attendances (70% decrease) and hospital admissions for bronchiolitis (86% decrease) were lower during April–June in 2020 than during these same months in the five preceding years.

Then, during the latter part of 2020, an increase in RSV detections occurred in Australia. For example, in Western Australia, RSV detections increased from late September 2020. By November, the weekly number of detections exceeded the median seasonal peak from 2012–2019, with this high number of weekly detections continuing into summer. The median age of children in whom RSV was detected in 2020 was higher than the annual upper range from 2012–2019 (18.4 months versus 7.3–12.5 months).

What happened to respiratory syncytial virus disease burden in New Zealand in 2021?

Following the opening of the trans-Tasman travel bubble between Australia and New Zealand in April 2021, an increase in RSV identifications has occurred in New Zealand. This surveillance is laboratory based and consists of the World Health Organization National Influenza Centre at the Institute of Environmental Science & Research Limited (ESR) and six hospital laboratories in Auckland (two hospital laboratories), Waikato, Wellington, Christchurch and Dunedin. This reporting is based upon testing of specimens ordered by clinicians working in normal clinical practice in hospital inpatient and outpatient settings that serve approximately 70% of the New Zealand population.

During 2021, the weekly number of RSV detections nation-wide first exceeded five during week 21 (week ending 30 May 2021). The weekly number of RSV detections increased rapidly from week 21, with the detections in successive weeks being 37, 110, 258, 590, 774 and 892, peaking in week 28 at 951 and being 787 in week 29 and 542 in the most recently reported week (week 30, ending 1 August 2021). When expressed as a rate per million population, the peak weekly RSV detection rates in 2021 were at least five-fold higher than those observed in 2015–2019.

In addition to the number of RSV detections being greater during 2021 compared with 2019, the age distribution also differed. As shown in data reported from Laboratory Services at Middlemore Hospital (which includes Kidz First Children’s Hospital), the number of RSV detections among children...
0–<12 months were two-fold higher in 2021 versus 2019, whereas the number of RSV detections among children 12–<48 months were at least five-fold higher (Figure 1). These findings are consistent with older preschool-aged children presenting with ALRIs, presumably because of increased susceptibility to more severe disease following their first exposure to RSV during 2021 rather than 2020.

What does this mean for the respiratory infection disease burden in New Zealand in the future?

PHARMAC-approved funding, initiated this year, for the prophylactic use of the monoclonal antibody palivizumab for infants aged >6 months with extreme prematurity and chronic lung disease, or with severe congenital heart disease, will help to protect those most at risk of life-threatening RSV disease.

From a more general respiratory virus perspective, what we have seen happen with RSV in 2021 may just be the first of several variances resulting from the impact of COVID-19 on the relationships established between humans and respiratory pathogens. In addition to the current adult COVID-19 vaccination programme, the vaccine protection of children in New Zealand against other respiratory pathogens needs urgent attention.

We should anticipate and plan for influenza epidemics to differ in size and age distribution similarly to the increase in proportion of the New Zealand population that is susceptible to more severe disease following exposure to RSV. There is the potential that children will be more vulnerable to future influenza epidemics. Influenza vaccine should be added to the schedule of vaccines for all children in New Zealand.

New Zealand should also anticipate an increase in incidence in bacterial respiratory pathogen disease. Reports of reductions in invasive pneumococcal disease, and invasive group A streptococcal disease incidence, in association with the public health measures instituted to control the COVID-19 pandemic, and with the reductions that occurred in influenza circulation, will likely be reversed with the return of RSV, and particularly so if influenza infection becomes re-established in New Zealand.

Urgent attention is required to address the critical current failure of our childhood immunisation programme if we are to prevent children in New Zealand from experiencing epidemics of pertussis and measles.

Figure 1: Number of respiratory syncytial virus (RSV) detections by age group in 2021* compared with 2019.

* 2021 compared with 2019 in each age group, with the number above each 2021 bar indicating the ratio of 2021 to 2019 RSV detections in each age group.
† Data from Laboratory Services, Middlemore Hospital, Counties Manukau District Health Board. 2021 data limited to weeks 0–30 (1 January–1 August 2021).
following their, at times horrific, 2021 RSV experience, and to protect them against influenza and invasive pneumococcal disease.

The New Zealand childhood immunisation schedule begins in pregnancy.\textsuperscript{21} Receipt during pregnancy of influenza and pertussis vaccine protects young infants against illnesses caused by these infections and requiring hospital admission.\textsuperscript{26–28} In New Zealand, coverage during pregnancy for women giving birth in 2018 was 31\% for influenza vaccine and 44\% for pertussis vaccine.\textsuperscript{29} From 2013 to 2018, the odds of Māori and Pacific women receiving either of these vaccines were lower than women living in New Zealand of non-Māori and non-Pacific ethnic groups, and were lower for women living in households in more versus less deprived areas.\textsuperscript{29}

For the three months 1 April–30 June 2021, only 75.3\% of New Zealand children aged six months were fully immunised.\textsuperscript{30} At age six months, coverage for the six-week, three-month and five-month scheduled vaccines among NZ European was 80.1\%, among Māori 54.9\%, among Pacific 68.7\%, among Asian 93.0\% and among children of other ethnic groups 78.8\%.\textsuperscript{30} Coverage for children living in the most deprived quintile of households was 64\% and in the least deprived quintile it was 83\%.\textsuperscript{30}

The 470\% variance in early childhood RSV-ALRI hospitalisation rates by ethnicity, and the 290\% variance by household deprivation in New Zealand, are both simply unacceptable and indefensible. As New Zealand has now entered an important phase of health reform, RSV provides us with insight into what to expect. From a health perspective we should expect and plan for the unexpected. The worst-case scenarios are likely to be worse than what we have come to expect. We must use the opportunity present now to eliminate inequities in vaccine access based upon ethnicity, socioeconomic status and age. Influenza, measles, pertussis and invasive pneumococcal disease all have the potential to make our 2021 RSV experience appear relatively trivial in retrospect.
Competing interests:
Nil.

Author information:
Cameron C Grant: Head, Department of Paediatrics: Child & Youth Health, University of Auckland; Professor, University of Auckland; General Paediatrician, Starship Children's Hospital, Auckland District Health Board, Auckland, New Zealand.
Qiu Sue Huang: Virologist and Director, WHO National Influenza Centre, Institute of Environmental Science & Research, Wellington, New Zealand.
Adrian Trenholme: General Paediatrician, Kidz First Children's Hospital, Counties Manukau District Health Board; Honorary Senior Lecturer, Department of Paediatrics: Child & Youth Health, University of Auckland, Auckland, New Zealand.
Susan Taylor: Microbiologist, Department of Microbiology, Counties Manukau District Health Board, Auckland, New Zealand.
Tim Wood: Senior Scientist (Epidemiology), Health Intelligence Group, Institute of Environmental Science & Research Limited, Wellington, New Zealand.

Corresponding author:
Cameron Grant, Department of Paediatrics: Child & Youth Health, University of Auckland, Private Bag 92019, Wellesley Street, Auckland 1142, 09 923 6192 cc.grant@auckland.ac.nz

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Restructuring management of thoracic trauma: a neglected entity

Zoe J Clifford, Harsh P Singh

Thoracic trauma universally is a major cause of morbidity and mortality across all ages and socioeconomic backgrounds, and in this issue of the *New Zealand Medical Journal*, McGuinness et al demonstrate that adverse events in patients with rib fractures are starting at a younger age than much of the current literature suggests. In New Zealand, 40% of patients presenting with major trauma have thoracic injuries, and with 27,000 trauma admissions per year and 450 admissions to Christchurch Hospital for thoracic trauma in particular, the relevance of this new research must not be overlooked.

Thoracic trauma impacts lifestyle and adds a financial burden both personally and to society. In addition to the universal incidence of motor vehicle accidents, New Zealanders are predisposed to thoracic trauma by our national pastimes. These include rugby, the national sport, as well as a multitude of adventure sports, like mountain biking, snow sports and hiking, to name a few. We’ve also suffered at the hands of natural and man-made disasters in recent years.

With this in mind, New Zealand’s experience in the care of a variety of trauma types looks extensive. We should be well placed to establish a comprehensive and up-to-date guideline for providing all ages with high-quality care for thoracic trauma. Multiple guidelines for thoracic trauma across the globe give the ages 65+ as being at greater risk of morbidity and mortality. However, in light of McGuinness et al’s study, this appears to be nothing more than an educated guess.

In New Zealand, the age group 45–65 represent 45% of the thoracic trauma patients. This group has the greatest average employment rate (83.45%), so an extended stay in hospital and prolonged recovery associated with rib fractures and concomitant pneumonias needs to be minimised for the benefit of these patients, their whānau and the wider community. Traditionally, the mainstay of treatment for rib fractures is analgesia and physiotherapy, which have varying degrees of success. This group had the greatest access to patient control analgesia (PCA) and ketamine infusion, arguably the most effective modes of analgesia, and yet their length of stay and rate of pneumonia was comparable to those of the >65 group.

Despite the further physical trauma of surgery, rib fixation has been suggested to be superior for multiple rib fractures, promoting a shorter recovery period (shorter ICU and hospital stay and early return to work) and reducing the likelihood of other complications such as respiratory sepsis. Randomised controlled trials have reviewed the benefits of rib fixation on ventilated patients with flail segments, with Tanaka et al and Marasco et al showing reductions in pneumonia, tracheostomy and ICU stay and even an increase in return to work at six and 12 months. A further study in patients who had a flail segment indicated that rib fixation can reduce the incidence of pneumonia. The surgical treatment of patients with three or more displaced rib fractures without flail segment has also been shown by Peiracci et al to improve recovery when compared to conservative management, showing a decreased pain score and narcotic requirement and increased quality of life. However, a 24-month follow-up of fixated and conservatively managed patients by Marasco et al hasn’t shown any improvement in long-term quality of life.

The consensus of current centres is to consider fixation as an option in anyone...
with a flail segment; of the patients in McGuinness et al's study, 22% sustained flail segments but only 4% had fixation. Given the evidence of the above papers, it is worth considering fixation in anyone over the age of 45 with three or more contiguous rib fractures in a pattern that is technically possible to access surgically, especially if they have failed a trial of adequate analgesia including PCA and erector spinae block.

It seems that more aggressive management in these patients may be beneficial. However, barriers to this include the local skillset and education of inpatient medical teams and general practitioners.

Across the world, rib fixation is variably undertaken by general surgeons, orthopaedic surgeons as well as cardiothoracic surgeons. In New Zealand the main operators are at the major centres, including Christchurch, Waikato and Auckland. As evidenced by McGuinness et al, thoracic trauma patients in district health boards without cardiothoracic surgeons are commonly admitted under more general services. Depending on local knowledge and regional associations, these patients may not have access to the same opportunities. In Christchurch, cardiothoracic surgery has a close working relationship with the trauma team including a weekly multidisciplinary team (MDT) meeting. The meeting is attended by the cardiothoracic surgeons, trauma team, physiotherapists and pain management team. All thoracic trauma patients are discussed and a management plan is developed.

Albeit with a small sample size, McGuinness et al highlight a variation in management strategies due to regional practice, its implication on society and the need to address a more dynamic approach in a younger population, which comprises the largest group of patients affected by thoracic trauma.

There is a need for a national review and audit of thoracic trauma management. This would help to define the extent of thoracic trauma and its physical and financial impacts on society, and ultimately should lead to the formation of a standardised thoracic trauma care pathway. This should be easily accessible to all inpatient care teams and GPs. This system could allow constant review of treatment strategies implemented to ensure a uniform standard of care for all patients with thoracic trauma. A virtual regional weekly MDT meeting for thoracic trauma would allow smaller centres the opportunity to get specialist advice and provide ongoing education. And if GPs were able to refer patients, this would allow inpatients and community cases equal access.

The development of a national thoracic trauma care pathway should aim to improve care and in doing so reduce hospital stay, morbidity and costs to the health service and ACC and at a community and personal level for our patients. Any change takes time though, and it could be resisted by those who are attached to the more traditional approaches.
Competing interests:
Nil.

Author information:
Zoë J Clifford: Cardiothoracic Registrar, Canterbury District Health Board.
Harsh P Singh: Cardiothoracic Surgeon, Canterbury District Health Board.

Corresponding author:
Zoë J Clifford, Cardiothoracic Registrar, Canterbury District Health Board
zoe.clifford@cdhb.health.nz

URL:

REFERENCES
Mortality following severe liver trauma is declining at Auckland City Hospital: a 14-year experience, 2006–2020
Nicholas J Fischer

ABSTRACT

INTRODUCTION: Liver injuries sustained in blunt and penetrating abdominal trauma may cause serious patient morbidity and even mortality.

AIM: To review the recent experience of liver trauma at Auckland City Hospital, describing the mechanism of injury, patient management, outcomes and complications.

METHODS: A retrospective cohort study was performed, including all patients admitted to Auckland City Hospital with liver trauma identified from the trauma registry. Patient clinical records and radiology were systematically examined.

RESULTS: Between 2006–2020, 450 patients were admitted with liver trauma, of whom 92 patients (20%) were transferred from other hospitals. Blunt injury mechanisms, most commonly motor-vehicle crashes, predominated (87%). Stabbings were the most common penetrating mechanism. Over half of liver injuries were low risk American Association for the Surgery of Trauma (AAST) grade I and II (56%), whereas 20% were severe grade IV and V. Non-operative management was undertaken in 72% of patients with blunt liver trauma and 92% of patients with penetrating liver trauma underwent surgery. Liver complications occurred in 11% of patients, most commonly bile leaks (7%), followed by delayed haemorrhage (2%). Thirty-two patients died (7%), with co-existing severe traumatic brain injury as the leading cause of death. There was a significant reduction in death from haemorrhage in patients with grade IV and V liver trauma between the first and second half of the study period (p=0.0091).

CONCLUSION: Although the incidence and severity of liver trauma at Auckland City Hospital remained stable, there was a reduction in mortality, particularly death as a result of haemorrhage.

The liver is commonly injured in both blunt and penetrating abdominal trauma.1,2 Liver trauma can cause life threatening internal haemorrhage and even exsanguination. Delayed liver injury complications are also possible.3 Auckland City Hospital is a tertiary referral hospital that receives approximately 380 major trauma patients every year from both Auckland and the surrounding regions. Auckland City Hospital has a trauma service and hepatobiliary and liver transplantation units. Throughout the world, as trauma systems and management continue to improve, trauma mortality rates have decreased.

The aim of this study was to review all cases of patients admitted to Auckland City Hospital with liver trauma and to provide a descriptive analysis of the data by evaluating the incidence, mechanism, severity, management, complications and mortality, including any change in outcomes over time.

Methods

The Trauma Services department at Auckland City Hospital collects data on all adults (age 15 and older) admitted to Auckland City Hospital. This database was used to identify all patients admitted with liver trauma. Electronic clinical records
and radiology images were accessible from 2006 onwards. A retrospective review of all patients admitted to Auckland City Hospital with liver trauma between January 2006 and June 2020 was performed. The patients’ electronic and scanned hardcopy clinical notes were reviewed, and the mechanism of injury, haemodynamic status, management and complications were recorded. Patients’ computed tomography (CT) imaging was reviewed, and the liver injury severity was graded according to the American Association for the Surgery of Trauma (AAST) organ injury scale (2018 revision) for liver trauma.4 Follow-up using the electronic clinical record was undertaken to examine the patient records for liver-related complications. The number of deaths from haemorrhage in patients with grade IV and V liver trauma was compared between the first (2006–2013) and second (2013–2020) half of the study period, and the number of patients with grade IV and V injuries who underwent laparotomy for shock in the first and second half of the study were also compared. To prevent survivorship bias, these comparisons excluded patients transferred from other hospitals. Fisher exact and Chi Square tests were used for these comparisons, with an alpha significance level of p=0.05. The statistical analysis was performed using SPSS version 27.0 (IBM, Armonk, NY, USA). Data collection and analysis was performed in accordance with local ethical protocols and approval.

Results

Between January 2006 and June 2020, 450 patients were admitted to Auckland City Hospital with liver trauma. The number of patients per year fluctuated between 23 and 40, with a mean of 32 and a stable trend over time (Figure 1). Ninety-two patients were transferred from other hospitals for tertiary trauma services (Figure 2). Blunt injury mechanisms predominated (87%), led by motor vehicle crashes, which accounted for half, followed by falling from a height (Figure 3). Penetrating mechanisms, most commonly stabbings, affected 13% of patients (Figure 4).

In terms of liver trauma severity, milder grades (AAST I and II) accounted for 56%, whereas the most severe grades (AAST IV and V) accounted for 20% (Figure 5). The incidence of severe liver injury was consistent over time. Blunt liver trauma was managed non-operatively for 72% of patients (Figure 6), and 92% of penetrating liver trauma was managed with surgery (Figure 7). Haemodynamic instability requiring laparotomy occurred in 16% of patients with blunt trauma and 10% with penetrating trauma. All four patients with grade V injuries in the first half of the study (2006–2013), and all six patients with grade V injuries in the second half (2013–2020), underwent laparotomy for shock. For grade IV injuries, three out of 19 patients (16%) in the first half, and five out of 27 patients

Figure 1: Annual number of patients with liver trauma admitted to Auckland City Hospital.
**Figure 2:** Patient transfers from other district health boards.

![Bar chart showing patient transfers from other districts.]

**Figure 3:** Blunt injury mechanisms.

![Bar chart showing blunt injury mechanisms.]

- Motor vehicle crash: 198
- Fall from a height: 58
- Motorcycle crash: 41
- Pedestrian vs motor vehicle: 31
- Bicycle crash: 25
- Crash injury: 12
- Blunt assault: 8
- Horse kick: 6
- Pedestrian vs train: 4
- Rugby: 4
- Other: 3
(19%) in the second half, underwent lapa-
rotomy for shock (p=0.810). Interventional
radiology procedures were performed on
haemodynamically stable liver trauma
patients with radiological evidence of active
bleeding and those who were initially
unstable but responded to fluid resusci-
tation. Selective hepatic arterial branch
angioembolisation was performed on 2% of
blunt liver trauma patients within the first
24 hours after injury and a further 2% for
delayed haemorrhage (24 hours or more)
after injury (Figure 6).

Failed non-operative management
occurred in 17 patients with blunt liver
trauma (4%), predominantly for the surgical
management of bile leakage. Liver compli-
cations occurred in 50 patients (11%):
30 patients (7%) with bile leaks and 10
patients (2%) with delayed haemorrhage.
Liver necrosis occurred in eight patients
and intrahepatic arterial branch pseudo-
aneurysms in seven patients (Figure 8). As
expected, liver complications were more
common in high-grade injuries. Additionally,
itis found that delayed complications
were more common following a blunt (12%)
rather than stabbing mechanism (2%).

Thirty-two patients (7%) died, with co-ex-
isting severe traumatic brain injury as the
leading cause of death. Six patients died
from haemorrhage (Figure 9) and all deaths
occurred between 90 minutes and 17 hours
after injury. Deaths reduced in the second
half of the study, with 21 deaths between
2006–2013 and 11 between 2013–2020. This
10-death reduction predominantly came
from an absence of deaths from haem-
orrhage and multiple organ dysfunction
syndrome (MODS) in the second half (Figure
10). All four patients with grade V liver
trauma in the first half of the study period
died from haemorrhage, but all six patients
with grade V injuries in the second half
survived. There was a significant reduction
in death from haemorrhage in patients with
severe liver trauma (grades IV and V) from
the first and second half of the study, with
five deaths out of 20 patients in the first half
versus no deaths out of 28 patients in the
second (p=0.0091). The median follow-up
period using the electronic clinical record
was five years. No previously unrecognised
liver complication was diagnosed after
hospital discharge in any of the 450 patients
in this cohort.

Discussion
Solid abdominal organ injuries are feared
for their potential for catastrophic haem-
orrhage and shock, which may lead to a
lethal triad of metabolic acidosis, hypo-
Figure 5: Liver injury severity by AAST grade.

Figure 6: Management of blunt liver trauma.
**Figure 7:** Management of penetrating liver trauma.

**Figure 8:** Complications.
Figure 9: Causes of death in patients with liver trauma.

Figure 10: Cause of death: 2006–2013 vs 2013–2020.
thermia and coagulopathy resulting in an irreversible downward spiral and ultimately exsanguination. However, unlike the spleen, the liver is a vital organ and cannot be completely resected when it is severely injured. Attaining haemostasis in a lacerated liver can prove challenging for the surgeon during laparotomy. Additionally, a severely injured liver may lead to late complications. The Auckland City Hospital experience suggests that, with contemporary trauma management, exsanguination from liver trauma is in fact very rare and appears to be declining. Richardson et al published a landmark paper on the Louisville liver trauma experience of 25 years that included 1,842 patients. They demonstrated that increasing non-operative management of liver trauma reduces associated mortality over time, postulating that operative intervention can actually worsen bleeding and, subsequently, complications from liver trauma. Since then, non-operative management of liver trauma has evolved to become the standard of care for haemodynamically stable patients. The Auckland City Hospital experience demonstrates a clear preference for non-operative management of blunt liver trauma, with patients only undergoing surgery in cases of haemodynamic instability despite fluid resuscitation, or for other indications for laparotomy (eg, hollow visceral injury or delayed complications).

Our overall mortality rate of 7% was similar to other recent Australasian series. However, during the second half of our study period, there was a trend towards a further decrease in the mortality rate to 5%, predominantly due to an absence of death from haemorrhage and MODS, and almost all deaths during the second half were due to co-existing severe traumatic brain injury. Interestingly, there was no change in the non-operative management rate for patients with high-grade liver injuries between the 2006–2013 and 2013–2020 periods, suggesting it is unlikely that changes in surgical management can explain this reduction in haemorrhagic death. Furthermore, our data also suggest that interventional radiology procedures were unlikely to have had a significant impact on this reduction in haemorrhagic death, since early angioembolisation was only performed in a small subset of patients (2%) with active arterial bleeding seen on their CTs and who were haemodynamically stable enough to be taken to the angio-suite.

Therefore, the explanation for this reduction in haemorrhagic death is likely multifactorial and a result of improvements in multidisciplinary trauma management and critical care. Evidence emerging in trauma literature suggests that changes in fluid resuscitation practice, and in particular utilising haemostatic resuscitation principles with early administration of blood products (eg, coagulation factors, avoidance of crystalloid fluids and increasing use of tranexamic acid), may help prevent coagulopathy and fatal haemorrhage. Further research into specific factors responsible for this reduction in fatal haemorrhage seems warranted.

Overall, the liver-specific complication rate of 11% predominantly occurred in high-grade and blunt liver trauma. This led to a failure of non-operative management in 4% of patients with blunt liver trauma, mostly due to bile leak. Interestingly, though, there was not one patient that developed a new liver complication after discharge from hospital, as all liver complications were diagnosed during index admission.

Limitations of the applicability of these findings to other centres include its single centre nature in a New Zealand hospital and its retrospective data collection, and thus the risk of inherent bias in such methodology. Furthermore, Auckland City Hospital is a tertiary referral centre and receives a disproportionately high grade of severity of liver trauma specifically for trauma and liver surgical expertise.

**Conclusions**

The incidence and severity of liver trauma at Auckland City Hospital has remained stable over time. However, with improvements in multidisciplinary trauma management, there has been a reduction in mortality from haemorrhage. Further research into changes in management during this time may elucidate specific beneficial practice changes.
Competing interests:
Nil.

Acknowledgements:
Thank-you to everyone in the Trauma Service at Auckland Hospital, in particular Prof Ian Civil and Mr Li Hsee. Thanks also to Associate Professor Adam Bartlett and Professor John McCall.

Author information:
Nicholas J Fischer: MBChB FRACS, Liver Transplantation Fellow, New Zealand Liver Transplant Unit, Auckland City Hospital.

Corresponding author:
Nicholas J Fischer: MBChB FRACS, Liver Transplantation Fellow, New Zealand Liver Transplant Unit, Auckland City Hospital
NFischer@adhb.govt.nz

URL:

REFERENCES
The societal cost of unintentional childhood injuries in Aotearoa

Michael Young, Tom Love, Melissa Wilson, Moses Alatini, Michael Shepherd

ABSTRACT

AIMS: To estimate the burden and inequity of unintentional childhood injury for children in Aotearoa.

METHODS: We used administrative data from the Accident Compensation Corporation (ACC) and the Ministry of Health to estimate the direct, indirect and intangible costs of unintentional injuries in children aged under 15 and the inequity of the impact of childhood injury on discretionary household income. We used an incidence approach and attributed all costs arising from injuries to the year in which those injuries were sustained.

RESULTS: 257,000 children experienced unintentional injury in 2014, resulting in direct and indirect costs of almost $400 million. The burden of lost health and premature death was the equivalent of almost 200 full lives at perfect health. Pacific children had the highest incidence rates. Māori had the lowest rates of ACC claims but the highest rate of emergency department attendance. Children living with the highest levels of socioeconomic deprivation had the highest rate of hospital admission following injury. The proportional loss in discretionary income arising from an injury was higher for Māori and Pacific compared to non-Māori, non-Pacific households.

CONCLUSION: The burden of unintentional childhood injury is greater than previously reported and has a substantial and iniquitous societal impact. There should be a focus on addressing inequities in incidence and access to care in order to reduce inequities in health and financial impact.

Approximately 66 children (0–14 years) die from unintentional injuries each year, and unintentional injury is the leading cause of death in 1- to 14-year-olds. An additional 7,700 hospitalisations occur as a result of these injuries. Tamariki Māori are 3.4 times more likely to die from unintentional injuries than European children. The frequency, severity, potential for death and disability, inequities and costs of unintentional injury make it a significant childhood health problem.¹

Despite the significance of unintentional childhood injuries in Aotearoa, little is known about their immediate and long-term costs, which include the direct costs (eg, medical treatment and rehabilitation) and indirect costs (eg, productivity losses and intangible human costs of resulting disability and avoidable deaths). Current injury-prevention policy development and spending is heavily influenced by existing economic data, which are largely derived from the Accident Compensation Corporation (ACC). These measured costs are largely compensation for the lost earnings of injured adults. Thus child injury prevention is interpreted as costing much less.

Although the need to reduce health inequities is widely acknowledged, particularly for Māori,² little is known about the economic costs associated with the disproportionate burden of unintentional injuries experienced by tamariki Māori.

This study seeks to quantify the economic costs of unintentional child injuries for all tamariki in Aotearoa aged 0–14 years, including the direct and indirect costs of these injuries, and to identify inequities that exist between unintentional injury rates for tamariki Māori and non-Māori children in Aotearoa.
Methods

This analysis was incidence based and aimed to estimate the societal costs of all unintentional injuries that occur in one year for children aged 0–14 years. Given the need for a sufficient period of post-injury follow-up time, we chose 2014 as our base year for injury incidence, allowing for up to five and a half years of post-injury data from ACC and the Ministry of Health (MoH).

The first part of our study used ACC claims data for unintentional childhood injuries in 2014 to establish the incidence. The second part of our study quantifies the burden of costs across a range of categories based on the incidence data. We estimated the societal cost burden in three forms:

- **Direct costs**: those relating to the medical treatment and rehabilitation of unintentional childhood injuries.
- **Indirect costs**: the lost potential productivity in the workplace resulting from absences due to unintentional childhood injuries (i.e., these costs relate to caregivers).
- **Intangible costs**: these cannot readily be monetised (e.g., the pain, stress, physical limitations or loss of life as a result of unintentional childhood injuries). We measured these in disability-adjusted life years (DALYs).

Incidence data for unintentional childhood injuries were based upon individual level claims data for 2014 provided by ACC. We provide details of the data cleansing process in the supplementary materials to this paper.

We used prioritised ethnicity codes. Children who do not have either Māori or Pacific as a recorded ethnicity are grouped in the non-Māori, non-Pacific (NMNP) group.

We used prices from the midpoint of the time period of the analysis (2017) for inpatient, day patient and non-admitted secondary care events. We applied an additional 20% to these calculated costs to represent the deadweight cost that taxation imposes on the economy.1

We adopted a human capital approach for estimating the indirect costs of lost productivity, using wages to estimate the productivity loss. Household incomes were based on 2017 median equivalised income before housing costs from Perry.4 We assumed an average two-adult, two-children household for our analysis, which equates to a multiplier of 2.1. We choose this household type as our ‘standard’ household as it is the most common type among those where children are present.5 This is the case across all ethnicities, although Māori and Pacific women are more likely to have three or more children, and Māori and Pacific children are more likely to live in a sole parent household.5,6

As a conservative estimate for lost productivity and lost income, we assumed that each unique date on which an inpatient, day patient, non-admitted secondary care (including outpatient and emergency department) and/or ACC event occurred was equal to one lost day of productivity and income. This presupposes that a caregiver would need to take time off work for these attendances. While it is unlikely that all attendance days occurred on working days, this was likely more than offset by additional time off work for caregivers caring for injured children.

To calculate the median daily income/productivity loss, we based household income on 1.5 incomes (i.e., one full-time and one half-time income), in accordance with the living wage calculations and 260 paid working days a year.7

Measurement of health loss due to injuries had to account for both the loss in health due to premature mortality for fatal injuries and the loss in health-related quality of life due to disability for non-fatal injuries. We measured the health losses due to unintentional injury in disability-adjusted life years (DALYs). Details of our DALY estimation are included in the supplementary materials to this paper.

We explored how an injury may impact household discretionary income for the first year following an injury for different groups. Although the monetised value of time off work may be lower for those on lower incomes, this loss may represent a relatively higher burden compared to those on higher incomes. For this impact approach to inequity, we used the median income by ethnicity reported by Perry.4 For the breakdown by deprivation, we assigned the midpoint of the quintile: for instance, we assigned the 90th percentile figure to quintile 1 (least deprived) the
10th percentile figure to quintile 5 (most deprived). As a benchmark for our equity impact analysis, we used the 2017 living wage 2017 ($20.20 per hour).

Our ethnicity equity analysis broke the previous NMNP ethnicity group into ‘European’ and ‘All Other’. Multiple response ethnicity was prioritised in order of Māori, Pacific people, All Other and then European.

We used a discount rate of 3.5% per annum for all costs, consistent with standard practice for economic analysis at PHARMAC.

Ethics approval was obtained from the Auckland Health Research Ethics Committee and the ACC Ethics Panel.

Results
Incidence and costs
During the 2014 calendar year, more than one in four children aged 0–14 (257,000 of 911,000, or 28%) suffered at least one injury. There were almost 345,000 ACC claims for unintentional childhood injuries. Approximately 40% of these were due to falls, and almost 30% due to sports-related injuries (Table 1).

The loss in health of 5,400 DALYs (Table 2) is equivalent to almost 200 full lives in perfect health. The cost of the injuries to the health sector and ACC equates to over $200 million. Unintentional childhood injuries also resulted in productivity losses of almost $170 million. Applying a full-time annual salary for the ages 18–64 for the fatal injuries in 2014 equates to a further productivity loss of $29 million.

The health and ACC cost per injury for Māori is higher than for Pacific people and NMNP (24% and 30% higher, respectively) (Table 4). This offsets the lower ACC claim rate such that the overall health and ACC cost rate is more in line with the average.

In comparison to total incidence, the hospital admission rate for Māori following an unintentional injury exceeds the rate for NMNP, and the Māori emergency department (ED) attendance rate is the highest across the three ethnicities (Table 5).

Deprivation is based on the New Zealand Index of Deprivation 2013 (NZDep2013) decile groupings, grouped into quintiles (Table 6). Children in quintile 1 have the highest rates of injury across almost all causes, especially sports-related injuries. Except for quintile 5, total (all-cause) injury rates fall as deprivation increases. This trend is primarily driven by fewer sports-related injuries. Both transport incidents and injuries from fire, heat and hot substances tend to increase with deprivation. The rate of injury from animate mechanical forces is relatively flat for quintiles 1 to 4 but is around 50% higher for quintile 5.

Children in quintile 1 have the highest rates across all the four measures of Table 7. Although the health and ACC cost rates per 1,000 children are similar, the cost per injury is higher for quintile 5 than any of the other quintiles.

Equity of injury impacts
Higher incomes combined with higher attendance days for Europeans are reflected in higher absolute loss in household income following an injury. However, due to the higher income, the percentage loss in discretionary income is the lowest. Māori households have the highest percentage loss of discretionary income.

Median incomes for Pacific people are already below the living wage, highlighting broader societal inequities. We therefore do not report the percentage change, as this cannot be directly compared, but note that the deficit is increased.

When analysed by deprivation, the highest absolute loss following an injury is for households in quintile 1. However, the relative loss for this group is the lowest. Quintile 4 and 5 incomes are already below the living wage before an injury. These groups, like Pacific people households (discussed above), are likely to be impacted the most from lost income arising from caring for an injured child.
Table 1: Injuries by cause.

<table>
<thead>
<tr>
<th>Injury cause</th>
<th>Non-fatal injuries</th>
<th>Fatal injuries</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Falls</td>
<td>137,524</td>
<td>3</td>
<td>137,527</td>
</tr>
<tr>
<td>Sports</td>
<td>98,079</td>
<td>2</td>
<td>98,081</td>
</tr>
<tr>
<td>Animate mechanical forces¹</td>
<td>42,070</td>
<td>2</td>
<td>42,072</td>
</tr>
<tr>
<td>Other</td>
<td>31,213</td>
<td>3</td>
<td>31,216</td>
</tr>
<tr>
<td>Inanimate mechanical forces¹</td>
<td>26,505</td>
<td>3</td>
<td>26,508</td>
</tr>
<tr>
<td>Transport incident</td>
<td>3,871</td>
<td>16</td>
<td>3,887</td>
</tr>
<tr>
<td>Fire, heat and hot substances</td>
<td>3,105</td>
<td>1</td>
<td>3,106</td>
</tr>
<tr>
<td>Inhaled/swallowed object</td>
<td>2,501</td>
<td>0</td>
<td>2,501</td>
</tr>
<tr>
<td>Drowning</td>
<td>29</td>
<td>4</td>
<td>33</td>
</tr>
<tr>
<td>Total</td>
<td>344,897</td>
<td>34</td>
<td>344,931</td>
</tr>
</tbody>
</table>

¹ 'Animate mechanical forces' refer to injuries that are caused by living things able to move on their own accord. This includes injuries like dog and insect bites, as well as being struck by another person. ‘Inanimate mechanical forces’ refers to injuries that are caused by moving non-living things, such as moving machinery or explosions.

Table 2: Societal costs by injury cause.

<table>
<thead>
<tr>
<th>Injury cause</th>
<th>Incidence</th>
<th>DALYs</th>
<th>Health and ACC cost</th>
<th>Caregiver productivity loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Falls</td>
<td>137,527</td>
<td>1,623</td>
<td>$81.53M</td>
<td>$61.64M</td>
</tr>
<tr>
<td>Sports</td>
<td>98,079</td>
<td>1,580</td>
<td>$56.22M</td>
<td>$64.08M</td>
</tr>
<tr>
<td>Animate mechanical forces</td>
<td>42,072</td>
<td>621</td>
<td>$16.09M</td>
<td>$14.54M</td>
</tr>
<tr>
<td>Other</td>
<td>31,213</td>
<td>422</td>
<td>$15.42M</td>
<td>$12.70M</td>
</tr>
<tr>
<td>Inanimate mechanical forces</td>
<td>26,505</td>
<td>333</td>
<td>$12.97M</td>
<td>$10.10M</td>
</tr>
<tr>
<td>Transport incident</td>
<td>3,871</td>
<td>606</td>
<td>$10.36M</td>
<td>$3.41M</td>
</tr>
<tr>
<td>Fire, heat and hot substances</td>
<td>3,105</td>
<td>64</td>
<td>$4.37M</td>
<td>$2.24M</td>
</tr>
<tr>
<td>Inhaled/swallowed object</td>
<td>2,501</td>
<td>33</td>
<td>$5.03M</td>
<td>$0.87M</td>
</tr>
<tr>
<td>Drowning</td>
<td>33</td>
<td>118</td>
<td>$0.07M</td>
<td>$0.01M</td>
</tr>
<tr>
<td>Total</td>
<td>344,931</td>
<td>5,400</td>
<td>$202.05M</td>
<td>$169.60M</td>
</tr>
</tbody>
</table>
Table 3: Injuries by cause and ethnicity.

<table>
<thead>
<tr>
<th>Injury cause</th>
<th>Māori</th>
<th>Pacific people</th>
<th>NMNP</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Counts</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Falls</td>
<td>29,612</td>
<td>14,440</td>
<td>93,475</td>
<td>137,527</td>
</tr>
<tr>
<td>Sports</td>
<td>19,098</td>
<td>8,809</td>
<td>70,174</td>
<td>98,081</td>
</tr>
<tr>
<td>Animate mechanical forces</td>
<td>11,326</td>
<td>7,042</td>
<td>23,704</td>
<td>42,072</td>
</tr>
<tr>
<td>Other</td>
<td>7,652</td>
<td>3,390</td>
<td>20,174</td>
<td>31,216</td>
</tr>
<tr>
<td>Inanimate mechanical forces</td>
<td>6,115</td>
<td>3,351</td>
<td>17,042</td>
<td>26,508</td>
</tr>
<tr>
<td>Transport incident</td>
<td>988</td>
<td>386</td>
<td>2,513</td>
<td>3,887</td>
</tr>
<tr>
<td>Fire, heat and hot substances</td>
<td>959</td>
<td>455</td>
<td>1,692</td>
<td>3,106</td>
</tr>
<tr>
<td>Inhaled/swallowed object</td>
<td>686</td>
<td>209</td>
<td>1,606</td>
<td>2,501</td>
</tr>
<tr>
<td>Drowning</td>
<td>12</td>
<td>3.0</td>
<td>18</td>
<td>33</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>76,448</td>
<td>38,085</td>
<td>230,398</td>
<td>344,931</td>
</tr>
</tbody>
</table>

| **Rate per 1,000**           |       |                |       |        |
| Falls                         | **126 | **164          | 159   | 151    |
| Sports                        | **81  | **100          | 120   | 108    |
| Animate mechanical forces     | **48  | **80           | 40    | 46     |
| Other                         | **32  | **38           | 34    | 34     |
| Inanimate mechanical forces   | **26  | **38           | 29    |    |
| Transport incident            | 4.2   | 4.4            | 4.3   | 4.3    |
| Fire, heat and hot substances | **4.1 | **5.2         | 2.9   | 3.4    |
| Inhaled/swallowed object       | 2.9   | *2.4           | 2.7   | 2.7    |
| Drowning                      | 0.05  | 0.03           | 0.03  | 0.04   |
| **Total**                     | **324 | **431          | 392   | 379    |

** Rate ratio is significant at the 99% level compared to NMNP.
* Rate ratio is significant at the 95% level compared to NMNP.
Table 4: Societal costs by ethnicity.

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Incidence</th>
<th>DALYs</th>
<th>Health and ACC cost</th>
<th>Productivity loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Counts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Māori</td>
<td>76,448</td>
<td>1,459</td>
<td>$54.22M</td>
<td>$34.77M</td>
</tr>
<tr>
<td>Pacific people</td>
<td>38,085</td>
<td>429</td>
<td>$21.73M</td>
<td>$16.51M</td>
</tr>
<tr>
<td>NMNP</td>
<td>230,398</td>
<td>3,511</td>
<td>$126.11M</td>
<td>$118.32M</td>
</tr>
<tr>
<td>Total</td>
<td>344,931</td>
<td>5,400</td>
<td>$202.05M</td>
<td>$169.60M</td>
</tr>
<tr>
<td>Rate per 1,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Māori</td>
<td><strong>324</strong></td>
<td>6.2</td>
<td><strong>$230K</strong></td>
<td><strong>$147K</strong></td>
</tr>
<tr>
<td>Pacific people</td>
<td><strong>431</strong></td>
<td><strong>4.9</strong></td>
<td><strong>$246K</strong></td>
<td><strong>$187K</strong></td>
</tr>
<tr>
<td>NMNP</td>
<td>392</td>
<td>6.0</td>
<td>$215K</td>
<td>$202K</td>
</tr>
<tr>
<td>Total</td>
<td>379</td>
<td>5.9</td>
<td>$222K</td>
<td>$186K</td>
</tr>
</tbody>
</table>

** Rate ratio is significant at the 99% level compared to NMNP.
* Rate ratio is significant at the 95% level compared to NMNP.

Table 5: Summary of attendance rates by ethnicity—rates per 1,000.

<table>
<thead>
<tr>
<th>Attendance rate</th>
<th>Māori</th>
<th>Pacific people</th>
<th>NMNP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injury</td>
<td>324</td>
<td>431</td>
<td>392</td>
</tr>
<tr>
<td>Inpatient or day patient</td>
<td>18</td>
<td>22</td>
<td>15</td>
</tr>
<tr>
<td>ED attendance</td>
<td>67</td>
<td>50</td>
<td>59</td>
</tr>
<tr>
<td>Outpatient/non-hospital</td>
<td>242</td>
<td>362</td>
<td>321</td>
</tr>
</tbody>
</table>

All rate ratios for Māori:NMNP and Pacific people:NMNP for the rates shown in Table 5 are significant at the 99% level.

Key

Highest
Middle
Lowest
Table 6: Injuries by cause and NZDep2013 quintile.

<table>
<thead>
<tr>
<th>Injury cause</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q5</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate per 1,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Falls</td>
<td>169</td>
<td>**153</td>
<td>**146</td>
<td>**139</td>
<td>**142</td>
<td>151</td>
</tr>
<tr>
<td>Sports</td>
<td>142</td>
<td>**112</td>
<td>**105</td>
<td>**93</td>
<td>**84</td>
<td>108</td>
</tr>
<tr>
<td>Animate mechanical forces</td>
<td>40</td>
<td>40</td>
<td>39</td>
<td>**42</td>
<td>**61</td>
<td>46</td>
</tr>
<tr>
<td>Other</td>
<td>35</td>
<td>**33</td>
<td>**33</td>
<td>*33</td>
<td>**36</td>
<td>34</td>
</tr>
<tr>
<td>Inanimate mechanical forces</td>
<td>29</td>
<td>**28</td>
<td>*28</td>
<td>**27</td>
<td>**32</td>
<td>29</td>
</tr>
<tr>
<td>Transport incident</td>
<td>4.0</td>
<td>4.2</td>
<td>4.3</td>
<td>4.0</td>
<td>*4.4</td>
<td>4.3</td>
</tr>
<tr>
<td>Fire, heat and hot substances</td>
<td>2.7</td>
<td>*3.1</td>
<td>2.7</td>
<td>**3.5</td>
<td>**4.5</td>
<td>3.4</td>
</tr>
<tr>
<td>Inhaled/swallowed object</td>
<td>2.7</td>
<td>2.5</td>
<td>2.9</td>
<td>2.9</td>
<td>2.6</td>
<td>2.8</td>
</tr>
<tr>
<td>Drowning</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>Total</td>
<td>423</td>
<td>**375</td>
<td>**361</td>
<td>**344</td>
<td>**366</td>
<td>380</td>
</tr>
</tbody>
</table>

1 The rates by quintile exclude injuries where NZDep2013 data for injuries are missing (1.6%). Therefore, quintile specific rates are slightly undercounted.
** Rate ratio is significant at the 99% level compared to Q1.
* Rate ratio is significant at the 95% level compared to Q1.

Table 7: Societal costs by deprivation quintile.

<table>
<thead>
<tr>
<th>Quintile</th>
<th>Incidence</th>
<th>DALYs</th>
<th>Health and ACC cost</th>
<th>Productivity loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate per 1,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1—least deprived</td>
<td>423</td>
<td>6.5</td>
<td>$231K</td>
<td>$226K</td>
</tr>
<tr>
<td>2</td>
<td>**375</td>
<td>6.1</td>
<td>**$225K</td>
<td>**$193K</td>
</tr>
<tr>
<td>3</td>
<td>**361</td>
<td>**5.4</td>
<td>**$216K</td>
<td>**$180K</td>
</tr>
<tr>
<td>4</td>
<td>**344</td>
<td>**5.5</td>
<td>$199K</td>
<td>**$164K</td>
</tr>
<tr>
<td>5—most deprived</td>
<td>**366</td>
<td>**5.7</td>
<td>$228K</td>
<td>**$164K</td>
</tr>
<tr>
<td>Total</td>
<td>380</td>
<td>5.9</td>
<td>$222K</td>
<td>$186K</td>
</tr>
</tbody>
</table>

1 The rates by quintile exclude injuries where NZDep2013 data for injuries are missing (1.6%). Therefore, quintile specific rates are slightly undercounted.
** Rate ratio is significant at the 99% level compared to Q1.
* Rate ratio is significant at the 95% level compared to Q1.
This breakdown shows fewer attendance days per injury by deprivation.

**Discussion**

**Key results**

Unintentional childhood injuries have a significant societal cost. Our methodology consistently used conservative assumptions, meaning that the results presented here should be interpreted as lower limits for the true level of burden imposed by unintentional childhood injury. Our main findings are of substantial cost and material inequalities in childhood trauma.

We investigated the impact of injury on households according to the distribution of discretionary income. Injuries could have a particularly significant impact on low-income households, which may result in borrowing or avoiding essential household expenditure, and if debt were used to cover the deficits, interest on any additional debt would exacerbate the impact. Similarly, forgoing essential expenditure, such as for food, medicine or heating, may worsen health outcomes.

Households are likely to first spend income on the goods and services that are of most importance and the highest value. That is, there are diminishing marginal benefits to increases in income. For lost income, this means that the ‘value’ of each dollar lost is greater for lower-income households. For households with negative discretionary income before any losses in income, it is likely that they will already be forgoing essential goods and services. A reduction in income for these households likely means forgoing even more vital essential goods and services.

**Importance**

The level of cost of injury we found is significant in a New Zealand context. Our finding of nearly $400 million in annual costs is substantial, particularly because it applies only to children aged under 15. The $200 million we found in direct costs was approximately 12% of ACC’s entire annual expenditure of $1.7 billion on health services. The disparities we found across ethnic groups can be explained, at least to some extent, by existing research on access to primary healthcare. Poorer access to primary care for Māori, Pacific people and people with higher levels of deprivation, which has already been documented in the established literature, is likely to be at least one important factor behind these key findings:

- Māori had the lowest rates of ACC claims for injuries, but the highest ED attendance rate and, given the collected data, are 50% more likely to be admitted to hospital following an injury than NMNP. This signals a possible gap between Māori and non-Māori use of and access to

| Table 8: Reduced income due to injuries by ethnicity. |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|
| Median annual household income  | Māori           | Pacific people  | All Other       | European        |
|                                 | $69,930         | $58,170         | $76,440         | $87,150         |
| less Living wage                | $63,024         | $63,024         | $63,024         | $63,024         |
| Remaining discretionary income  | $6,906          | -$4,854         | $13,416         | $24,126         |
| less Lost caregiver income¹     | $374            | $301            | $439            | $540            |
|                                 | (2.1)           | (2.0)           | (2.2)           | (2.4)           |
| Discretionary income after one injury | $6,532         | -$5,155         | $12,977         | $23,586         |
| Percentage change in discretionary income | -5.7%         | -3.4%           | -2.3%           | -2.3%           |

¹Numbers in brackets reflect the average number of attendance days in the first year following injury.
primary healthcare following lower acuity unintentional injuries.

- Pacific people had higher incidence rates, but apparently fewer long-term disabilities and therefore lower health impacts. This indicates that there may be gaps in longer-term follow-up treatment for Pacific children, who appeared to have fewer long-term injuries due to lack of events past one year of age.

The finding of lower health service presentation rates following injury for Māori could also be due to differential treatment by health providers when Māori present to the health sector, which would lead to fewer ACC claims. If fewer attendance days for more deprived households are, at least in part, due to lost income, then caregivers may be needing to make the difficult trade-off between their children’s health and other life necessities. Factors such as effective and culturally appropriate patient–provider communication may impact on a patient’s understanding of health processes.\textsuperscript{10,11,12} Therefore, the quality of the healthcare received by Māori may be as important (if not more) than poorer access to healthcare.

There is a growing body of research into the cost of injury in New Zealand. However, due to different methodologies and time-frames, the absolute values are difficult to compare. For instance, few studies have estimated the costs of childhood injuries, let alone unintentional childhood injuries specifically. Other studies focus on hospital admissions and/or fatalities, which account for less than 5% of the total number of injuries in our analysis.

Research completed by Mills, Reid and Vaithianathan found similar disparities between Māori and non-Māori. They found that between 2003–2007 there was a Māori-to-non-Māori rate ratio of 0.68 of ACC claims. We found that the rate ratio for 2014 was 0.80, which may show a slight closing of the gap, although we note that our analysis was only for one year and considers only unintentional injuries.

Previous research into differences between levels of deprivation showed trends similar to those we found. Mistry et al found the same increasing rate of burn injuries by deprivation for all New Zealanders,\textsuperscript{14} and Hosking found road traffic injuries increasing with deprivation for children.\textsuperscript{15}

## Conclusions

Our approach to analysing equity provides insight into areas that have not previously been quantified. Our analysis showed that Māori and Pacific people are much more impacted than All Other and European households. As expected, the most deprived

<table>
<thead>
<tr>
<th>Table 9: Reduced income due to injuries by deprivation quintile.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quintile</td>
</tr>
<tr>
<td>Median annual household income</td>
</tr>
<tr>
<td>less Living wage</td>
</tr>
<tr>
<td>Remaining discretionary income</td>
</tr>
<tr>
<td>less Lost caregiver income</td>
</tr>
<tr>
<td>Discretionary income after one injury</td>
</tr>
<tr>
<td>Percentage change in discretionary income</td>
</tr>
</tbody>
</table>

\textsuperscript{1} Numbers in brackets reflect the average number of attendance days in the first year following injury.
households are also more heavily impacted by an injury than the least deprived. This impact is likely even more substantial than the analysis we have shown. Firstly, those on lower incomes or who identify as Māori or Pacific people may be more likely to be in casual employment. These workers are less likely to be entitled to paid sick leave compared to those in permanent employment, from whom paid sick leave may help to alleviate the financial impact of time off work.

Secondly, the most deprived households are more likely to have other health issues, and Māori and Pacific people typically have poorer health outcomes than NMNP, even after the data are adjusted for deprivation. Therefore, even if paid sick leave were available to these groups, they would be more likely to have use their allocation for other health issues.

This analysis has contributed a new perspective to the burden of unintended childhood injury in Aotearoa. We adopted an incidence approach, which we anticipate will be useful in future cost–benefit analysis of injury prevention interventions. We also explored issues of inequitable impact and showed clearly that the impact of a childhood injury varies for different families, and that the ability to manage the costs arising from an injury varies systematically by ethnicity and deprivation.

These results present a starting point for a number of research questions that could expand upon our analysis, draw in different datasets, or develop our findings in the context of other literature. In particular, we see a number of questions and areas for future research that arise from our results:

- How do households with little or no discretionary income manage childhood injury?
- To what extent do issues of poor access to primary care impose a greater and inequitable injury burden on households, particularly for Māori?
- To what extent do issues of poor access to rehabilitation and longer-term care impose a greater and inequitable injury burden on households, particularly for Pacific people?
- What are the wider policy implications of the inequity of injury burden, particularly for Pacific people?
- Analysis of the household burden of injury, taking into account household size and income in a more granular manner, potentially using Integrated Data Infrastructure data on income and living circumstances.
- Analysis of Pacific outcomes by Total Response ethnicity, as well as Prioritised ethnicity, in order to explore the impact on Pacific communities further.

The current findings have three significant points. The first is the sheer size of unintended childhood injury supports the view that childhood injury is a significant burden to New Zealanders. It is a particularly high burden for Māori and Pacific people. The second point is that the impact of a childhood injury may magnify pre-existing inequities in access to healthcare. The existing, well established inequity in access to primary care for key groups of New Zealanders is seen here in lower rates of presentation for less severe injuries. There is room for further research on the impact that inequity of access has on the outcome of injuries.

Lastly, the impact of a childhood injury magnifies wider, pre-existing socioeconomic inequities in Aotearoa. We have shown that households with low discretionary income sustain a higher proportionate impact from the costs of an injury. In the extreme cases of households with very low average incomes, where there is no discretionary income even before an injury occurs, there is significant potential for an injury to cause harm to the household, and for the impact to be significantly out of proportion to the impact upon a whānau with more resources. This finding applies in particular to Pacific people and those living in high socioeconomic deprivation.

Overall, there is significant scope for reducing the absolute burden of unintended childhood injury in Aotearoa. Work to address that burden has the potential to reduce inequalities, both in the immediate treatment of injury and, more widely, upon the inequitable impact that childhood injury has on households and whānau. Health promotion programmes that work with local communities to support injury prevention...
for tamariki have the potential to reduce an important source of inequity in health outcome for children in Aotearoa.

**Supplementary materials**

**Data cleansing**

Incidence data for unintentional childhood injury was based upon claims data provided by the Accident Compensation Corporation (ACC) for 2014. All ACC payments relating to these claims to 28 September 2019 were provided. Data for inpatient, day patient, non-admitted secondary care events (such as outpatient and emergency department visits) and mortality events for the children identified by ACC were provided by the Ministry of Health (MoH). These data were matched by National Health Index (NHI) and ACC claim number. The MoH also provided a cohort dataset, which contained patient demographics. The data were cleaned in accordance with the following rules:

- Claims were removed where the injury cause was either ‘Criminal Act’ or ‘Medical Treatment’.
- MoH demographic data were prioritised over the ACC provided data.
- Claims were removed where the age at accident was greater than 14.
- MoH inpatient and day patient data were filtered to include only events where an accident date was recorded within seven days before or after the accident year and month reported by ACC and at least one of a) an external cause code, b) a diagnostic code under the ICD-10 umbrella group ‘Injury, poisoning and certain other consequences of external causes’, or c) the ‘accident_flag’ was set to ‘Y’.
- Outpatient and emergency department visits were filtered to include only events where the service date occurred between the accident year and month provided by ACC and the greater of a) two months from the accident year and month provided by ACC, or b) the time between the last service paid by ACC and the accident date added to the end of the month in which the accident occurred.
- Mortality Collection data were filtered to include only events where the underlying cause of death was recorded under the ICD-10 umbrella ‘External causes of morbidity and mortality’, ‘Accident’.
- DALY calculations

Calculation of the DALY requires a ‘disability weight’, calculated from the results tool of the World Health Organization’s (WHO) 2017 Global Burden of Disease (GBD) study. We calculated the average disability weights by nature of injury for the age groups 0–14.

We applied the following rules when determining the duration of disability arising from an injury:

- if the injury was fatal, use remaining life-expectancy; else
- if the nature of injury was an amputation, use remaining life-expectancy; else
- determine the length of time from injury to the last relevant inpatient, day patient, non-admitted secondary care or ACC payment event:
  - if less than seven days, use seven days; else
  - if greater than or equal to 365 days, use remaining life-expectancy; else
  - length of time from injury to the last relevant inpatient, day patient, non-admitted secondary care or ACC payment event.

For life expectancy, we used life table data from Stats NZ (2015). We used the aggregate life expectancy for New Zealand, and we did not differentiate life-expectancy between different demographic groups since this would have discriminated against those with lower life-expectancies. For instance, a fatal or life-long injury for a Māori child would have resulted in a lower societal cost than one for a non-Māori, non-Pacific child due to lower life-expectancy.

Injuries were categorised in order to align with the disability weight data, in accordance with James et al.
Competing interests:
Nil.

Acknowledgements:
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Author information:
Tom Love: Director, Sapere Research Group Wellington; Adjunct Senior Research Fellow, Department of Primary Health Care and General Practice, University of Otago, Wellington.
Melissa Wilson: General Manager Strategy and Change, Provider Arm Auckland DHB, Auckland.
Michael Shepherd: Director of Child Health and Paediatric Emergency Specialist, Starship Hospital; Honorary Senior Lecturer, University of Auckland, Auckland.

Corresponding author:
Moses Alatini, Senior Policy Analyst, Safekids Aotearoa, Auckland DHB, Auckland
MosesA@adhb.govt.nz

URL:

REFERENCES


Outcomes in patients with fractured ribs: middle aged at same risk of complications as the elderly

Matthew J McGuinness, Liam Ryan Ferguson, Imogen Watt, Christopher Harmston

ABSTRACT

AIMS: Rib fractures occur in up to 10% of hospitalised trauma patients and are the most common type of clinically significant blunt injury to the thorax. There is strong evidence that elderly patients have worse outcomes compared with younger patients. Evolving evidence suggests adverse outcomes start at a younger age. The aim of this study was to explore the effect of age on outcomes in patients with rib fractures in Northland, New Zealand.

METHOD: A two-year retrospective study of patients admitted to any Northland District Health Board hospital with one or more radiologically proven rib fracture was performed. Patients with an abbreviated injury scale score >2 in the head or abdomen were excluded. The study population was stratified by age into three groups: >65, 45 to 65 and <45 years old.

RESULTS: 170 patients met study inclusion criteria. Patients <45 had a significantly shorter length of stay (LOS) and lower rates of pneumonia compared to patients 45 and older, despite a higher Injury Severity Score and pulmonary contusion rate. There was no difference seen between groups in rates of intubation, ICU admission, mortality, empyema or acute respiratory distress syndrome.

CONCLUSION: This study found higher rates of pneumonia and an increased LOS in patients 45 and older despite their lower overall injury severity when compared to patients under 45. Patients aged 45–64 had outcomes similar to patients >65. Future clinical pathways and guidelines for patients with rib fractures should consider incorporating a younger age than 65 in risk stratification algorithms.

Trauma is an important cause of mortality in New Zealand. It is the leading cause of death between the ages of 1 and 34 and the fifth largest cause of health loss across all age groups.1,2 Thoracic trauma is second only to head and spinal cord injuries as the cause of death in trauma patients.3,4 In New Zealand over 40% of patients presenting with major trauma have thoracic injuries with most of these patients having rib fractures.5 Rib fractures occur commonly in hospitalised trauma patients and are the most common type of clinically significant blunt injury to the thorax.6,7 The pain from rib fractures and associated underlying pulmonary pathology may lead to impaired gas exchange and increase the risk of pneumonia and respiratory failure.8 Rib fractures are associated with a significant mortality rate ranging from 3% to 13% and up to 20% in elderly patients.8,9 Although rib fractures are a marker of injury severity and rarely the proximate cause of death, there are a group of patients with isolated thoracic injury that are also at risk of morbidity and mortality directly related to rib fractures. This is especially true in the elderly, who poorly tolerate the subsequent respiratory failure and pneumonia.10 Mortality in young patients with rib fractures is generally attributed to associated injuries.

There is strong evidence that elderly patients, usually defined as 65 and older, have worse outcomes and a higher mortality rate compared with younger patients with isolated thoracic trauma.
There is, however, evolving evidence to suggest the inflection point for adverse outcomes starts at a younger age.\(^{11-22}\) Despite this, current clinical guidelines for management of patients with rib fractures mainly include age 65 and older as a trigger for increased level of care in patients with rib fractures.\(^{23,24}\)

The care of trauma patients in New Zealand poses certain unique challenges. New Zealand is geographically diverse and patients often travel large distances to access care. There are high rates of co-morbidity, including obesity and diabetes, and significant inequities in care and outcomes for Māori, Pacific Islanders and low-income populations.\(^{25-27}\) A large proportion of trauma care for patients in New Zealand occurs outside of major trauma centres: this is a key difference to much of the published literature on rib fractures, which is predominantly based on studies from large trauma centres.\(^{28}\) There are no previous studies in New Zealand that have addressed age and its association with outcomes in patients with rib fractures.

The aim of this study was to explore the effect of age on outcomes in patients with rib fractures in Northland, New Zealand.

**Methods**

A retrospective study was performed of patients admitted to all hospitals in Northland District Health Board (NDHB) between 1 January 2018 and 31 December 2019. NDHB includes Whangārei Hospital, Dargaville Hospital, Kaitaia Hospital, Bay of Island Hospital and Rawene Hospital. Data were collected from the NDHB’s data warehouse, which was searched to identify patients admitted with rib fractures. Inclusion criteria were patients aged 16 and older with one or more radiologically proven rib fractures sustained secondary to blunt trauma. Exclusion criteria were delayed presentation >48 hours after injury, penetrating trauma, intubation for reason other than thoracic trauma, injury as a result of cardiopulmonary resuscitation or an Abbreviated Injury Scale score >2 in the head or abdomen to remove the impact of polytrauma on management and outcomes of rib fractures.\(^{28}\) Radiological confirmation of a rib fracture was based on a consultant radiologist’s report of either a computer tomography scan or a chest x-ray. NDHB’s electronic medical records were accessed to review injury characteristics, hospital management and outcomes. Number of rib fractures and associated injuries were collected from consultant radiology reports and electronic records. Injury Severity Score (ISS) and Trauma and Injury Severity Score (TRISS) were retrospectively calculated where possible from radiology reports and clinical notes.\(^{30,31}\) Hospital discharge summaries and representation notes were reviewed to determine rates of complications. Patients were followed for six months after their index admission.

The primary outcomes of interest were rates of complications associated with rib fractures and length of stay (LOS). The secondary outcomes of interest were mortality, intensive care unit (ICU) admission rates and rates of intubation.

Data were entered into IBM SPSS for analysis. Median and interquartile range (IQR) were calculated for number of rib fractures, LOS, TRISS and ISS. Non-parametric data were tested with a Mann-Whitney U test. Nominal data was tested using a Chi-square or Fischer’s exact test.

This study was deemed out of scope by the New Zealand Health and Disability Ethics Committee. Locality approval was gained from NDHB and the project guidance was given by a representative from the Northland Māori Health Directorate.

**Results**

**Demographics**

One hundred and seventy patients who met study criteria were identified. Fifty-two (31%) were female and 118 (69%) were male. One hundred and four (61%) were New Zealand European, 49 (29%) were Māori and 17 (10%) were other ethnicities. Median age was 60 (IQR 21). The study population was stratified by age into three groups: 59 patients (35%) were >65 years old, 77 (45%) were aged 45 to 65 and 34 (20%) were aged <45. Demographic difference between groups is outlined in Table 1. The difference found between ethnicities was expected and aligned with ethnicity-specific age structures.\(^{32}\) The incidence was calculated at 75/100,000 people per year based on the 2018 Northland census data.\(^{32}\)
Injury characteristics

The injury characteristics are outlined in Table 2. The mechanism of injury was significantly different between groups. Road traffic crash (RTC) was the most common mechanism in patients <45 and 45–65, and a fall from height <2m was the most common mechanism in patients >65. Patients aged <45 sustained more severe injuries, evidenced by significantly more severe ISS and TRISS and higher rates of pulmonary contusions, pneumothoraces and clavicular fractures. There was a significant difference in number of flail segments between groups, with the highest rate in patients aged 45–65, and a significant difference in the number of patients with bilateral rib fractures, with the highest rates in patients aged >65.

Hospital management

Hospital management is outlined in Table 3. A significant difference in the admitting services was found between groups, with 20% of patients aged >65 admitted to general medicine. Regional block use, paracetamol use and placement of a chest drain and rib plating was similar across groups. There was a significantly higher rate of patient-controlled analgesia (PCA) and ketamine use in patients aged 45–65 and significantly less use of non-steroidal anti-inflammatory drugs (NSAIDs) in patients >65.

Primary and secondary outcomes

The primary and secondary outcomes are outlined in Table 4. Patients aged <45 had a significantly shorter LOS and significantly lower rates of pneumonia compared to patients aged 45 and older. There was no difference seen between groups in rates of intubation, ICU admission, mortality, empyema or acute respiratory distress syndrome (ARDS).

Discussion

This study shows increased rates of pneumonia and a longer LOS in patients aged 45 and older, despite their lower overall injury severity when compared to patients under 45. Patients aged 45–64 showed a LOS and rate of pneumonia similar to patients aged 65 and older, adding evidence to the growing literature that suggests increased complications after age 45.

Management guidelines for patients with rib fractures often include age 65 and older as a trigger for increased level of care.23,24 Although the literature points to age as a continuous variable with respect to risk, it is still often necessary to choose an age cut-off for the purpose of patient decision-making and clinical guidelines. This study adds to the literature suggesting a younger age should be considered in these clinical guidelines, given patients over age 45 have outcomes more closely aligned with patients over age 65, rather than those aged <45. This is highlighted in this study by pneumonia rates of 23% and 19% in patients aged 45–65 and >65 respectively, compared with 3% in patients aged <45.

Multiple studies from trauma centres have examined the relationship between age and outcomes in patients with rib fractures. Different age cut-offs have been used, including ages 45, 50, 60, 65 and 70.11–22 There is strong evidence that patients aged 65 and older have higher mortality rates and worse outcomes, with growing evidence to suggest adverse outcomes starts at a

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**Table 1: Demographics by age group.**

<table>
<thead>
<tr>
<th></th>
<th>&lt;45</th>
<th>45–65</th>
<th>&gt;65</th>
<th>Overall</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
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<td><strong>Ethnicity</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>NZ European</td>
<td>14(41%)</td>
<td>45(58%)</td>
<td>45(76%)</td>
<td>104(61%)</td>
<td>0.007</td>
</tr>
<tr>
<td>Māori</td>
<td>17(50%)</td>
<td>23(30%)</td>
<td>9(15%)</td>
<td>49(29%)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>3(9%)</td>
<td>9(12%)</td>
<td>5(8%)</td>
<td>17(10%)</td>
<td></td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.966</td>
</tr>
<tr>
<td>Male</td>
<td>23(68%)</td>
<td>54(70%)</td>
<td>41(69%)</td>
<td>118(69%)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>11(32%)</td>
<td>23(30%)</td>
<td>18(31%)</td>
<td>52(31%)</td>
<td></td>
</tr>
</tbody>
</table>
Table 2: Injury characteristics by age group.

<table>
<thead>
<tr>
<th></th>
<th>&lt;45</th>
<th>45–65</th>
<th>&gt;65</th>
<th>Overall</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mechanism</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall from height &lt;2m</td>
<td>0(0%)</td>
<td>13(17%)</td>
<td>28(47%)</td>
<td>41(24%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fall from height &gt;2m</td>
<td>1(3%)</td>
<td>7(9%)</td>
<td>4(7%)</td>
<td>12(7%)</td>
<td></td>
</tr>
<tr>
<td>RTC</td>
<td>31(91%)</td>
<td>41(53%)</td>
<td>24(41%)</td>
<td>96(56%)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>2(6%)</td>
<td>16(21%)</td>
<td>3(5%)</td>
<td>21(12%)</td>
<td></td>
</tr>
<tr>
<td><strong>Median number of rib fractures (IQR)</strong></td>
<td>4 (4)</td>
<td>5 (6)</td>
<td>4 (4)</td>
<td>5 (5)</td>
<td>0.524</td>
</tr>
<tr>
<td><strong>Flail segment</strong></td>
<td>2(6%)</td>
<td>17(22%)</td>
<td>6(10%)</td>
<td>25(15%)</td>
<td>0.04</td>
</tr>
<tr>
<td><strong>Bilateral rib fractures</strong></td>
<td>4(12%)</td>
<td>6(8%)</td>
<td>15(25%)</td>
<td>25(15%)</td>
<td>0.014</td>
</tr>
<tr>
<td><strong>Pulmonary contusion</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unilateral</td>
<td>15(44%)</td>
<td>24(31%)</td>
<td>7(12%)</td>
<td>46(27%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Bilateral</td>
<td>7(21%)</td>
<td>7(9%)</td>
<td>4(7%)</td>
<td>18(11%)</td>
<td></td>
</tr>
<tr>
<td><strong>Haemothorax</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.781</td>
</tr>
<tr>
<td>Unilateral</td>
<td>6(18%)</td>
<td>15(19%)</td>
<td>8(14%)</td>
<td>29(17%)</td>
<td></td>
</tr>
<tr>
<td>Bilateral</td>
<td>0(0%)</td>
<td>1(1%)</td>
<td>0(0%)</td>
<td>1(1%)</td>
<td></td>
</tr>
<tr>
<td><strong>Pneumothorax</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.037</td>
</tr>
<tr>
<td>Unilateral</td>
<td>15(44%)</td>
<td>31(40%)</td>
<td>12(20%)</td>
<td>58(34%)</td>
<td></td>
</tr>
<tr>
<td>Bilateral</td>
<td>0(0%)</td>
<td>1(1%)</td>
<td>1(2%)</td>
<td>2(1%)</td>
<td></td>
</tr>
<tr>
<td><strong>Scapula fracture</strong></td>
<td>5(15%)</td>
<td>11(14%)</td>
<td>3(5%)</td>
<td>19(11%)</td>
<td>0.177</td>
</tr>
<tr>
<td><strong>Clavicular fracture</strong></td>
<td>8(24%)</td>
<td>15(19%)</td>
<td>2(3%)</td>
<td>25(15%)</td>
<td>0.004</td>
</tr>
<tr>
<td><strong>First rib fracture</strong></td>
<td>5(15%)</td>
<td>8(10%)</td>
<td>5(8%)</td>
<td>17(11%)</td>
<td>0.641</td>
</tr>
<tr>
<td><strong>Sternomanubrial fracture</strong></td>
<td>3(9%)</td>
<td>9(12%)</td>
<td>11(19%)</td>
<td>23(14%)</td>
<td>0.414</td>
</tr>
<tr>
<td><strong>Median ISS (IQR)</strong></td>
<td>13 (8)</td>
<td>10 (5)</td>
<td>9 (4)</td>
<td>10 (5)</td>
<td>0.047</td>
</tr>
<tr>
<td><strong>Median TRISS (IQR)</strong></td>
<td>0.991 (0.01)</td>
<td>0.968 (0.08)</td>
<td>0.968 (0.05)</td>
<td>0.968 (0.03)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Table 3: Hospital management by age group.

<table>
<thead>
<tr>
<th></th>
<th>&lt;45</th>
<th>45–65</th>
<th>&gt;65</th>
<th>Overall</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admitting team</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>General medicine</td>
<td>0(0%)</td>
<td>1(1%)</td>
<td>12(20%)</td>
<td>13(8%)</td>
<td></td>
</tr>
<tr>
<td>General surgery</td>
<td>28(82%)</td>
<td>69(90%)</td>
<td>40(68%)</td>
<td>137(81%)</td>
<td></td>
</tr>
<tr>
<td>Orthopaedics</td>
<td>6(18%)</td>
<td>7(9%)</td>
<td>6(10%)</td>
<td>19(11%)</td>
<td></td>
</tr>
<tr>
<td>Urology</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>1(2%)</td>
<td>1(1%)</td>
<td></td>
</tr>
<tr>
<td>Regional blocks</td>
<td>3(9%)</td>
<td>14(18%)</td>
<td>10(17%)</td>
<td>27(16%)</td>
<td>0.444</td>
</tr>
<tr>
<td>PCA</td>
<td>19(56%)</td>
<td>60(78%)</td>
<td>32(54%)</td>
<td>111(65%)</td>
<td>0.007</td>
</tr>
<tr>
<td>NCA</td>
<td>0(0%)</td>
<td>1(1%)</td>
<td>0(0%)</td>
<td>1(1%)</td>
<td>0.288</td>
</tr>
<tr>
<td>Ketamine</td>
<td>6(18%)</td>
<td>24(31%)</td>
<td>6(10%)</td>
<td>36(21%)</td>
<td>0.01</td>
</tr>
<tr>
<td>Paracetamol</td>
<td>30(88%)</td>
<td>69(90%)</td>
<td>51(86%)</td>
<td>150(88%)</td>
<td>0.462</td>
</tr>
<tr>
<td>NSAIDs</td>
<td>23(68%)</td>
<td>53(69%)</td>
<td>20(34%)</td>
<td>96(56%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Chest drain</td>
<td>7(21%)</td>
<td>18(23%)</td>
<td>6(10%)</td>
<td>31(18%)</td>
<td>0.073</td>
</tr>
<tr>
<td>Rib plating</td>
<td>0(0%)</td>
<td>3(4%)</td>
<td>0(0%)</td>
<td>3(2%)</td>
<td>0.098</td>
</tr>
</tbody>
</table>

Table 4: Outcomes by age group.

<table>
<thead>
<tr>
<th></th>
<th>&lt;45</th>
<th>45–65</th>
<th>&gt;65</th>
<th>Overall</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median LOS (IQR)</td>
<td>3 (4)</td>
<td>4 (4)</td>
<td>4 (9)</td>
<td>4 (6)</td>
<td>0.045</td>
</tr>
<tr>
<td>60-day Mortality</td>
<td>0(0%)</td>
<td>2(3%)</td>
<td>2(3%)</td>
<td>4(2%)</td>
<td>0.573</td>
</tr>
<tr>
<td>ICU admission</td>
<td>2(6%)</td>
<td>10(13%)</td>
<td>4(7%)</td>
<td>16(9%)</td>
<td>0.345</td>
</tr>
<tr>
<td>Intubation</td>
<td>0(0%)</td>
<td>3(4%)</td>
<td>1(2%)</td>
<td>4(2%)</td>
<td>0.542</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>1(3%)</td>
<td>18(23%)</td>
<td>11(19%)</td>
<td>30(18%)</td>
<td>0.033</td>
</tr>
<tr>
<td>Empyema</td>
<td>0(0%)</td>
<td>1(1%)</td>
<td>0(0%)</td>
<td>4(2%)</td>
<td>1</td>
</tr>
<tr>
<td>ARDS</td>
<td>0(0%)</td>
<td>1(1%)</td>
<td>0(0%)</td>
<td>1(1%)</td>
<td>1</td>
</tr>
</tbody>
</table>
younger age. Two large retrospective studies have concordant results: both showed stepwise increases in morbidity and mortality in patients aged 45 and older compared to patients aged <45. Two small single institution studies, similar to this study, have investigated adverse outcomes starting at a younger age with an age cut-off of 45. The findings are in line with this study, which has shown increased morbidity, in the form of respiratory complications, in patients aged 45 and older.

The mortality rate of 2% found in this study is similar to that of other studies also focused on isolated thoracic trauma. Rib fracture mortality is consistently quoted in the literature as ranging from 3–20%. However, this high mortality rate is largely due to associated injuries, with rib fractures being a marker of injury severity rather than the proximate cause of death. The low mortality rate in this study is therefore likely due to the exclusion of patients with major head or abdominal injuries. The high rates of pneumonia in this study are also in line with literature reporting rates ranging from 6–31% in patients with rib fractures.

This study is limited by its sample size and retrospective methodology. The relatively small sample size potentially obscures clinically relevant, significant differences in parameters that are known to have low rates between groups, including a difference in mortality found in studies with greater power. However, the sample is contemporary and all patients were individually reviewed with a reasonable follow-up time allowed. The results of this study are in line with recent publications and add further evidence to the growing body of work that suggests a younger inflection point for adverse outcomes. It is likely that these findings are generalisable to a large number of provincial centres throughout New Zealand. Larger prospective studies are needed to confirm these findings, but consideration should be given to using local data to drive changes in guidelines if needed.

**Conclusion**

This study found higher rates of pneumonia and an increased LOS in patients aged 45 and older despite their lower overall injury severity when compared to patients under the age of 45. Patient aged 45–64 had outcomes similar to patients aged >65, in keeping with literature that suggests adverse outcomes increase in patients aged 45 and older. Future clinical pathways and guidelines for patients with rib fractures should consider incorporating a younger age than 65 in risk stratification algorithms.
Competing interests:
Nil.

Author information:
Matthew J McGuinness: MBChB; General Surgical Registrar, Department of General Surgery, Northland District Health Board.
Liam Ryan Ferguson: Medical student, University of Auckland.
Imogen Watt: Medical student, University of Auckland.
Christopher Harmston: FRCS(Eng), FRACS; Consultant Colorectal and General Surgeon, Department of General Surgery, Northland District Health Board; Honorary Associate Professor, University of Auckland.

Corresponding author:
Matthew J McGuinness, Department of General Surgery, Whangārei Hospital, Manu Road, Whangarei 0148, New Zealand
Matt@McGuinness.net.nz

REFERENCES


A comparison of major trauma admissions to Christchurch Hospital during and after COVID-19 lockdown in New Zealand

Dali Fan, Hannah Scowcroft, Andrew McCombie, Ruth Duncan, Christopher Wakeman

ABSTRACT

AIMS: To describe any change in the volume and mechanisms of injury of major trauma admissions during and after COVID-19 lockdown, and in doing so, to provide information for resource planning and identification of priority areas for injury prevention initiatives.

METHODS: A retrospective, descriptive study conducted on Canterbury District Health Board trauma registry data. The study population consisted of all major trauma patients of all age groups admitted to Christchurch Hospital over three 33-day periods: before, during and after COVID-19 lockdown in New Zealand. Broadly speaking, major trauma is defined as having an injury severity score ≥13 or death following injury.

RESULTS: There was a 42% reduction in the volume of major trauma admissions during lockdown. Falls were the most common injury during lockdown, and transport-related injuries after lockdown. Alcohol intoxication was associated with 19 to 33% of all injuries across the study periods.

CONCLUSION: Major trauma inevitably occurred during lockdown, although at considerably lower volumes. After lockdown, once restrictions were eased, major trauma admissions reverted to pre-lockdown patterns. Injury prevention strategies can reduce avoidable pressures on hospitals at a time of pandemic. In New Zealand, focus should be placed on reducing alcohol- and transport-related injuries and increasing community awareness on falls prevention.

In 2020, the coronavirus disease 2019 (COVID-19) pandemic managed to overwhelm many healthcare systems worldwide. Although such a catastrophe has so far been avoided in New Zealand, largely due to stringent and timely public health measures, the trajectory of the ongoing pandemic is difficult to predict. In view of this, repurposing of health resources has been necessary in order to reduce the potential morbidity and mortality associated with the virus.

However, amid the influx of COVID-19 patients, injuries will continue to occur in the community and trauma patients will continue to arrive at the hospital. While it is imperative to maintain the highest level of care for trauma patients to reduce complications, this may impact on the availability of resources such as ventilators and hospital beds for the severely unwell COVID-19 patients. In this complex setting, especially in the event of significant resource constraints, clinicians will have to consider the needs of trauma and COVID-19 patients while ensuring that critical resources are preserved as far as possible.

On 25 March 2020 at 11.59pm, the New Zealand government commenced a nationwide alert level 4 lockdown (Figure 1). In this unprecedented event, people were instructed to stay at home (in their ‘bubble’—with members of the same household) and remain local if exercising or accessing essential services. Public health experts highlighted the need to
reduce avoidable pressures on hospitals in order to achieve better resilience for the health system in the face of COVID-19. In particular, emphasis was placed on reducing preventable injuries, including those caused by home accidents, alcohol intoxication and transport-related injuries. Given the novelty of the situation, there is limited evidence examining the pattern of trauma admissions in times of nationwide lockdown and restrictions on movements and activities. Therefore, the demand for trauma services, and the subsequent impact on scarce hospital resources, was difficult to predict.

This study was conducted with the primary aim of assessing the change in volume and mechanisms of injury of trauma admissions during and after lockdown, with a specific focus on major trauma; and secondarily, to provide information for resource planning and identification of priority areas for injury prevention initiatives.

Methods

A retrospective, descriptive study was conducted on Canterbury District Health Board (CDHB) trauma registry data. Information for the CDHB registry is collected by dedicated trauma nurses at the time of case presentation for contribution to the New Zealand Major Trauma Registry (NZ-MTR). The study population consisted of all patients of all age groups admitted to Christchurch Hospital with major trauma before, during and after alert level 4 lockdown (22 February 2020 to 30 May 2020). The three study groups consisted of major trauma admissions in the 33 days pre-lockdown (which acted as the principal comparison period), during lockdown (a total of 33 days) and in the first 33 days post-lockdown.

Major trauma was defined as having an injury severity score (ISS) ≥13 or death following injury, with a focus on intra-hospital mortality. The ISS is a scoring system used to assess trauma severity. It is derived from the Abbreviated Injury Scale (AIS), an internationally used anatomical scoring system that classifies injuries in body regions on a scale from 1 (minor) to 6 (maximal or non-treatable). Patients excluded from the CDHB major trauma registry are those with ISS <13 (non-major injury), delayed admissions more than seven days after injury and admissions for drownings, hangings, poisoning, medical and other surgical emergencies and complicated births. Pre-hospital deaths are also excluded. These exclusions align with criteria used by the NZ-MTR. Terms for mechanisms and places of injury were consistent with those used in the annual reports of the New Zealand National Trauma Network. Falls were further subcategorised into low falls (≤1 metre in height), high falls (>1 metre in height) and falling down stairs (Table 3). Car, motorcycle, pedal cycle, E-scooter, pedestrian and quad bike were grouped into transport-related injuries (including on-road and off-road causes). Alcohol intoxication was defined as either strong clinician suspicion of intoxication and/or a documented blood alcohol level (BAL) greater than the legal driving limit (50mg/100mL) at the time of emergency department (ED) presentation. Outdoor places of injury included public reserves/parks and outdoor sports area (Table 4). Places of injury by urban/rural descriptors were determined using the domicile code where the injury event occurred.

De-identified data were extracted from the CDHB trauma registry and included patient demographics (sex and age), date of ED presentation, ISS, mechanism of injury, place of injury and alcohol intoxication status. Data were compiled and categorised on Excel (Microsoft, version 16.24) and analysed on R. Statistical analysis of associations between patient demographics and admission volumes, mechanisms of injury and places of injury were performed using Chi-squared tests. Ethical approval was granted by the University of Otago Human Ethics Committee (reference number HD20/054).

Results

Patient demographics and admission volumes

Over the entire study period, a total of 83 patients were admitted with major trauma: 36 in the 33 days pre-lockdown, 21 during lockdown (a total of 33 days) and 26 post-lockdown. The first 33 days post-lockdown
is comprised of 16 days in alert level 3 and 17 days in level 2 (Table 1). There was no significant difference in ISS noted between the study periods.

During lockdown, there was a 42% overall reduction in the number of major trauma admissions. Reductions were observed in all subgroups, except in females (no change). The most marked reductions occurred in those under 25 years of age (66% reduction) and males (47% reduction). Post-lockdown, the daily average admissions during level 3 was 0.63/day, which is comparable to 0.64/day during lockdown; and during level 2, the average was 0.94/day, an increase from level 3, albeit still less than 1.09/day pre-lockdown.

Admission volumes were compared with the corresponding time periods in 2018 (Table 2). This showed a noticeable reduction in admissions during lockdown and level 3, although there was a slight increase during level 2. Data from 2019 were not included for comparison due to the Christchurch Mosque Shootings on 15 March 2019.

Mechanisms of injury
Pre-lockdown, major trauma admissions were most commonly due to transport-related injuries and falls, which accounted for 50% (n=18) and 31% (n=11) of overall admissions, respectively (Table 3). During lockdown, this was reversed. Falls were the most common injury, accounting for 48% (n=10) of overall admissions, followed by transport-related injuries, which accounted for 38% (n=8). Post-lockdown, transport-related injuries became increasingly more common from level 3 to 2, accounting for 40% (n=4) and 50% (n=8) of admissions in their respective periods. Falls, on the other hand, remained relatively stable, accounting for 30% (n=3) of admissions in level 3 and 31% (n=5) in level 2.

Low falls were the most common type of fall in the pre-lockdown period (n=7). During lockdown, there was an increase in the number of high falls (n=5) compared to pre-lockdown (n=3). High falls occurred in a variety of situations, including falling from ladders, balconies, roofs, trees and construction areas. During level 2, falling

<table>
<thead>
<tr>
<th>Level ONE PREPARE</th>
<th>Level TWO REDUCE</th>
<th>Level THREE RESTRICT</th>
<th>Level FOUR ELIMINATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>COVID-19 is contained in NZ but not overseas</td>
<td>Disease contained, but risk of transmission remains</td>
<td>Risk that disease is not contained</td>
<td>Likely that disease is not contained</td>
</tr>
<tr>
<td>Border entry measures to minimise risk of importing COVID-19 cases</td>
<td>Domestic travel permitted</td>
<td>People to stay at home other than for essential personal movement</td>
<td>People to stay at home other than for essential personal movement</td>
</tr>
<tr>
<td>Intensive testing</td>
<td>No more than 100 people at gatherings</td>
<td>Low risk local recreation activities are allowed</td>
<td>Low risk local recreation activities are allowed</td>
</tr>
<tr>
<td>No restrictions on gatherings and domestic travel</td>
<td>Public venues, businesses and event facilities can open</td>
<td>Gatherings of up to 10 people are allowed for very selected occasions</td>
<td>Gatherings of up to 10 people are allowed for very selected occasions</td>
</tr>
<tr>
<td>Schools and workplaces open but must operate safely</td>
<td>Schools and education services can resume</td>
<td>Schools and early childhood education centres can safely open but will have limited capacity</td>
<td>Schools and early childhood education centres can safely open but will have limited capacity</td>
</tr>
<tr>
<td>Physical distancing encouraged</td>
<td>Sports and recreation are allowed</td>
<td>Businesses can open premises, but cannot physically interact with customers</td>
<td>Businesses can open premises, but cannot physically interact with customers</td>
</tr>
<tr>
<td>Stay home if unwell</td>
<td>All of the above must be in accordance with appropriate public health measures</td>
<td>Work must be from home unless it is not possible</td>
<td>Work must be from home unless it is not possible</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Public venues remain closed</td>
<td>Public venues remain closed</td>
</tr>
</tbody>
</table>

Figure 1: New Zealand COVID-19 alert levels.
Table 1: Pre-, during and post-lockdown period major trauma admission volumes at Christchurch Hospital (date range represent 2020 ED presentation dates).

<table>
<thead>
<tr>
<th>Overall</th>
<th>Pre-lockdown (22/02 to 25/03)</th>
<th>During level 4 lockdown (26/03 to 27/04)</th>
<th>% Change pre- vs during lockdown</th>
<th>Post-lockdown</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>33</td>
<td>33</td>
<td>n/a</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Number of admissions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>36</td>
<td>21</td>
<td>-42%</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Daily average admissions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.09/day</td>
<td>0.64/day</td>
<td></td>
<td>0.63/day</td>
<td>0.94/day</td>
</tr>
<tr>
<td>ISS</td>
<td>Mean ISS (± SD)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>21 (±9.1)</td>
<td>22 (± 6.1)</td>
<td></td>
<td>17 (±3.1)</td>
<td>19 (±7.5)</td>
</tr>
<tr>
<td>Sex</td>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>17</td>
<td>-47%</td>
<td>9</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>4</td>
<td>0%</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Age group</td>
<td>&lt; 25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1</td>
<td>-66%</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>25–65</td>
<td>24</td>
<td>-42%</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>65+</td>
<td>9</td>
<td>-33%</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Mean age (± SD)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>51 (± 21)</td>
<td>54 (±20)</td>
<td></td>
<td>49 (±20)</td>
<td>61 (±15)</td>
</tr>
</tbody>
</table>

ISS: injury severity score. SD: standard deviation.
*Chi-squared test for goodness of fit. **One-way ANOVA. ***Fisher’s exact test.

Table 2: Comparison of major trauma admission volume for same time periods in 2018 and 2020.

<table>
<thead>
<tr>
<th>Time period</th>
<th>2018 (n)</th>
<th>2020 (n)</th>
<th>% change</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>22/02 to 25/03</td>
<td>39</td>
<td>36</td>
<td>-7.7%</td>
<td>0.22*</td>
</tr>
<tr>
<td>26/03 to 27/04</td>
<td>36</td>
<td>21</td>
<td>-42%</td>
<td></td>
</tr>
<tr>
<td>28/04 to 13/05</td>
<td>21</td>
<td>10</td>
<td>-52%</td>
<td></td>
</tr>
<tr>
<td>14/05 to 30/05</td>
<td>14</td>
<td>16</td>
<td>+14%</td>
<td></td>
</tr>
</tbody>
</table>

Data from 2019 were not included for comparison due to the Christchurch Mosque Shootings in the month of March.
$n$: number of major trauma admissions.
*Chi-squared test for independence.
downstairs was the most common \((n=4)\), and two of these four cases were related to alcohol intoxication.

Car and motorcycle formed the bulk of transported-related injuries across all periods. Apart from pedal cycle, there was a decrease in all types of transport-related injuries during lockdown.

Aside from mechanisms of injury, injuries associated with alcohol intoxication contributed to 25% \((n=9)\) of admissions pre-lockdown, 33% \((n=7)\) during lockdown and 19% \((n=5)\) post-lockdown with levels 3 and 2 combined (Table 3). Overall, 63% \((n=52)\) of total admissions across the entire study period had a BAL recorded on arrival into hospital. The cases marked ‘unknown’ (Table 3) had neither a BAL or clinician suspicion of alcohol intoxication documented on admission.

**Table 3:** Pre-, during and post-lockdown period major trauma admission volumes at Christchurch Hospital grouped by mechanism of injury and alcohol intoxication (date range represents 2020 ED presentation dates).

<table>
<thead>
<tr>
<th></th>
<th>Pre-lockdown (22/02 to 25/03)</th>
<th>During level 4 lockdown (26/03 to 27/04)</th>
<th>Post-lockdown Level 3 (28/04 to 13/05)</th>
<th>Post-lockdown Level 2 (14/05 to 30/05)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of admissions</td>
<td>36</td>
<td>21</td>
<td>10</td>
<td>16</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Mechanism of injury</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Falls</td>
<td>11</td>
<td>10</td>
<td>3</td>
<td>5</td>
<td>n/a</td>
</tr>
<tr>
<td>Low falls</td>
<td>7</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>High falls</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Down stairs</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Transport-related injuries</td>
<td>18</td>
<td>8</td>
<td>4</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Car</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>4</td>
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<tr>
<td>Motorcycle</td>
<td>6</td>
<td>3</td>
<td>0</td>
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<tr>
<td>Pedal cycle</td>
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<td>E-scooter</td>
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</tr>
<tr>
<td>Pedestrian</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Quad bike</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Other§</td>
<td>7</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><strong>Alcohol intoxication</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.90*</td>
</tr>
<tr>
<td>Yes</td>
<td>9</td>
<td>7</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>15</td>
<td>8</td>
<td>3</td>
<td>7</td>
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<tr>
<td>Unknown</td>
<td>12</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

\(\dagger\) Falls is the sum of the low falls, high falls and falling down stairs.

\(\ddagger\) Transport-related injuries is the sum of car, motorcycle, pedal cycle, E-scooter, pedestrian and quad bike injuries

\(§\) Other includes crush, assault, sports-related injuries and deliberate self-harm.

\(||\) Alcohol intoxication is defined as either strong clinician suspicion of intoxication and/or documented BAL is greater than the legal driving limit (50mg/100mL) at the time of ED presentation.

\(*\) Chi-squared test for independence.
Place of injury

The most common places of injury across all periods were on the road and at home (Table 4). During lockdown, a reduction in the volume of admissions from all places of injury was observed, except the footpath, where there was an increase from two to three cases. The most considerable reductions occurred on the road and outdoors, both of which had five fewer cases.

Post-lockdown, specifically during level 2, eight out of 16 admissions were due to road injuries. This represented an appreciable increase in the proportion of admissions attributed to road injuries relative to that observed in any other period.

When place of injury was assessed by urban/rural descriptors, the most marked reductions during lockdown were observed in rural areas (nine cases less) (Table 4). Six out of the 12 cases in rural areas pre-lockdown were transport-related injuries. During lockdown, all rural cases were transport-related, as were one of the two cases in level 3 and three of the four cases in level 2.

Discussion

This study assessed the changes in the volume and mechanisms of injury of major trauma admissions to Christchurch Hospital during and after alert level 4 lockdown in New Zealand. The study revealed a 42% overall reduction in major trauma admissions during lockdown. Falls were the most common injury during lockdown, and transport-related injuries post-lockdown. Patterns in major trauma admissions trended towards pre-lockdown levels from level 2 onwards.

In this study, several themes emerged. During lockdown, the greatest reduction in admission volumes was seen in the young age groups and in males. Presumably the non-elderly population were more likely to be on the road, at work, playing sports

Table 4: Pre-, during and post-lockdown period major trauma admission volumes at Christchurch Hospital grouped by place of injury and urban/rural descriptor (date range represents 2020 ED presentation dates).

<table>
<thead>
<tr>
<th></th>
<th>Pre-lockdown (22/02 to 25/03)</th>
<th>During level 4 lockdown (26/03 to 27/04)</th>
<th>Post-lockdown Level 3 (28/04 to 13/05)</th>
<th>Post-lockdown Level 2 (14/05 to 30/05)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of admissions</td>
<td>36</td>
<td>21</td>
<td>10</td>
<td>16</td>
<td>n/a</td>
</tr>
<tr>
<td>Place of Injury</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home</td>
<td>10</td>
<td>6</td>
<td>2</td>
<td>5</td>
<td>n/a</td>
</tr>
<tr>
<td>Road</td>
<td>14</td>
<td>9</td>
<td>4</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Footpath</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Outdoors†</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Other‡</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Place of injury by urban/rural Descriptor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metropolitan (≥100,000)</td>
<td>11</td>
<td>11</td>
<td>2</td>
<td>5</td>
<td>n/a</td>
</tr>
<tr>
<td>Regional (1,000 to 99,999)</td>
<td>10</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Rural settlements and other</td>
<td>12</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

† Outdoors includes public reserve/park and outdoor sports area.
‡ Other includes farm, trade/service area and construction/industrial area.
or engaging in high-risk activities before lockdown. The discrepancy in male and female trauma admissions is not unexpected. In the 2018–2019 annual report by the New Zealand National Trauma Network, 73% of the trauma caseload were males. The reason for this discrepancy is likely multifactorial. For instance, higher rates of male employment in occupations that are at increased risk of workplace injuries (including forestry, fishing and construction) and more time spent on average participating in sports; or this discrepancy may reflect males having an increased intrinsic willingness to engage in risk-taking behaviours. Post-lockdown, admission volumes, as indicated by daily average admissions, began to increase only from level 2 onwards. This was somewhat anticipated, as restrictions in level 3 were similar to those during lockdown. Unsurprisingly, admissions due to transport-related injuries fell during lockdown, as may be expected with any decline in road usage secondary to severe travel restrictions. Conversely, admissions due to transport-related injuries increased post-lockdown, particularly from level 2 onwards, when travel restrictions eased and school and workplaces re-opened. Interestingly, the number of admissions due to falls remained largely unchanged during lockdown, despite an overall reduction in admission volumes when compared with the pre-lockdown period. This may be explained by community risk factors for falls that persist even in the presence of lockdown conditions: for instance, elderly age and comorbidities associated with low falls, and alcohol intoxication contributing to overall falls. High falls increased slightly during lockdown. Most of these injuries resulted from falling from ladders and trees in the home environment, possibly related to do-it-yourself (DIY) activities.

It is noteworthy that 33% of all injuries leading to major trauma admissions during lockdown were associated with alcohol intoxication—an appreciable increase from the 25% pre-lockdown. In the post-lockdown period, this was 19%. The increase during lockdown may be explained by an increase in alcohol consumption. An online survey by the New Zealand Health Promotion Agency showed that, of 1,190 respondents, 20% increased their alcohol consumption during lockdown, citing stress, boredom and anxiety as key driving factors. Of relevance, a number of admissions across all periods were marked ‘unknown’, as no alcohol intoxication status was documented on presentation. Therefore, the actual percentages could be even higher. These findings are consistent with previous research that has demonstrated between 18 to 35% of injury-based ED presentations are alcohol-related. Moreover, these findings highlight an ongoing issue: that even during a pandemic, one constant for our already overloaded health system is the avoidable burden created by alcohol-related injuries.

In terms of place of injury, the greatest reductions during lockdown occurred on the road and outdoors, in keeping with restrictions on non-essential movements. On the other hand, there was a small increase in the number of injuries on the footpath, as may be expected under lockdown conditions, when walking and running locally are permitted as forms of exercise. Encouragingly, despite the huge increase in time spent at home by individuals, the number of home injuries during lockdown fell, suggesting that the general public were being more mindful of the potential for injury. In level 2 post-lockdown, there was an increase in the proportion of admissions due to road injuries compared to all other periods. This may be explained, at least in part, by level 2 coinciding with the Queen's Birthday long weekend, and possibly an element of compensatory behaviour as people sought domestic ‘getaways’ following weeks of travel restrictions.

Furthermore, when assessing place of injury by urban/rural descriptors, there was a substantial reduction in injuries from rural areas during lockdown. This paralleled the reduction in transport-related injuries, a finding consistent with previous New Zealand statistics, which show rural residents typically have higher rates of transport-related trauma than urban residents. The findings of this study are comparable to those of Christey et al, who reported a 43% reduction in the volume of all injury-related admissions to Waikato Hospital during lockdown, particularly major injuries, with falls being the most common.
mechanism of injury. In their subsequent follow-up study, Christey et al.\textsuperscript{16} reported a “rebound” effect in trauma admissions when COVID-19 restrictions were eased, analogous to the post-lockdown findings observed in this study. In New Zealand and overseas, hospitals have generally reported substantial reductions in overall adult and paediatric trauma admissions during lockdown. Typically, transport-related injuries have reduced most significantly, with the number of falls being generally stable or not decreasing and more injuries occurring in the home environment.\textsuperscript{3–5,16–20}

To date, there is a paucity of evidence examining the pattern of trauma-related admissions in the COVID-19 post-lockdown period.\textsuperscript{16}

In addition to the above, anecdotal evidence from the Accident Compensation Corporation (ACC), New Zealand’s national accidental injury compensation entity, showed that overall claims for injury in the first week of lockdown were down about two thirds compared to the same week in the previous year. The injury with the most overall ACC claims was falls at home.\textsuperscript{21}

There are several limitations to this study. As a result of a single centre experience, as well as the limited timeframe of lockdown, the absolute number of patients included in the study is small. Data on ethnicity were not included, as no noticeable trends were identifiable to make meaningful comments. Likewise, the small population size precluded meaningful evaluation of mechanisms and places of injury in the context of other variables, such as age, sex and BAL. Furthermore, analysis of statistical significance could not be gained, especially not when involving a number of subgroups. Consequently, strong conclusions cannot be drawn. Ideally, future follow-up studies will include longer timeframes and larger patient numbers, perhaps by combining trauma registry data from multiple major trauma centres across New Zealand.

Despite the stated limitations, this study has contributed data to a growing field of literature. Importantly, this study has identified some key drivers of preventable injuries during and post-lockdown that are immediately amendable to policy changes, namely falls and alcohol- and transport-related injuries. Firstly, mass media campaigns on preventable home injuries may help. Particular emphasis should be placed on avoiding falls in the home environment. The importance of this has been acknowledged by ACC, which has released guidelines on ‘staying safe during bubble life’ that includes advice on reducing the risk of falls and injuries associated with DIY activities. Secondly, public health initiatives aimed at increasing awareness on the dangers of alcohol intoxication may promote responsible purchasing of alcohol, which was an essential item, along with food, during the COVID-19 pandemic. Such initiatives would highlight the general adverse effects of alcohol on health, the increased risk of respiratory complications for those who contract COVID-19, and the long-term sequelae of alcohol-related injuries. Additional alcohol strategies may include changing sales hours or setting a limit to maximum standard drinks per purchase in supermarkets. Lastly, lower speed tolerance and heavier policing may reduce transport-related injuries. Extra cautionary signs should be placed on roads in rural and smaller regional areas.

**Conclusion**

Major trauma of all age groups will inevitably occur during lockdowns, although at greatly reduced volumes. Post-lockdown, major trauma admissions reverted to pre-lockdown patterns once restrictions were eased. For resource planning, the resurgence in trauma admissions post-lockdown corresponded with the need to catch up on delayed healthcare appointments, putting a noticeable strain on hospitals in the Canterbury region. In terms of injury-prevention initiatives, the focus should be on reducing alcohol- and transport-related injuries, as well as increasing awareness of avoiding falls in the community. Every effort needs to be made to reduce avoidable stressors on hospitals if we are to achieve the best outcome for the greatest number of patients in the clinically challenging times ahead.
Competing interests:
Nil.

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Author information:
Dali Fan: House Officer, Canterbury District Health Board.
Hannah Scowcroft: Surgical Registrar, Canterbury District Health Board.
Andrew McCombie: Statistician, Canterbury District Health Board.
Ruth Duncan: Trauma Nurse Coordinator, Canterbury District Health Board.
Christopher Wakeman: Consultant General Surgeon, Canterbury District Health Board.

Corresponding author:
Dr Dali Fan, Department of Surgery, University of Otago, Christchurch, PO Box 4345, Christchurch 8140, New Zealand
dali.fan@cdhb.health.nz

URL:

REFERENCES
13. Humphrey G, Casswell


Nail gun injuries: not just an occupational hazard
Matthew J McGuinness, Gabrielle Thompson, Samuel Haysom, Ian Civil

ABSTRACT

INTRODUCTION: Nail guns are commonly used in the construction industry. They represent an occupational hazard, and in the context of mental illness can pose a threat to life.

AIM: To determine the number of patients admitted to Auckland City Hospital (ACH) with a nail gun injury, and to review the current New Zealand legislation surrounding nail guns.

METHODS: A 25-year retrospective review of patients admitted to ACH with a nail gun injury was performed by searching the ACH Trauma Registry. New Zealand legislation was reviewed.

RESULTS: Between 1994 and 2019, 45 patients were admitted to ACH with a nail gun injury. Two subgroups were identified: 31% with an intentional injury; 69% with an unintentional injury. All patients were male. The mean age was 36.3. Patients with an intentional injury had a higher mortality rate (21.4% vs 9.5%), Injury Severity Scores (24.2 vs 3.4) and ICU admission rate (50% vs 3%) and required more intensive post-injury care when compared to unintentional injuries. There is currently no legislation in New Zealand specifically governing the use of nail guns. Only powder-actuated nail guns require certification.

CONCLUSION: The continued occurrence of unintentional nail gun injuries and the high lethality of intentional injuries represent two distinct areas of concern. The Government should publish guidance aimed at improving safety and reducing the rate of intentional injury.

Nail guns are a ubiquitous tool in the construction industry. They have increased in popularity since their introduction in 1959 as they increase productivity and subsequently reduce costs.¹ As nail guns have become an essential construction tool, injuries associated with their use are being increasingly recognised.² The first nail gun injury was reported less than a year after their introduction.³ Since then a large and growing number of case reports and cases series have been published.⁴ Nail gun injuries can be divided into intentional and unintentional injuries. The majority of injuries are unintentional and associated with the construction industry. However, a significant number of injuries in consumers have also been reported.⁵,⁶ Users with little experience are at the highest risk of unintentional injury, highlighted by a study showing 45% of apprentice carpenters had sustained a nail gun injury in the past year.⁷ These injuries predominantly affect the extremities and less than 10% require hospital admission.⁸ Intentional nail gun injuries, although less common than unintentional injuries, are being reported in the literature with increasing frequency.⁹ Intentional injuries, which are often intracranial, are associated with a good prognosis compared to other intracranial penetrating injuries, due to the low velocity of the nails.¹⁰ Concern has been raised that the frequency of injuries is increasing as nail guns continue to become more powerful and more available to the public.¹¹,¹²

The aim of this study is to determine the number of patients admitted to Auckland City Hospital (ACH) with a nail gun injury and to understand the factors associated with these admissions. This study's secondary aim is to review the current Government guidance surrounding nail guns.

Methods

A 25-year retrospective review of patients admitted to ACH with a nail gun injury was performed. The ACH Trauma Registry database, established in 1994, was used to detect all patients admitted with a nail gun injury. The trauma department collects data prospectively on all admitted trauma patients. There were 38,021 patients in the database as of 31 December 2019.
The database was searched by injury description with the keyword's 'nail' and 'gun'. A retrospective review of the patients identified from this search was then performed to confirm inclusion of only patients admitted to ACH with a nail gun injury. Data prospectively collected in the database pertinent to this study include patients’ demographics, injuries, intention (self-inflicted, unintentional, inflicted by other or unknown), date of injury, location injury occurred, type of transport to hospital, trauma call activation, hospital admitting team, patient occupation, Injury Severity Scores, operations performed, ICU admission, length of stay, discharge destination and patient follow-up.

A second search was performed with the pre-determined registry coding ‘self-inflicted injury’ to determine the number of patients admitted following an intentional injury in the past 25 years. This search captured all patients admitted with an intentional injury, including patients with an injury cause by a nail gun, which allowed for comparison of intentional nail gun injuries with all other intentional injuries. Patient records were retrospectively reviewed and aspects relevant to the circumstances of injury, nature of injury, treatment and outcomes were collected.

Data were entered into IBM SPSS version 25 (Armonk, New York, USA) for analysis. Scale data were tested for normality with a Shapiro-Wilk test. Non-parametric data were tested with a Mann-Whitney U test. Parametrically distributed data were tested using a student t-test. Nominal data were tested using a Chi-squared or Fischer’s exact test. The null hypothesis was rejected if a p-value was <0.05.

New Zealand and Australian legal databases (Westlaw and LexisNexis Advance) and New Zealand legislation were searched to ascertain the law (case law, academic commentary, and legislation) regulating nail guns in New Zealand. The search was extended to include the WorkSafe New Zealand website, Hansard reports and finally Google Scholar for relevant coroners’ reports.

Results

Patient demographics

Forty-five patients were admitted to ACH with a nail gun injury between 1994 and 2019. Two distinct groups were identified: 31% (14) with intentional injuries and 69% (31) with an unintentional work-place injury. As evidenced in Table 1, there was no difference between groups in age

<table>
<thead>
<tr>
<th>Table 1: Patient demographics.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
<tr>
<td><strong>Age</strong></td>
</tr>
<tr>
<td>Median</td>
</tr>
<tr>
<td>IQR</td>
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<tr>
<td><strong>Ethnicity</strong></td>
</tr>
<tr>
<td>NZ European</td>
</tr>
<tr>
<td>Māori</td>
</tr>
<tr>
<td>Pacific Island</td>
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<tr>
<td><strong>Gender</strong></td>
</tr>
<tr>
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</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td><strong>Occupation</strong></td>
</tr>
<tr>
<td>Construction</td>
</tr>
<tr>
<td>Unknown</td>
</tr>
</tbody>
</table>
(P=0.228) or ethnicity (P=0.607). All patients were male and 91% were working in the construction industry.

Injury characteristics and admitting team

Table 2 shows unintentional injuries invariably happened at the worksite compared to the 29% of patients with an intentional injury. Home was the most common place for an intentional injury to happen. Eighty-five percent of intentional injuries were to the head, and 80% of unintentional injuries were to an extremity. Patients with an intentional injury were more likely to be admitted to neurosurgery (50%) and ICU (36%), whereas patients with an unintentional injury were primarily admitted to orthopaedics (74%) and the trauma service (16%).

Injury severity

Table 3 outlines factors associated with injury severity. Patients presenting with intentional injuries had a significantly higher Injury Severity Score (ISS) (24 vs 3), a higher fatality rate (3 vs 0), a higher ICU admission rate (50% vs 3%) and longer length of stay (6.5 vs 1.2 days). ISS is a score that aims to standardise the severity of injuries to predict morbidity and mortality. An operation was performed on 79% of patients with an intentional injury and 87% of patients with an unintentional injury. All patients with an unintentional injury were able to be discharged directly home compared with 21% of patients with an intentional injury. Fifty-seven percent of patients with an intentional injury required further care.

Trend in admissions

Figure 1 graphs nail gun admissions divided into five-year periods. Intentional injury admissions did not vary over the 25-year period. Unintentional injuries were low between 1994 to 1998 and have continued at a relatively steady rate since 1999.

Comparison of intentional injuries

The second search of the ACH Trauma Registry revealed 575 patients who presented with an intentional injury: 14 (2.4%) of these presented with an injury secondary to a nail gun. The median age was 33 (IQR 23); 416 (72%) were male; 338 (59%) were New Zealand European, 92 (16%) were Māori, 74 (13%) were Pacific Islanders. Overall, injury type was penetrating in 358 (62%), blunt in

<table>
<thead>
<tr>
<th>Site of injury</th>
<th>Intentional % group</th>
<th>Unintentional % group</th>
<th>Total % total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worksite</td>
<td>4 29%</td>
<td>30 97%</td>
<td>34 76%</td>
</tr>
<tr>
<td>Home</td>
<td>5 36%</td>
<td>0 0.0%</td>
<td>5 11%</td>
</tr>
<tr>
<td>Other</td>
<td>3 21%</td>
<td>0 0.0%</td>
<td>3 7%</td>
</tr>
<tr>
<td>Unknown</td>
<td>2 14%</td>
<td>1 3%</td>
<td>3 7%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of injury</th>
<th>Intentional % group</th>
<th>Unintentional % group</th>
<th>Total % total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>12 86%</td>
<td>3 10%</td>
<td>15 33%</td>
</tr>
<tr>
<td>Extremities</td>
<td>0 0.0%</td>
<td>25 80%</td>
<td>25 56%</td>
</tr>
<tr>
<td>Other</td>
<td>2 14%</td>
<td>3 10%</td>
<td>5 11%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Admitting team</th>
<th>Intentional % group</th>
<th>Unintentional % group</th>
<th>Total % total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurosurgery</td>
<td>7 50%</td>
<td>1 3%</td>
<td>8 18%</td>
</tr>
<tr>
<td>Trauma</td>
<td>0 0%</td>
<td>5 16%</td>
<td>5 11%</td>
</tr>
<tr>
<td>Orthopaedics</td>
<td>0 0%</td>
<td>23 74%</td>
<td>23 51%</td>
</tr>
<tr>
<td>ICU</td>
<td>5 36%</td>
<td>0 0%</td>
<td>5 11%</td>
</tr>
<tr>
<td>Other</td>
<td>2 14%</td>
<td>2 7%</td>
<td>4 9%</td>
</tr>
</tbody>
</table>
Figure 1: Nail gun injury admissions trends.

<table>
<thead>
<tr>
<th>Table 3: Injury severity.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td><strong>ISS</strong></td>
</tr>
<tr>
<td>Median</td>
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<tr>
<td>IQR</td>
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<tr>
<td><strong>LOS</strong></td>
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<tr>
<td>Median</td>
</tr>
<tr>
<td>IQR</td>
</tr>
<tr>
<td><strong>ICU</strong></td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td><strong>Mortality</strong></td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td><strong>Operation</strong></td>
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<td>Yes</td>
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<td><strong>Discharge destination</strong></td>
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<tr>
<td>Hospital Transfer</td>
</tr>
<tr>
<td>Rehabilitation</td>
</tr>
<tr>
<td>Death</td>
</tr>
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</table>
216 (38%) and burn in one patient. Cause of injury was stabbing in 320 (56%), fall in 138 (24%), gunshot in 32 (6%), motor vehicle in 27 (5%) and other in 58 (9%). Median length of stay was four days (IQR 8) and there were 54 (9.4%) deaths in total.

Table 4 compares nail gun related intentional injuries to all other intentional injuries. There was no difference in age ($P=0.508$) or ethnicity ($P=0.119$). There was a significant difference found in sex ($P=0.010$) and ISS ($P<0.001$). Although mortality rate was higher (21% vs 9.4%), it did not reach statistical significance ($P=0.136$).

**Legislation and government guidance**

The Health and Safety at Work Act 2015 came into force on 4 April 2016. It was adapted from the Australian Model Work Health and Safety Act, with amendments to reflect the differences between the New Zealand and Australian work environments. Under New Zealand’s previous legislation, the Health and Safety in Employment Act 1992, effective risk management was not enforced and the rising workplace death and injury toll needed to be addressed. A search of New Zealand and Australian legislation produced no results that specifically addressed the use of nail guns. Nail guns are not included in New Zealand’s Arms Act 1983 or its subsequent amendments.

Although there is no legislation directly governing the use of nail guns in New Zealand, the Department of Labour (disestablished in 2012) published the *Approved code of practice for powder-actuated handheld fastening tools* in May 1995. Of note is the emphasis in clause 2.2 on the responsibility of operators to protect themselves and others from hazards associated with nail guns. The code also stipulates the requirement for certification prior to operation of powder-actuated nail guns. An applicant must provide evidence they have “suitable training in the operation of powder-actuated fastening tools and a thorough knowledge of the safe practices relating to that operation.”

The guidance contained in this code is specific to powder-actuated hand tools. WorkSafe provides a disclaimer signalling that the code has not been updated since its conception despite the new health and safety legislation enacted in 2015. Included in the disclaimer is the intention to progressively review and either update, replace or revoke the guidance.

Although the Health and Safety at Work (General Risk and Workplace Management) Regulations 2016 provide general guidance on identifying hazards and risks and implementing effective control measures, there is nothing current that highlights the dangers that nail guns can present and the importance of certification—certification not being a requirement, as detailed below.

The results from a search of the UK Health and Safety Executive website support concerns regarding nail gun incidents and the risks of intentionally or unintentionally defeating their safety features. This search reinforced the need for workers to be trained prior to operating nail guns. The level of recommended supervision is dependent on the age, experience, ability, and attitude of each worker.
There is no requirement that someone must hold a licence before they can hire a nail gun. After the intentional death of a man in the Kāpiti Coast in 2009, Wellington coroner Ian Smith recommended the Government rule that people must be licensed to operate before hiring nail guns. There have been no resulting law changes.

A search of Hansard reports, a collection of the official reports of debates in the House of Representatives, again produced no results. It can safely be assumed that to date there have been no discussions in the House of Representatives regarding nail guns. Therefore, it is unlikely legislation will be enacted in the near future.

Discussion

This study revealed two causes of nail gun injury, each with a different effect on injury severity and mortality. Intentional nail gun injuries are associated with more serious injuries and have a higher fatality rate compared to both unintentional nail gun injuries and other means of intentional injury. Nail gun injuries continued to occur at a similar rate throughout the study period.

New Zealand trade workers in the construction industry were responsible for 41,900 work-related Accident Compensation Corporation claims in 2018. This was the highest claim rate by occupation: one in five of all work-related claims. Power tool related injury is one of the leading causes of injury in this group. It is concerning that there is no legislation that specifically regulates the safe use of nail guns in New Zealand (excluding the Health and Safety at Work Act 2015, which takes a broad approach to health and safety related risks), and a code of practice that was published in 1995 is likely to require review and updating. This code is also only specific to powder-actuated nail guns and has no recommendation for other forms of nail guns.

Nail guns can be divided into high- and low-velocity guns. Powder-actuated nail guns, powered by an explosive charge, are high-velocity and can fire a projectile up to 10cm in length at velocities as high as 1,400 feet per second. Low-velocity nail guns traditionally use compressed air, and newer models use combustion or an electric motor to fire the nail.

Given the ongoing occurrences of injuries during the study period, the prevalence of nail guns and the inability to practically enact targeted legislation, New Zealand should publish new guidelines and requirements including:

- explicit and specific guidance on the safe use of nail guns within the construction industry and domestically (at home)
- guidance on training, workplace procedures, personal protective equipment, and trigger type (sequential-actuation triggers have been shown to be safer than contact-actuation triggers)
- certification that takes into consideration the duty imposed by the Health and Safety at Work Act 2015 to minimise risks to workers.

A lack of training or safety guidelines on a construction site is likely to be found to be an offence, with WorkSafe New Zealand often taking action regarding training issues. The risk that nail gun injuries occur via domestic use is still very much a real concern. This concern supports the need for certification to be a prerequisite for the purchase of a nail gun.

New Zealand suicide rates continue to rise. The 2018/2019 suicide rate of 13.93 per 100,000 people is the highest recorded in 20 years. Suicide in New Zealand disproportionately affects young New Zealanders, which was reflected in the median age of 33 in this study. These increasingly high rates led to New Zealand’s first suicide prevention office being opened by the Government within the Ministry of Health. The office’s substantial budget acknowledges the significant work that will need to be undertaken. Regulations are needed to target and reduce the high lethality and increased injury severity of intentional nail gun injuries. Interventions should include certification prior to hiring a nail gun, inbuilt safety features that limit firing against skin and safe storage regulations.

This study offers a snapshot into the injury pattern of patients admitted with nail gun injuries. The associated burden of disease is likely significantly underrepresented,
as over 90% of injuries do not require admission and are treated in the emergency department.⁸

The continued occurrence of unintentional nail gun injuries and the high lethality of intentional injuries represent two areas of concern. There is currently no specific legislation in New Zealand around purchasing, storing, or using nail guns, and only powder-actuated nail guns require certification. Government guidance should be developed with a view to improving safety and reducing the rate of nail gun related injuries.

Competing interests:
Nil.

Author information:
Matthew J McGuinness: General Surgical Registrar, Whangārei Hospital, New Zealand.
Gabrielle Thompson: Senior Solicitor, Henderson Reeves, Whangārei, New Zealand.
Samuel Haysom: Medical Student, Trauma Service, Auckland City Hospital, New Zealand.
Ian Civil: General and Trauma Surgeon, Trauma Service, Auckland City Hospital, New Zealand.

Corresponding author:
Matthew J McGuinness, General Surgical Registrar, Whangārei Hospital, New Zealand; Auckland City Hospital, 2 Park Road, Grafton, Auckland, New Zealand, 1023; +64 21 038 5481 Matt@McGuinness.net.nz

URL:

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Variation in resources and impact on performance: results of the emergency department benchmarking survey

Peter Jones, Sophia Faure, Andrew Munro

ABSTRACT

AIM: The resources and capacity of New Zealand’s emergency departments (EDs) to cope with surges in demand are unknown. The aims were to describe the current resources and capacity of New Zealand EDs and explore how these relate to ED performance.

METHODS: A survey of EDs in New Zealand was conducted to capture elements of governance, staffing and structure of the EDs in the calendar year 2018. These were linked to processes and outcomes of care.

RESULTS: Eighteen of 26 EDs responded. These were representative of the range of EDs nationally. There was wide variability between the EDs across all the surveyed elements. Although no single element was strongly related to performance measures, combinations of elements were. When there was a lack of doctors and available ED or hospital beds relative to the workload, then performance was worse. The correlations were: for time to assessment $r=0.728$, $p=0.001$, for ED length of stay $r=0.759$, $p<0.001$, for patients who did not wait $r=0.619$, $p=0.006$ and for deaths in the ED $r=0.649$, $p=0.004$.

CONCLUSION: There is marked variation among New Zealand hospitals with respect to structure, staffing and workload, which may be impacting negatively on ED performance and limit the ability of some hospitals to cope with surges in demand for acute care.

In the context of the current severe acute respiratory syndrome coronavirus 2019 (COVID-19) pandemic, lack of capacity and resources for acute healthcare has been recognised internationally. Many acute healthcare systems operate near, at or over capacity, with emergency department (ED) crowding and access block (admission delays for acute inpatients) a widely recognised problem worldwide. ED crowding driven by access block impairs quality of care and is a major cause of morbidity and mortality for acute patients. It is unclear whether New Zealand’s EDs are prepared for a ‘slow moving mass casualty incident’, such as has been seen in countries like the USA over the past 18 months. Another unknown is whether EDs in New Zealand have comparable staffing and capacity, so some regions may be more able to cope with such disasters than others. To facilitate understanding and interpretation of international comparisons of acute care, the International Federation for Emergency Medicine (IFEM) recently developed a template for uniform reporting of ED structure, staffing, governance and performance. This survey includes the performance measures time to assessment, which is related to patient satisfaction and experience, and ED length of stay (LOS), which is related to patient outcomes including mortality.

The primary aim of this study was to document the current state of EDs in New Zealand according to the IFEM template and to look for opportunities to reduce variation nationally. The secondary aim was to
explore whether any of the structural and staffing variables were associated with the process and outcome measures.

Methods

This was a retrospective cross-sectional survey of EDs in New Zealand for the calendar year 2018.

Site selection

All 25 EDs in New Zealand that report data to the Ministry of Health (MOH) for the SSED target were eligible to participate. Participants were invited to contribute data via email to the ED clinical director. Participation was voluntary and not incentivised.

Survey instrument

The survey questions were those suggested by the IFEM. The template has sections based on ED structure, staffing and governance, attending population, processes and outcomes. In acknowledgement that ED processes and outcomes depend on the bed-state of the hospital, the template also includes a section on the number of hospital beds for the population served by the hospital.

Data collection and checking

An electronic link to an online survey managed by the MOH was provided, and on request a Microsoft Word document was also available for manual data entry. A manual with data definitions was provided with the survey instruments. The survey opened for responses on 22 May 2019 and closed on 22 July 2019. Survey questions are shown in the supplementary material. Where data were incomplete or incongruent, follow-up emails were sent with a request to complete or check the validity of the data. Data on hospital bed numbers were also cross checked with individual district health board (DHB) websites and the MOH website for each DHB. Where individual hospital populations could not be determined, the DHB population and total DHB hospital bed numbers were used in the calculation of beds/1,000 population. The correlation between the bed numbers reported from survey respondents and the MOH website was r=0.99, with the MOH website estimating 5.2% more beds than the survey respondents.

Data analysis

Data were downloaded and entered into a spreadsheet (Microsoft Excel™ 2016). Analysis was descriptive, using proportion with 95% confidence interval (95%CI), median with interquartile range (IQR) or mean with standard deviation.

The relationship between variables was assessed visually using scatter plots. Where appropriate, correlations were performed using SPSSv22 (IBM corporation, Armonk, NY, USA). The distribution of each variable was assessed visually using histograms and Q-Q plots and statistically with the Kolmogorov–Smirnoff test. Pearson correlation was used for normally distributed variables; otherwise Spearman's correlation was used. Statistical significance was adjusted for multiple comparisons using the Bonferroni calculation (alpha/number of comparisons), so statistical significance was set at p<0.001. A sample size calculation was not performed as this was an exploratory survey with a maximum sample size of 25.

Ethics

As a survey of administrative data, this study was out of scope for the New Zealand Health and Disability Ethics Committees.

Results

Responses were received from 18/26 hospitals (69%), which together were representative of smaller regional hospitals through to major urban tertiary hospitals. The number of hospital beds ranged from 43 to 1,005, and hospital beds per 1,000 population ranged from 1.5 to 2.3. The number of presentations ranged from fewer than 20,000 per year to more than 100,000, with the presentations per 1,000 DHB population ranging from 163 to 352 (Table 2).

Governance, staffing and structure

Table 1 shows the variation in size, structure and staffing of EDs. The number of beds ranged from 12 with no ED short stay unit to 57 with a 23-bed short stay unit. Staffing also varied: 105 to 259 nursing hours per 100 patient visits; 0 to 28 advanced care (nurse) practitioner hours per 100 patient visits; and 68.7 to 146 physician hours per 100 patient visits. Only one ED reported direct admitting rights, and
one reported having an emergency medicine specialist in the ED 24/7.

Population presenting to ED

Table 2 shows the variation in patient age and acuity of ED presentations to the different departments. Excluding Starship Children’s Hospital and Auckland City Hospital, which see only children or adults respectively, the proportion of children aged 0–5 ranged from 4.2% to 19.4%. The number of adults over 75 years ranged from 9.6% to 19.3%. There was also a wide variation in the proportion of ambulance arrivals (7.2% to 33.3%). Triage acuity also varied. One marked difference was in the higher proportion of resuscitation cases that presented to Auckland City Hospital (more than 4%) when all other departments saw <1% (Table 2).

Processes and outcomes

Table 3 shows ED process times. The wait to be seen ranged from median of 13 (IQR 6, 37) to 92 (IQR 41, 162) minutes. The ED LOS varied from a median of 135 (IQR 76, 222) to 288 (IQR 177, 517) minutes. With respect to outcomes, patients not waiting to be seen ranged from 1.0% to 8.0%, whereas admission rates ranged from 9.6 to 40.0%. There were few deaths in the ED (<0.01% to 0.14%). The proportion of patients who re-presented to the ED within 72 hours and were subsequently admitted ranged from 0.6% to 5.1%, and all but two sites reported proportions less than 2%.

Relationship of structure, workload and staffing to processes and outcomes

Structural measures

Examination of the scatterplots showed no linear relationship between either ED spaces per 1,000 presentations or hospital beds per 1,000 DHB population for any process or outcome (see the supplementary material).

Workload measures

The scatterplots suggested a there may be a relationship between the proportion of ambulance presentations and most processes and outcomes. There were some moderate correlations:

- time to assessment $r=0.590$, $p=0.010$
- ED LOS $r=0.593$, $p=0.012$
- did not wait (DNW) $r=0.566$, $p=0.014$
- deaths in ED $r=0.513$, $p=0.029$

Although the proportion of admissions was uncorrelated to outcomes (scatterplots shown in the supplementary material), the proportion of admissions was moderately correlated to ED processes:

- time to assessment $r=0.494$, $p=0.037$
- ED LOS $r=0.609$, $p=0.009$

The proportion of high acuity presentations was associated with the proportion who died in ED ($r=0.564$, $p=0.015$) but no other processes or outcomes.

Staff measures

The scatterplots showed no linear relationship between nursing hours or advanced care practitioners per 100 patients and any of the process or outcome measures (see the supplementary material). Doctor hours per 100 patients was negatively correlated to time to assessment ($r=-0.617$, $p=0.006$) and DNW ($r=-0.515$, $p=0.029$), although not to other processes and outcomes (scatterplots shown in the supplementary material).

Combinations of measures

Exploratory analysis looking at different combinations of structural, workload and staffing measures found stronger correlations with process and outcome measures than with the individual variables:

- For time to assessment, the strongest correlation was seen when sites had high ambulance presentations, high admissions to hospital and low doctor hours: $r=0.728$, $p=0.001$.
- For ED LOS, the strongest correlation was with high ambulance presentations, high admission rates, fewer beds per 1,000 DHB population and low doctor hours: $r=0.759$, $p=0.001$.
- For DNW, the strongest correlation was with high ambulance presentations and fewer ED treatment spaces per 100,000 DHB population: $r=0.619$, $p=0.006$.
- For deaths in the ED, the strongest correlation was for high ambulance presentations, fewer ED treatment spaces per 100,000 DHB population and low doctor hours: $r=0.649$, $p=0.004$.

Figure 1 shows the scatterplots for these associations and the full table of all
Table 1: Structure, staffing and governance.

<table>
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<td>23</td>
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<td>0.85</td>
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<td>0.55</td>
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<td>Per 100,000 population</td>
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<td>12.6</td>
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ED=emergency department; ACP=advanced care practitioner; EM=emergency medicine.
Table 2: Presenting population.

<table>
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<tbody>
<tr>
<td></td>
<td>Presentations</td>
<td>Presentations per 1,000 population</td>
<td>Children (0–5yr)</td>
<td>n (%)</td>
<td>Older (&gt;75yr)</td>
<td>n (%)</td>
<td>Ambulance patients</td>
<td>n (%)</td>
<td>Triage category</td>
<td>1</td>
<td>n (%)</td>
<td>2</td>
<td>n (%)</td>
<td>3</td>
<td>n (%)</td>
<td>4</td>
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<td>13,040</td>
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<td>15,279</td>
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<td>14,634</td>
<td>15,944</td>
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<td>16,783</td>
<td>11,092</td>
<td>21,172</td>
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<td>497</td>
<td>3,745</td>
<td>1,933</td>
<td>4,060</td>
<td>1,582</td>
<td>2,401</td>
<td>2,765</td>
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<td>2,825</td>
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</table>

* Triage category according to the Australasian Triage Scale: 1=most urgent, 5=least urgent.
Table 3: Processes and outcomes.

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<tbody>
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<td>Time to assess</td>
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<tr>
<td></td>
<td>61 (26, 122)</td>
<td>17 (8, 39)</td>
<td>20 (5.50)</td>
<td>13 (6, 37)</td>
<td>55 (29, 100)</td>
<td>29</td>
<td>46 (19, 96)</td>
<td>49 (20, 103)</td>
<td>49 (15, 100)</td>
<td>74 (26, 159)</td>
<td>53 (22, 102)</td>
<td>46 (20, 98)</td>
<td>59 (21, 120)</td>
<td>53 (24, 110)</td>
<td>51 (16, 119)</td>
<td>80 (28, 157)</td>
<td>67 (23, 106)</td>
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<tr>
<td>Mean (sd)</td>
<td>89 (88)</td>
<td>35 (55)</td>
<td>39 (54)</td>
<td>37 (67)</td>
<td>76 (72)</td>
<td>45 (43)</td>
<td>67 (67)</td>
<td>73 (74)</td>
<td>66 (68)</td>
<td>109 (108)</td>
<td>70 (61)</td>
<td>71 (74)</td>
<td>80 (8)</td>
<td>76 (70)</td>
<td>78 (79)</td>
<td>106 (261)</td>
<td>100 (106)</td>
<td>114 (94)</td>
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<td>ED LOS</td>
<td>Median (IQR)</td>
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<td></td>
<td>135 (76, 222)</td>
<td>138 (83, 208)</td>
<td>156 (92, 238)</td>
<td>216 (139, 314)</td>
<td>177 (111, 267)</td>
<td>179 (105, 269)</td>
<td>209 (129, 317)</td>
<td>183 (109, 282)</td>
<td>258 (160, 393)</td>
<td>223 (143, 331)</td>
<td>197 (111, 290)</td>
<td>168 (91, 252)</td>
<td>184 (109, 260)</td>
<td>212 (137, 304)</td>
<td>246 (158, 345)</td>
<td>277 (169, 433)</td>
<td>288 (177, 517)</td>
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</tr>
<tr>
<td>Mean (sd)</td>
<td>267 (243)</td>
<td>159 (111)</td>
<td>155 (98)</td>
<td>178 (120)</td>
<td>244 (156)</td>
<td>208 (143)</td>
<td>195 (122)</td>
<td>245 (173)</td>
<td>213 (154)</td>
<td>325 (240)</td>
<td>265 (204)</td>
<td>220 (148)</td>
<td>181 (123)</td>
<td>192 (119)</td>
<td>230 (137)</td>
<td>274 (194)</td>
<td>346 (1913)</td>
<td>458 (495)</td>
</tr>
<tr>
<td>DNW</td>
<td>n (%)</td>
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<tr>
<td>1,027 (5.9%)</td>
<td>253 (1.4%)</td>
<td>363 (1.7%)</td>
<td>280 (1.0%)</td>
<td>418 (1.2%)</td>
<td>1,572 (4.5%)</td>
<td>1,598 (3.8%)</td>
<td>1,749 (3.8%)</td>
<td>4,286 (9.1%)</td>
<td>1,873 (3.9%)</td>
<td>1,818 (3.3%)</td>
<td>4,402 (8.0%)</td>
<td>2,823 (5.1%)</td>
<td>3,264 (5.1%)</td>
<td>2,777 (4.7%)</td>
<td>4,077 (3.5%)</td>
<td>4,151 (3.5%)</td>
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<tr>
<td>Disposition</td>
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<tr>
<td>Admit ward n (%)</td>
<td>1,678 (9.6%)</td>
<td>3,361 (19.0%)</td>
<td>4,845 (22.8%)</td>
<td>6,570 (23.9%)</td>
<td>9,687 (28.7%)</td>
<td>6,493 (18.9%)</td>
<td>11,898 (34.1%)</td>
<td>12,283 (28.9%)</td>
<td>9,369 (28.2%)</td>
<td>16,220 (34.6%)</td>
<td>15,245 (31.9%)</td>
<td>15,385 (27.9%)</td>
<td>20,407 (37.0%)</td>
<td>18,180 (14.7%)</td>
<td>15,454 (24.4%)</td>
<td>29,452 (40.0%)</td>
<td>31,275 (36.2%)</td>
<td>38,117 (32.3%)</td>
</tr>
<tr>
<td>ICU admit n (%)</td>
<td>15 (0.1%)</td>
<td>0 (0.0%)</td>
<td>753 (2.1%)</td>
<td>582 (2.1%)</td>
<td>287 (0.9%)</td>
<td>166 (0.2%)</td>
<td>83 (0.2%)</td>
<td>215 (0.5%)</td>
<td>233 (0.5%)</td>
<td>468 (1.0%)</td>
<td>253 (0.5%)</td>
<td>123 (0.2%)</td>
<td>0 (0.0%)</td>
<td>318 (0.5%)</td>
<td>571 (0.5%)</td>
<td>193 (0.2%)</td>
<td>570 (0.5%)</td>
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<td>ED SSU n (%)</td>
<td>790 (4.5%)</td>
<td>0 (0.0%)</td>
<td>0 (0.0%)</td>
<td>1,981 (5.9%)</td>
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<td>1,824 (5.2%)</td>
<td>1,195 (2.8%)</td>
<td>8,161 (17.6%)</td>
<td>0 (0.0%)</td>
<td>3,957 (8.3%)</td>
<td>0 (0.0%)</td>
<td>4,858 (8.8%)</td>
<td>4,990 (9.0%)</td>
<td>7,638 (12.0%)</td>
<td>8,029 (10.9%)</td>
<td>16,732 (19.4%)</td>
<td>4,685 (4.0%)</td>
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</tr>
<tr>
<td>Transfer n (%)</td>
<td>1,369 (7.9%)</td>
<td>126 (0.7%)</td>
<td>12 (0.1%)</td>
<td>80 (0.3%)</td>
<td>60 (0.2%)</td>
<td>174 (0.5%)</td>
<td>101 (0.3%)</td>
<td>317 (0.7%)</td>
<td>1 (0.0%)</td>
<td>162 (0.3%)</td>
<td>126 (0.3%)</td>
<td>86 (0.2%)</td>
<td>6,493 (8.4%)</td>
<td>48 (0.1%)</td>
<td>912 (1.2%)</td>
<td>2,816 (3.3%)</td>
<td>1,690 (1.4%)</td>
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</tr>
<tr>
<td>Died ED n (%)</td>
<td>12 (0.07%)</td>
<td>8 (0.05%)</td>
<td>1 (0.00%)</td>
<td>9 (0.03%)</td>
<td>12 (0.00%)</td>
<td>19 (0.00%)</td>
<td>23 (0.00%)</td>
<td>18 (0.00%)</td>
<td>36 (0.00%)</td>
<td>21 (0.00%)</td>
<td>84 (0.00%)</td>
<td>29 (0.05%)</td>
<td>36 (0.00%)</td>
<td>51 (0.08%)</td>
<td>61 (0.08%)</td>
<td>82 (0.09%)</td>
<td>166 (0.14%)</td>
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<tr>
<td>Discharge n (%)</td>
<td>13,549 (77.8%)</td>
<td>14,195 (80.2%)</td>
<td>15,608 (73.6%)</td>
<td>20,299 (73.7%)</td>
<td>21,685 (64.3%)</td>
<td>27,610 (60.2%)</td>
<td>20,932 (60.1%)</td>
<td>28,400 (66.9%)</td>
<td>30,483 (65.0%)</td>
<td>27,905 (58.5%)</td>
<td>36,547 (66.3%)</td>
<td>29,720 (53.8%)</td>
<td>37,821 (67.9%)</td>
<td>39,332 (62.9%)</td>
<td>34,657 (47.0%)</td>
<td>35,356 (40.9%)</td>
<td>72,780 (61.7%)</td>
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<tr>
<td>R72A n (%)</td>
<td>97 (0.6%)</td>
<td>370 (2.1%)</td>
<td>-</td>
<td>427 (1.6%)</td>
<td>511 (1.5%)</td>
<td>478 (1.4%)</td>
<td>-</td>
<td>694 (1.6%)</td>
<td>140 (0.3%)</td>
<td>695 (1.5%)</td>
<td>640 (1.3%)</td>
<td>414 (0.8%)</td>
<td>341 (0.6%)</td>
<td>354 (0.6%)</td>
<td>-</td>
<td>851 (1.2%)</td>
<td>4,372 (5.1%)</td>
<td>1,437 (1.2%)</td>
</tr>
</tbody>
</table>

ED=emergency department, LOS=length of stay; DNW=did not wait; R72A=represent within 72 hours with subsequent admission; ICU=intensive care unit.
correlations tested is provided in the supplemental material.

The scatterplots showed that the proportion of patients re-presenting and being re-admitted within 72 hours was not linearly related to any structure, workload or staffing measure, or any combination of these measures, as most sites had fewer than 2% re-presentations requiring admission, with two notable outliers heavily influencing the observed correlations.

Discussion

The survey found marked variation in the presenting population, structure, staffing and governance of New Zealand EDs. The reasons for the variation are likely to be multifactorial and may be inter-related. Some of the variation is most likely due to the locations of hospitals and the availability of alternative care. For example, the populations presenting to smaller rural or regional hospitals that have limited availability of after-hours primary or urgent care was more likely to be lower acuity, since the only available option for care is the ED. This was different in major centres, where urgent care clinics deal with the vast majority of minor injury and medical complaints. This was reflected in the lower presentation rates, higher admission to hospital rates and corresponding longer lengths of stay observed in larger urban tertiary hospitals compared to rural and regional centres. A notable exception among tertiary urban referral hospitals was the sole specialist paediatric hospital, which had fewer patients, lower triage acuity, higher staffing, shorter times to assessment, fewer admissions and few patients leaving prior to assessment. In contrast, the sole adult hospital had a high proportion of triage 1 cases, which reflected its role as the regional trauma, stroke and 24-hour interventional cardiology centre.

There was marked variation in the number of bed spaces per 1,000 presentations, ranging from under 0.6 to more than 1.0. Sites with fewer ED beds per 1,000 presentations were likely to be more fully occupied more of the time and be less able to cope with surges in demand, such as has been seen internationally during the COVID-19 pandemic. Similarly, hospital bed numbers per 1,000 population varied considerably. The average of 1.9 was significantly lower than 2.6 of beds per 1,000 population reported for New Zealand by the Organisation for Economic Co-operation and Development (OECD). In the context of a national disaster or pandemic, those hospitals with lower bed number per head of population will less likely cope with surges in demand. In sites with few ED spaces and very low hospital bed numbers per 1,000, there is an opportunity for infrastructure investment to redress this deficiency.

There was wide variation in nursing hours per 100 presentations. No clear pattern with respect to number of presentations was observed. Physician plus advanced care provider ratios per 100 patients varied less, except for the two busiest EDs, which had had the lowest clinician-to-patient ratios. A notable exception was the specialist paediatric hospital, which had much higher staffing ratios than other sites.

Most EDs had a short stay unit run by an emergency medicine specialist, which allowed for longer periods of ED care and prevented unnecessary hospital admissions. The use of ED short stay units increased considerably in the last decade, partially in response to the SSED health target.

The reporting measures used in isolation were not associated strongly with the observed variation in performance. Only the proportion of ambulance presentations seemed possibly related to most ED process and outcome measures. The proportion of admissions was also related to ED processes, although the observed relationships were not strong. Unsurprisingly, a higher proportion of ambulance arrivals was associated with more deaths in the ED: patients who arrive by ambulance are typically more unwell. The impact of ambulance arrivals on ED process measures may have reflected the extra time required to investigate and treat these especially unwell patients. It was also recognised that the efficiency of admission processes within the hospital has an influence on ED LOS for admitted patients.

When structural, staffing and workload measures were combined, there were clearer relationships between the processes and outcomes of care. When sites with higher proportions of ambulance arrivals
and higher admission rates also had fewer doctors, less space or fewer hospital beds, then there were prolonged times to assessment, longer ED LOS, more patients leaving without being seen and more deaths in the ED. Investment in infrastructure and staffing may be required at these sites to improve processes and outcomes of care and reduce variation across the country.

Limitations

The main limitation of this report is that the IFEM benchmarking measures were intended to provide a description of the state of a particular ED to facilitate indirect comparisons between different settings in quality and research reports, rather than being a definitive template for benchmarking quality in the New Zealand setting. The IFEM measures are only high-level and so do not drill down into details like the number of junior and senior doctors and particular models of care. This may be why individual measures did not relate strongly to the time and disposition outcomes. The total number of hospital beds may not have reflected the number of beds available for acute admissions, as there is much daily, and sometimes hourly, variation within hospitals with regard to the elective workload competing for beds and whether beds are staffed or ‘open’.

It was not possible to check the reliability of the survey data at their source, so it is possible that there were errors in the data that were provided. Some sites were not able to provide all data fields, highlighting a lack of capacity for analysis and reporting of simple metrics in some DHBs. This highlights an opportunity for investment in systems analytics in those DHBs. As this was an observational study, causality cannot be attributed to the observed associations. The small number of hospitals in New Zealand limits statistical power and the ability for more in-depth analysis.

Conclusion

There is marked variation among New Zealand hospitals with respect to structure, staffing and workload, which may limit the ability of some hospitals to cope with surges in demand for acute care and impact negatively on ED performance.

Supplementary material

- Supplementary table of correlations
- Supplementary survey questions
- Supplementary scatterplots
Competing interests:
Dr Jones reports being the Ministry of Health's Shorter Stays in Emergency Departments health target champion. Sophia Faure reports being a Senior Advisor in the Ministry of Health.

Author information:
Peter Jones: Emergency Physician, Adult Emergency Department, Auckland City Hospital, Auckland District Health Board, Department of Surgery, School of Medicine, University of Auckland.
Sophia Faure: Senior Advisor, Ministry of Health, Wellington.

Corresponding author:
A/Prof Peter Jones, Emergency Physician, Adult Emergency Department, Auckland City Hospital, Auckland District Health Board, Department of Surgery, School of Medicine, University of Auckland
Peterj@adhb.govt.nz

URL:

REFERENCES
Tertiary survey by trauma nurse specialist at a paediatric trauma centre

Matt Sawyer, Bridget Kool, James K Hamill

ABSTRACT

INTRODUCTION: Tertiary surveys aim to detect injuries missed in the initial assessment of trauma. We introduced a process by which the trauma nurse specialist performed a number of the tertiary surveys (NTSs) at our paediatric trauma centre.

METHODS: Data from the first six months following introduction of the NTS were compared to retrospective data from the six months prior to NTS implementation (pre-NTS), when trauma surveys were completed by medical staff.

RESULTS: Over the 12-month period, 130 children met the criteria for a tertiary survey. Pre-NTS, 57/62 eligible patients received a tertiary survey, compared to 61/68 during NTS (p=0.77). There were significantly more road traffic crash patients in the NTS group (p=0.008) but no significant differences by demographics, injury pattern, injury severity score or outcomes. New injuries were found in three patients pre-NTS compared to five patients during NTS (odds ratio 1.3 (95%CI 1.3–2.0, p=0.73)).

CONCLUSION: This study conservatively supports the hypothesis that, with training and support, a trauma nurse specialist can perform tertiary surveys as effectively as doctors. A larger study is required to confirm these findings.

Trauma is a major health problem globally, with road injuries alone accounting for more deaths than any other cause among 10–19-year-olds and being the third most common cause of death among 5–9-year-olds. To optimise outcomes, trauma clinicians use primary surveys as a systematic means of rapidly assessing and treating life threatening injuries. Secondary surveys follow, which include a head-to-toe evaluation of the trauma patient, taking a complete history, performing a thorough clinical examination and reevaluating the patients’ vital signs to identify all other potentially significant injuries. The primary and secondary surveys can fail to detect some injuries that may adversely affect patient outcomes.

The rate of undetected injuries during primary and secondary surveys in paediatric trauma ranges from 1–19%. Enderson et al first described the tertiary survey (TS) over 30 years ago. The TS focuses on detecting injuries missed by the primary and secondary surveys. A TS includes a complete review of all investigations and an additional comprehensive clinical examination by a member of the trauma team. The TS is usually performed within the first 24 hours after admission and has become a standard of care. Approximately 15–20% of injuries detected on the TS are clinically significant. Therefore, it is important that TSs are performed consistently and to an adequate standard.

Trauma nurse specialists have been involved in performing TSs since their inception. However, TSs are commonly seen as the domain of doctors. At some centres, including our own, doctors performing TSs can be quite junior and inexperienced, and they rotate on a regular basis, which leads to an ongoing need to train new staff. In addition, trauma patients are admitted under a range of specialties, such as orthopaedics, neurosurgery and general surgery, which may lead to variation in the quality of the TSs being performed.

Allocating TSs to a permanent member of the trauma team, such as the trauma nurse specialist, has the potential to help maintain the quality of TSs.
The role of a trauma nurse specialist is to coordinate and monitor patients' care and to link hospital resources. In their cohort study of 148 trauma patients, Curtis et al found that, when trauma cases were managed by experienced trauma nurses, the rate of undetected injuries at a major trauma centre reduced significantly; however, nurses did not perform the TSs in this study. In another, US study, where trauma nurse practitioners routinely performed the TSs, the authors reported that undetected injuries decreased and communication improved after they implemented a TS form. Resler et al reviewed TSs for previously undetected injuries at a US paediatric trauma centre and found a significant number of previously undetected injuries were detected when TSs were performed by nurse practitioners compared to TSs performed by residents. We recently developed an education and implementation programme for nurse-performed tertiary surveys (NTS) at our paediatric trauma centre. This paper presents the results of a study comparing the rates of injuries detected by TSs before and after implementation of the NTS and describes the NTS implementation process. We hypothesised that the undetected injury rate would not change with NTSs.

Methods

The study took place at Starship Children's Hospital (SCH), a tertiary paediatric hospital and major trauma centre that admits over 1,000 child trauma patients (0–15 years of age) annually from around New Zealand. All children eligible for a TS during the study dates (1 July 2018–30 June 2019) were included. There are no set criteria in the literature identifying TS eligibility. Therefore, at SCH we developed our own criteria based on a review of the relevant literature regarding which patients were more likely to have an injury undetected from their primary or secondary survey. SCH patients who met one or more of these criteria were eligible for a TS (Figure 1):

- high-risk mechanism (pedestrian, passenger or cyclist involved in a road traffic crash, or fall >3 metres)
- meeting trauma call activation criteria
- admitted from another facility for definitive care.

We excluded patients who were admitted with non-accidental injury, minor penetrating injury or isolated injury (i.e., those for whom the mechanism offered only a single point of impact that had already received full examination and imaging) and those who died in either the Children's Emergency Department or Paediatric Intensive Care Unit. Our hospital does not admit major burns patients. For the purposes of this study, undetected injuries were those undetected on the primary or secondary surveys but detected on completion of the TS.

Nurse-performed tertiary survey development

Following a review of the relevant literature, existing TS guidelines and anecdotal evidence from the SCH trauma service regarding which patients are most likely to have injuries undetected on a primary or secondary survey, a revised TS guideline was developed. The key elements of the guideline included the pre-existing pathway for identifying patients eligible for TS (Figure 1) and a framework looking at all the components of the TS (Table 1). The framework, similar to that proposed by Janjua et al, included a complete physical examination and formal review of all blood

<table>
<thead>
<tr>
<th>Table 1: Framework used during the nurse-performed tertiary survey process for completing a tertiary survey.</th>
</tr>
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<tbody>
<tr>
<td>1. Review the clinical history.</td>
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<tr>
<td>2. Address clinical care components (e.g., DVT prophylaxis, tetanus/immunisations, pain management, concussion screening).</td>
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<tr>
<td>3. Review radiology and laboratory results, ensure all reports are finalised and either repeat or discuss abnormal laboratory results with the admitting team.</td>
</tr>
<tr>
<td>4. Perform a physical examination; order plain radiology if clinically indicated.</td>
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<tr>
<td>5. Report and record the findings.</td>
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</table>
tests and radiology (ensuring all radiology has been formally reported by a consultant paediatric radiologist), a complete review of the history (in case any pertinent details may have been missed on initial presentation), a review of the care components relevant to trauma patients (such as venous thromboembolism (VTE) prophylaxis and vaccination status) and contingency processes put in place for reporting back any positive or contentious findings to both the trauma team and admitting service. Upon completion of the TS, all findings are recorded on a customised form (Figure 2). The draft guideline was presented to relevant key stakeholders in paediatric surgery, orthopaedics and neurosurgery, after which some minor adjustments were made and the guideline finalised.

The nurse specialist had previously learnt many of the clinical skills required for the head-to-toe examination from working as an emergency nurse specialist, such as abdominal and extremity assessment. They were taught other skills, such as cranial nerve assessment, prior to conducting the supervised TSs. After discussion with the medical team and on their agreement, the nurse specialist could order radiology investigations and blood tests and seek subspecialty consultation as appropriate, as adjuncts to the TS clinical examination. Verbal informed consent was gained from caregivers for all TSs performed by the nurse specialist during the training phase and the subsequent audit phase of the study. Patient assent was also sought on conscious, school-aged children. The nurse specialist observed two TSs being performed by the trauma director and two by a paediatric surgical registrar, each of which focused on good head, neck, chest, abdomen and extremity examination technique. Next the nurse specialist performed

Figure 1: Flow chart for tertiary trauma survey eligibility.
Figure 2: Starship Child Health trauma tertiary survey form.
a further 10 TSs on a range of eligible patients under medical supervision and received feedback on their performance and technique from the supervising doctor. No unanticipated performance issues were identified. The trauma director reviewed the TS findings. At the end of the supervision period the nurse specialist was deemed competent in the process and able to conduct TSs independently, being required to provide feedback on their findings to both the trauma director and the admitting team. The training took place over the six-month period 1 July 2018–31 December 2018, after which the NTS was formally implemented.

Data collection

Trauma survey results from the first six months of the NTS (1 January 2019–30 June 2019) were compared with data from the prior six-months’ training period. During the NTS period the nurse specialist and medical staff collaborated such that the nurse specialist performed most TSs during office hours and doctors performed TSs after hours and when the nurse specialist was not available. The aim was to determine whether there was any change in the rate that missed injuries were detected with NTS. Variables of interest included age, date of injury, date of admission, cause of injury, diagnosis, patient outcome, outcome of the TS and who performed the TS. These data were collected prospectively during the NTS period and obtained retrospectively for the training period (pre-NTS) from the Children’s Trauma Service Trauma Registry (Collector®, Digital Innovation, Forest Hill, MD, USA). The rate at which previously undetected injuries were detected was compared between the two six-month periods and between TSs performed by the nurse specialist and doctors.

Follow-up

All children admitted for trauma were followed-up in hospital by the nurse specialist until discharge. All patients who had NTSs were followed-up two weeks after discharge by a telehealth phone call, during which they were asked a variety of questions relating to any potential issues, such as pain, difficulty mobilising, cognitive impairment, excessive fatigue, anorexia, nausea and problems toileting, and the appropriate advice was given thereafter.

Statistical analysis

There are no existing quality standards for the NTS; however, given the range of undetected injuries in paediatric studies is 1–19%,7–10 we estimated that the TS should detect new injuries in about 5% of our patients. In a retrospective two-sample power analysis, sample sizes of 57 and 61 in each group gave a power of 0.77 at a significance level of 0.05 for a medium (0.5) Cohen conventional effect size.10

The primary outcome was the odds of detecting a previously undetected injury during the NTS period compared to the pre-NTS period. Categorical variables were compared by Fisher’s exact test. The distribution of continuous variables was inspected in frequency plots and tested by the Shapiro-Wilks test. Non-parametric data were compared using the Wilcoxon rank sum test. Multivariate analysis was performed using a generalised linear model with the detection of a new injury as the outcome and group (before or after implementation), age, gender and injury severity score as additional explanatory variables. Additional analysis was undertaken to compare TSs performed by the nurse specialist to TSs performed by a doctor. All statistics were run in the statistical programme R®.

The study was registered with the institutional research office but was excluded as it was deemed a necessary business-as-usual activity.

Results

Over the 12-month period (1 July 2018–30 June 2019), 942 trauma patients were admitted, of whom 812 were excluded because of minor/isolated injury (n=703), non-accidental injury (n=13), minor penetrating injury (n=85), minor burns (n=5) or death (n=6).

The TS criteria were met by 130 patients, 68 of whom were assessed using the new NTS. These patients were compared with 62 patients who were assessed pre-NTS. Apart from more patients being injured in road traffic crashes during the NTS period, the two groups were similar in demographics, mechanism of injury, presence of head injury, and outcome (Table 2).
There was no significant difference in the proportion of eligible patients who received a TS between the NTS and pre-NTS groups. During the NTS period, seven eligible patients did not receive a TS, whereas five eligible patients did not receive a TS during the pre-NTS period (Table 2). Overall, 118 (91%) received a TS. The most common reason for not having a TS performed was admission and discharge over the weekend, when medical staffing levels were reduced and the nurse specialist was not available.

During the six-month period following the introduction of the NTS, 61 TSs were performed: 30 by the nurse specialist and 31 by a doctor. It felt important for the doctors to continue conducting some of the TSs during this time to promote and maintain their skills. In some cases (eg, teenage female patients) it was more appropriate for a female doctor to do the TS rather than the male nurse specialist. New injuries were found in five of the 61 cases, of which the nurse specialist detected three and the doctor two. In the pre-NTS period, 57 TSs were conducted: 10 by the nurse specialist (under medical supervision as part of the nurse’s training in TSs) and 47 by a doctor, with new injuries detected in three patients (Table 3). Most of the injuries were orthopaedic, usually involving a distal upper limb or a digit and requiring immobilisation only. Examples of previously undetected injuries were finger fracture, ankle fracture, concussion and dental injuries. The distal limb injuries were detected in patients who were intubated and ventilated and for whom a period time had passed since their primary and secondary surveys. These newly detected injuries were assigned an appropriate abbreviated injury severity (AIS) code and injury severity score (ISS), adjusted accordingly. None of the new injuries picked up by NTS required surgery. Although painful and, in relation to the

| Table 2: Characteristics of children eligible for a tertiary survey in the periods before and after the introduction of the nurse-performed tertiary survey (NTS). |
|---------------------------------|-----------------|-----------------|-----|
|                                | Pre-NTS n=62    | NTS n=68        | P   |
| Age in years                   | 9 (5.25, 12)    | 8 (3.75, 12)    | 0.33|
| Female gender                  | 19 (31%)        | 30 (44%)        | 0.15|
| Ethnicity                      |                 |                 |     |
| Māori                          | 12 (19%)        | 14 (21%)        | 1   |
| Pacífica                       | 14 (23%)        | 12 (18%)        | 0.52|
| Other ethnicity                | 36 (58%)        | 42 (62%)        | 0.72|
| Mechanism of injury *          |                 |                 |     |
| Motor vehicle crash            | 9 (15%)         | 24 (35%)        | 0.008|
| Pedestrian or driveway run-over| 17 (27%)        | 10 (15%)        | 0.32|
| Fall                           | 14 (23%)        | 10 (15%)        | 0.27|
| Bicycle                        | 9 (15%)         | 10 (15%)        | 1   |
| Motorcycle, quad or scooter    | 10 (16%)        | 5 (7%)          | 0.17|
| Head injury                    | 28 (45%)        | 33 (5%)         | 0.73|
| Injury severity score (ISS)    | 9 (5, 17.8)     | 9.5 (4, 21)     | 0.76|
| Length of stay (days)          | 2 (1, 4)        | 3 (1, 7)        | 0.37|
| Received a tertiary survey     | 57 (92%)        | 61 (90%)        | 0.77|

Categorical data as n (%). Continuous data as median (IQR).
concussion, impactful on the patient’s schooling, none of these previously undetected injuries were expected at discharge to affect the patients’ long-term outcomes. No further injuries were detected in any of the patients after completion of the NTS.

The odds of detecting a new injury were not significantly different on univariate analysis (p=0.72), or on multivariate analysis (OR 1.3, 95%CI -1.3–2.0, p=0.73), when the NTS and pre-NTS periods were compared. There was no significant difference in the odds of detecting a new injury during TS performed by the nurse specialist compared to TS performed by doctors (OR 2.1, 95%CI 0.44, 10, p=0.33).

Discussion

This study describes the process to implement an NTS in a paediatric trauma centre in New Zealand. The results showed that the nurse specialist was as effective as doctors at detecting previously undetected injuries in the TS. Importantly, our data show that neither the nurse specialist nor the doctor missed any injuries on completing the TS.

The present study is the first, to our knowledge, to describe a framework to train and support a nurse specialist in TSs. The framework included contingencies for any new injuries found on TSs. Trauma nurse specialists follow-up on aspects of clinical care as part of their regular duties. This includes ensuring radiology is formally reported and that abnormal lab test results are highlighted to the clinical teams and acted upon accordingly. The present study shows that up-skilling an experienced trauma nurse to perform TSs is a viable option; however, we feel it is important that TSs are not exclusively done by nurses, since TSs are an important part of training of junior doctors in trauma.

Our results are consistent with Resler et al, who showed an increase in the rate at which previously undetected injuries were detected with the introduction of nurse-practitioner performed TSs at a children’s trauma centre. The rate at which previously undetected injuries were detected in the present study was in keeping with detection rates of 1–19% seen in other studies in which TSs were performed by medical staff. Further research on NTSs in smaller trauma units or in hospitals that treat both adults and children could help confirm the generalisability of our results to other settings.

Adopting the NTS process has eased the workload on junior doctors at our institution, allowing them to carry out other aspects of their role while enabling the nurse specialist to further develop and enhance their skill set without compromising the safety of the patient. This synergistic effect with medical staff was also noted by Huynh et al, who found that TSs performed by non-physician practitioners

Table 3: Allocation of the tertiary surveys and new injury detection rates before and after the introduction of the nurse-performed tertiary survey (NTS).

<table>
<thead>
<tr>
<th></th>
<th>Before NTS introduced n=57</th>
<th>After NTS introduced n=61</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trauma nurse specialist</td>
<td>–</td>
<td>30</td>
</tr>
<tr>
<td>Cases with new injuries</td>
<td>–</td>
<td>3</td>
</tr>
<tr>
<td>Doctor</td>
<td>57*</td>
<td>31</td>
</tr>
<tr>
<td>Cases with new injuries</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Total cases with new injuries detected</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

* Before NTSs were introduced, 10 of the 57 tertiary surveys were performed with the doctor supervising the trauma nurse specialist.
reduced residents’ workloads and improved processes.\textsuperscript{24}

Undetected injuries represent a clinical risk in trauma care. NTSs transfer the responsibility for detecting previously undetected injuries from doctors to the trauma nurse; however, the trauma director remains ultimately responsible. Trauma directors must ensure that their staff are properly trained and supervised. In our service, the nurse specialist already had many years’ experience as a nurse specialist in paediatric trauma and the emergency department and had an established skill set in clinical history taking and examination. We also have a supportive team of surgeons in training and junior doctors who are readily available for support. In New Zealand, nurse specialists work collaboratively within a specialty team. They may have delegated medical responsibilities, undertake diagnostics, implement treatment protocols and prescribe according to standing orders.\textsuperscript{25} Therefore, a nurse specialist working within an established trauma service seems a good model for NTSs. A nurse practitioner role, with the ability to take on full clinical responsibility, would also suit the position.

Limitations

This study was limited by its small sample size and the retrospective control group. The study was not adequately powered to detect a medium difference in the detection rate of new injuries. A larger prospective study is required to confirm our findings. Such a study could be designed to have both a doctor and the trauma nurse perform TSs on the same patient and compare the results for inter-rater reliability and accuracy. Alternatively, patients could be randomised to either the nurse specialist or doctor to perform their TS. In addition, a study conducted over at least 12 months would account for seasonal variability commonly seen in trauma care. Interventions and outcomes were conducted by the same investigator, which poses a risk of bias. One trained and experienced nurse specialist but several different doctors performed the TSs, which might limit the generalisability of our findings. The nurse specialist performed the TS during office hours, whereas the junior medical staff could have been performing TSs after hours during a long weekend shift, which could impact on clinical assessment. The nurse specialist already had a pre-existing skill set that enabled this process to begin, whereas others new to the role would require further training. The nurse specialist performed some TSs during the ‘control’ period, which we addressed in the additional analysis. We have not evaluated the cost and time implications of NTSs, which should be considered in future studies. The follow-up at two weeks was the only follow-up and was conducted by phone call, not in clinic, so an injury undetected during the TS might possibly have been missed at follow-up. Future studies should pay close attention to follow-up to ensure their denominator of missed injuries is accurate. Nine percent of eligible patients failed to receive a TS in our study. This calls for a quality improvement initiative and should be addressed in future research.

Conclusions

This observational study suggests that trauma tertiary surveys may be undertaken by an experienced trauma nurse after a structured training programme and with ongoing supervision and support. To validate these findings, a larger, prospective study is required.
Competing interests:
Nil.

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Author information:
Matt Sawyer: Starship Children’s Health, Children’s Trauma Service.
Bridget Kool: University of Auckland, Faculty of Medical and Health Sciences.
James K Hamill: Starship Children’s Health, Children’s Trauma Service; University of Auckland, Faculty of Medical and Health Sciences.

Corresponding author:
Matt Sawyer, Trauma Nurse Specialist, Starship Children’s Hospital, Park Road, Private Bag 92024, Auckland 1142, New Zealand, 09 3078952 (fax), +64 93797440 (phone) msawyer@adhb.govt.nz

URL:

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Rethinking resuscitation: moving the goals
Alex Psirides, David G Tripp, Tammy J Pegg

ABSTRACT
Cardiopulmonary resuscitation (CPR) techniques have developed remarkably since first described. CPR is now both a default treatment and a public expectation. However, anticipated outcomes are not matched by reality. The differences between in- and out-of-hospital cardiac arrests are often not recognised and almost never taught. ‘Do Not Resuscitate’ orders developed to provide the ability to opt-out of this treatment. Nevertheless, CPR is still inappropriately used in settings where reversibility and likelihood of benefit are not meaningfully considered or discussed with the patient. Further, treatment escalation is a continuum, so resuscitation orders present a false dichotomy of ‘do’ or ‘do not’ resuscitate. Asking patients about their goals, and only offering treatments aligned with those goals, allows consideration of the burden of treatment and the likelihood of success. Shared decision models improve communication and patient autonomy. Tools are available to help clinicians with the difficult conversation and document the outcomes. Now, in both our training and practice, it is time to move beyond the stark and often irrelevant choice between CPR and ‘Not for Resuscitation’.

Mouth-to-mouth resuscitation of the victims of drowning was first performed in Paris in the 1700s. It was another 250 years until a group led by surgeon James Jude first described closed chest cardiopulmonary resuscitation (CPR), ostensibly as a treatment for the effects of excessive anaesthetic induction agents. Their technique replaced the previous method (an emergency sternotomy). Internal cardiac massage ensued until defibrillation or time did—or more often did not—restore spontaneous cardiac output. Modern CPR, a much less invasive closed chest technique, was born in a case series describing the technique in twenty patients and reporting 70% survival. That paper ends with an appropriately optimistic assessment: “Anyone, anywhere can now initiate cardiac resuscitative procedures. All that is needed are two hands.”

Outcome of arrests in a modern healthcare setting
Fast forward 50 years and CPR has become a standard of care. Indeed, it is one of few medical interventions provided by default, regardless of likely success or underlying condition, and without consent. If you are an in-patient in a New Zealand hospital and suffer a cardiac arrest, staff will perform CPR, unless you have formerly opted out.

In-hospital CPR is generally an ineffective intervention. A recent US review reported in-hospital arrest mortality at 80%—without CPR, it is 100%. This difference is small but important. We presume a small survival benefit is the reason CPR became a de facto treatment for all. However, in doing so, at least in a hospital setting, an important consideration has been overlooked. CPR does not treat most conditions leading to in-hospital arrest: for example, metastatic cancer, end-stage chronic obstructive pulmonary disease, worsening multi-organ failure from sepsis or extreme frailty. To put it simply, CPR works best when the heart is the first, not the last, organ to stop.

Further, outcomes should not just be considered through the binary lens of survival. A recent Australian study has shown that, of the minority who survive in-hospital cardiac arrest, nearly a third can expect a reduced level of function, and some will become fully dependent. Not surprisingly, survival diminishes as age increases, and most elderly survivors subsequently require institutional care. Longer hospital admission duration prior to in-patient arrest is also associated with worse patient outcomes. These outcomes are despite
In-hospital verses out-of-hospital cardiac arrests

The aetiology and outcomes of in-hospital and out-of-hospital cardiac arrests (IHCAs, OHCAs, respectively) vary markedly. Yet the management of both is taught as if they were the same.

The largest published review of IHCAs describes 81% of presenting rhythms as non-shockable (asystole or pulseless electrical activity) compared to 61% of OHCAs in New Zealand in 2020. There is also significant extrapolation of evidence-based guidelines from OHCAs to IHCAs. A systematic review of 92 randomised clinical cardiac arrest trials involving at least 50 patients between 1995 to 2014 only included four studies exclusively involving in-patient arrests.

The ‘Do Not Resuscitate’ dilemma

We now find ourselves in an uncomfortable situation. A treatment that is futile in most situations, and arguably harmful in others, has become an expected standard of care. We continue to extrapolate, in both evidence and practice, from an out-of-hospital to an in-hospital setting, despite material differences in these cohorts.

Negotiating this dilemma is further complicated by the large gap between public perceptions of the success of CPR (often informed by television medical dramas and selective media reporting of success) and the actual reality of poor outcomes.

Efforts to communicate and document when cardiopulmonary resuscitation is not appropriate have evolved since the 1970s. ‘Do Not Resuscitate’ (DNR) or ‘Not for CPR’ orders in turn became ‘Do Not Attempt CPR’. Subsequent terminology (‘Allow a Natural Death’) changed the language to reflect futility and that intervention may be unnatural. Whatever words are used, it is clear that we struggle with our own and public expectations and the difficulty of discussing futility. This has been especially true when decisions have been made without patients or their whānau being involved. Ostensibly this is no different to not offering other futile therapies; emotionally, this difference is significant.

Further, despite the development of DNR or equivalent orders, their coverage in New Zealand is poor, even among patients where futility is strongly supported by evidence.

In a study of elderly patients within an older adult rehabilitation ward (with a mean age 87 years, and half of whom were clinically frail), CPR forms were completed for 63%, with one third of these (12 patients) for ‘full CPR’. Only one patient had had this discussed with them. A subsequent review by the same authors two years later showed that electronic documentation of CPR status had improved recording of a decision to 81% of patients; however, only 38% of these documented any communication with the patient or their whānau about the decision.

An audit of community-acquired pneumonia in a New Zealand hospital found resuscitation decisions were only documented in a minority of cases, even among those at the highest risk of subsequent mortality.

A study in a single tertiary New Zealand hospital of 71 ward patients who had deteriorated acutely, to the point they required urgent review by a medical emergency team (MET), showed documentation of treatment limitation doubled from 32% to 62% after deterioration. Although this may reflect new irreversible decline for which further escalation would be futile, it also likely includes a significant number of patients for whom futility had either not been recognised, documented or discussed by the admitting team.

This poor coverage of DNR orders undermines two reasons that DNR orders were created to support: patient autonomy and harm caused by default provision of futile treatment.

Time for a more nuanced approach?

The current false dichotomy of ‘do’ or ‘do not’ resuscitate—even when this is documented—fails patients and clinical staff in several ways. Firstly, by giving such prominence to an end-stage and often fatal event,
such orders often detract from the actual treatments that may or may not still be indicated, each with their own risks and benefits. Secondly, a recommendation, or even suggestion, to not resuscitate may be perceived by patients and their family as a lack of commitment to other (more appropriate) treatments, straining trust at a time of critical vulnerability for the patient. Most importantly, traditional ‘resuscitation decisions’ invariably happen the wrong way round. They offer a treatment before a diagnosis and convey intention on the clinician’s part before gaining an understanding of the patient and their priorities. They make us talk first and listen later.

In part to address these issues, a study of the significant variability in systems used by New Zealand public hospitals to detect deterioration in hospital patients led the Health Quality and Safety Commission (HQSC) to fund a five-year national patient deterioration programme. Part of this programme for adult in-patients, perhaps most importantly, was the Shared Goals of Care (SGOC) initiative. This national quality improvement initiative was designed to listen to and talk with patients about their treatment expectations, with the intent of reducing unwanted or unwarranted treatment provided at the end of life. Workshops with clinicians, consumers and healthcare organisations were held in early 2018 to develop a series of key principles. These led to development and testing of a single A4 double-sided form to enable conversations and clear documentation of decisions.

A SGOC approach to treatment planning addresses several of the shortcomings of DNR. It enforces a partnership between clinician and patient to improve informed, shared decision-making. Rather than a clinician making assumptions about patient preferences and providing options accordingly, the process begins with a discussion around the patient’s goals. These are framed by establishing what the patient would accept, both in terms of outcomes and the treatment burden required to realistically achieve them. Rather than ‘do’ or ‘do not’ resuscitate, treatment options are determined in the context of aligning with one of four goals. Each goal with its corresponding intent is shown in Table 1.

Documentation of each goal includes the ability to list specific treatment modalities that may have been discussed (e.g., dialysis, antibiotics, nasogastric tube feeding) and whether the doctor would recommend these, and if so whether the patient would accept them or not. SGOC should be informed by a pre-existing advance care directive but are intended to be episodic, relating only to that particular hospital admission. Ideally the treatment plan should be discussed and completed early in admission, and treatment may be changed according to patient preferences or clinician recommendations as the illness resolves or worsens.

<table>
<thead>
<tr>
<th>Goal A</th>
<th>Treatment is curative or restorative. CPR is both clinically recommended and in accordance with the patient’s wishes. Any adverse sequelae would be acceptable to the patient.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Goal B</strong></td>
<td>Treatment is curative or restorative but also aims to prolong life and enhance quality. CPR should not be attempted as it is unlikely to be successful if required, or because if it is likely to be successful, it would cause more harm than benefit, or because it is not wanted by the patient under any circumstance.</td>
</tr>
<tr>
<td><strong>Goal C</strong></td>
<td>Treatment is aimed primarily at improving quality of life rather than prolongation at all costs. This involves controlling symptoms, enhancing wellbeing and providing treatments that are easily tolerated. CPR should not be attempted.</td>
</tr>
<tr>
<td><strong>Goal D</strong></td>
<td>The provision of comfort while dying. Treatment aims to alleviate suffering in the last hours or days of life and allow a natural death to proceed, which will not be achieved by CPR or MET review of escalation to intensive care.</td>
</tr>
</tbody>
</table>

Table 1: Summary of the four categories within the Shared Goals of Care approach.
Discussing goals of care

Talking to patients about not doing things is difficult. But avoiding these conversations leads either to futile escalation where ‘everything’ is done (it is easier to do so than to talk about not doing so), or treatment limitations are placed by clinicians without discussion with patients, whānau or families.

The Shared Goals of Care approach gives an alternative. Rather than discussing what we will not do, it frames conversations by what we will do to reasonably meet a patient’s goals.

In further recognition of this difficulty, the Serious Illness Conversation Guide was developed in the US and adapted for use in New Zealand with Māori and consumer consultation. This simple, structured communication tool, along with an associated training programme supported by most district health boards, better equips clinicians to have difficult but meaningful conversations.

This tool has subsequently been used in the Bay of Plenty, New Zealand, to improve shared decision-making with complex patients where the risks versus benefits of surgery were not immediately clear. Patients and their families or whānau were invited to attend a pre-assessment clinic with specialists in anaesthesia and intensive care. Using the structure of the Serious Illness Conversation Guide, supplemented with risk scoring tools (including the clinical frailty scale), enabled goals-of-care conversations. Over eighteen months, 49 high-risk patients were referred from a variety of surgical specialties. Once surgery was contextualised within the likelihood of achieving the patient’s goals, over half (53%) chose non-operative management of their condition.

Rethinking resuscitation training

This raises a pertinent question: how do we train doctors to negotiate this complexity of care, over and above learning the technical aspects and algorithms of CPR?

Currently, all junior medical staff must acquire certification for advanced cardiac life support by the end of their first postgraduate year in order to gain Medical Council of New Zealand registration. The New Zealand Resuscitation Council’s 14 guidelines, each with up to 11 subsections, contain less than 400 words on ‘Do Not Attempt Resuscitation’; by comparison, there are over 1,400 on ‘Duty to Rescue’. There is no recognition of the differences between OHCA and IHCA and the implications this may have for resuscitation.

Junior doctors must be trained in CPR to gain registration, yet they receive no training—and certainly not mandatory training—in the risks of this procedure or in how to ‘consent’ a patient for the procedure. The Medical Council’s policy on consent requires doctors to “communicate and work with the patient to help them make the best decision for themselves.” The Health & Disability Commissioner’s Code of Rights includes patients’ rights to effective communication, to be fully informed and to make an informed choice and give informed consent. These requirements from both national organisations have never been part of resuscitation certification in New Zealand.

The authors believe current resuscitation training requires some rethinking. Advanced cardiac resuscitation skills are absolutely required by community responders and in emergency departments, intensive care units, coronary care units and catheter labs. But junior doctors must also be taught to determine when these skills are not indicated and when they are likely to fail, alongside the skills themselves. Further, rather than teaching skills that are required when the patient has already arrested, training needs to be provided around the earlier detection of, and management for, deteriorating patients.

Perhaps most importantly, clinicians need the skills to talk about not doing any of these things. This could improve access to resources for those patients who would be most likely to benefit and save other patients from poor outcomes they wish not to live with. Replacing binary resuscitation orders with a Shared Goals of Care approach recognises the continuum of modern healthcare treatment. But most importantly it puts the patient at the centre of decisions that may have been previously made about them without them.
Competing interests:
Nil.

Author information:
Alex Psirides: Co-Director, Intensive Care Unit, Wellington Regional Hospital, Newtown, Wellington; Clinical Lead, National Patient Deterioration Programme, HQSC. David G Tripp: General Physician, Wellington Regional Hospital, Newtown, Wellington; Expert Advisory Group, National Patient Deterioration Programme, HQSC. Tammy J Pegg: Cardiologist, Nelson Hospital, Nelson; Clinical Lead, Shared Goals of Care Programme, HQSC.

Corresponding author:
Dr Alex Psirides, Intensive Care Unit, Wellington Regional Hospital, Newtown, Wellington
alex.psirides@ccdhb.org.nz

URL:

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Reversible BRAF inhibitor-induced acute exudative paraneoplastic polymorphous vitelliform maculopathy

Priya Samalia, Rachael Niederer

A 72-year-old Caucasian male was receiving vemurafenib and pembrolizumab treatment for BRAF VK600K mutation-positive metastatic cutaneous melanoma. He was initially started on vemurafenib alone, with pembrolizumab being added to therapy 3.5 months later.

He developed bilateral central scotomas six weeks after starting vemurafenib but prior to commencing pembrolizumab. He was reviewed by the ophthalmology service 3.7 months after commencing vemurafenib and one week after commencing pembrolizumab. Presenting vision was 6/9 right eye and 6/12 left eye.

Examination revealed bilateral blunted foveal reflexes (Figure 1). Fundus autofluorescence showed some hyper-autofluorescence centrally (Figure 2), and optical coherence tomography revealed bilateral neurosensory detachments (Figure 3). A diagnosis of acute exudative paraneoplastic polymorphous vitelliform maculopathy (AEPVM) secondary to vemurafenib (BRAF inhibitor) was made. Vemurafenib was discontinued and lesions resolved with vision improving to 6/6 in both eyes (Figure 4) within eight weeks of stopping vemurafenib. Pembrolizumab was continued without ocular complications, but the cancer progressed with new cerebral metastases.

Due to progressive metastatic disease, he was restarted on vemurafenib four months after the drug was initially discontinued but developed recurrence of AEPVM within two weeks of restarting vemurafenib.

Complete resolution of AEPVM following discontinuation of vemurafenib with recurrence on re-exposure to the drug suggested a causal relationship between vemurafenib and AEPVM.

Newer immune cancer therapies provide targeted therapy that increases survival for those with metastatic disease. Ocular complications associated with BRAF inhibitors typically include uveitis; AEPVM is rare. Aetiologic possibilities include immune-mediated inflammation, drug toxicity and idiosyncratic reaction.

Increased knowledge of the adverse ocular effects associated with these medications is necessary, and patients should be counselled to report visual symptoms on commencing these therapies. Prompt review of visual complaints is necessary to exclude uveitis and AEPVM.

These medications are lifesaving. Treatment is complex and requires careful discussion with the treating oncologists. Options may include local corticosteroids, switching immune therapy agents and medication cessation, but with risk of disease progression.
Figure 1: Widefield colour fundus photographs of right and left eye with blunted foveal reflexes.

Figure 2: Short-wavelength fundus autofluorescence showed a slight increase in autofluorescence centrally.
Figure 3: Heidelberg HRA Spectralis OCT scans (Heidelberg Engineering, Heidelberg, Germany) of right and left eye at presentation showing bilateral neurosensory retinal detachments.

Figure 4: Heidelberg HRA Spectralis OCT scans (Heidelberg Engineering, Heidelberg, Germany) of right and left eye at presentation showing resolution of bilateral neurosensory retinal detachments following discontinuation of vemurafenib.
Competing interests:
Nil.

Author information:
Priya Samalia: MBChB, PhD; Ophthalmology Fellow, Greenlane Clinical Centre, 214 Greenlane West, Epsom, Auckland, New Zealand.
Rachael Niederer: FRANZCO, PhD; Ophthalmologist, Greenlane Clinical Centre, 214 Greenlane West, Epsom, Auckland, New Zealand.

Corresponding author:
Priya Samalia, Eye Department, Greenlane Clinical Centre, 214 Greenlane West, Epsom, Auckland 1051, New Zealand, 09 367 0000
dr.priyasamalia@gmail.com

URL:

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What we can’t see: the intimate lived experience of rural New Zealand

Victoria Murphy, Emily Gill

There’s a man who is probably dead by the time you read this. He was prominent locally in his community and nationally, and continued his professional work until recently. He had a wife, children and loving grandchildren. He was receiving palliative care and expected to have weeks to short months left in his life.

For a medical student, palliative care placements can be deeply upsetting experiences. Being out here day to day, driving through rugged, rural hill country, under the shadow of maunga, you are privileged to be welcomed into patients’ homes, and exposed to crucial truths. One is that patients’ true circumstances are an enormous and near-infinite room; and you can only ever catch a glimpse of flashes of light through the keyhole. You gain a heartening respect for the boundaries of your lived experience and situations you can never speak for. In parallel, you learn the importance of trying to get closer to that keyhole.

There was an intensity in entering this man’s home; more dimensions than the hospital. First, there we were, in the middle of this rural landscape, on his doorstep. He and his wife hugged us and called us ‘guardian angels’. They were so warm toward us, though they were obviously both tired, and under unimaginable stress. His wife would sit next to him on the bed where he lay weakly and wipe his forehead. Lying there—breathing shallow, sweating despite the fan, choosing between pain control and consciousness. I fixated on small pieces of his humanity and the psychosocial context in the room—the beachy smell of moisturiser, the knick-knacks and family photos, the washing basket, slippers, orange walls in the corridor. The palliative care nurse discussed his attitudes towards death, dying and what he wanted in his last days.

The second time we saw him, three weeks later, more family were present. His wife and daughter had made permanent, culturally significant lifestyle changes in his honour. He had been moved to a couch. But only intermittently did he open his eyes, before they would slide shut again. This time we were discussing funeral plans. The family told us they would weave a korowai out of flax, and say karakia. Then they would take him up to the marae for tangihanga.1 We brushed the topic of organ donation; my mind reflexed back to the lab protocols I knew, but now they seemed a million miles removed.2,3

I suppose there are two important aspects to lived experience—knowing yours, and respecting others’.4,5 Lived experience relies on the idea that there is ‘unique personal knowledge about the world gained through direct, first-hand involvement in everyday events, rather than through representations constructed by other people’.6 I’ve discovered this to be surprisingly controversial, having had more than a few conversations with people about it. As a future doctor, on my palliative care visits I had my own lived experience and learned what you can’t learn from a book. In the first years of medical school, textbooks give you bulleted lists about health inequity—smoking, diabetes, socioeconomic status, housing, mental illness. But there is some limit to how much of the picture you can glean from textbooks, or even the anatomy lab. Trying to piece together a life from the nail polish on a hand. You can learn still more by listening deeply to the patient in their own domain.7

What people don't like about the concept of the lived experience is that it means those people affected by a social determinant of health always know the most about it.8 They
should be leaders in solving the issue. This especially applies to Māori health, where Māori should be in leadership positions at every level of equity measures and decision-making. However, people often confuse ‘stepping back’ in favour of those with lived experience as a slight to their own ability to experience empathy. In a recent Spinoff documentary discussing the resilience found in high-priority rural communities, I heard this: “Some people glide through life, never really touching the sharp edges that come with highs and lows.” The balance between empathy—the exploration of experience beyond our own worlds—versus the wisdom that only comes from lived experience, is a dilemma. I say to any future healthcare professional that, being out here, and touching the sharp edges, is the best we can do to understand.

Competing interests:
Nil.

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Author information:
Victoria Murphy: Faculty of Medical and Health Sciences, University of Auckland, Auckland, New Zealand.
Emily Gill: Faculty of Medical and Health Sciences, University of Auckland, Auckland, New Zealand; Department of General Practice and Primary Health Care, University of Auckland.

Corresponding author:
Victoria Murphy, Medical Student, University of Auckland Faculty of Medical and Health Sciences. Email: Vmur259@aucklanduni.ac.nz

URL:

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The rise of cannabis vaping: implications for survey design

Jude Ball, Jane Zhang, David Hammond, Joseph Boden, James Stanley, Richard Edwards

Until about 2010, smoking of cannabis (in a joint, pipe or bong) was by far the dominant mode of use, globally and in New Zealand. Whether a survey investigated prevalence of ‘smoking’ or ‘using’ cannabis, the results would be expected to be virtually the same. That is no longer the case.

Vaporisers are now available in New Zealand that allow users to vape (rather than smoke) dried cannabis leaf or buds.\(^1,2\) Additionally, in jurisdictions where cannabis has been legalised, vaping of e-liquids containing THC (the psychoactive component in cannabis) and edible cannabis products have become increasingly popular, particularly among young people.\(^3-5\) In some countries where cannabis use remains illegal, THC e-liquids and edibles are available on the black market (eg, they were widely used in Canada before legalisation of recreational cannabis in 2018).\(^6\)

In New Zealand, little is known about how the evolution of cannabis products and devices has affected mode of administration at the population level.

Aims

Our aim was to investigate changing modes of cannabis administration in New Zealand and inform question design in New Zealand health surveys.

The Youth Insights Survey is unusual among health surveys in this country in that it includes questions on both the smoking and vaping of cannabis. We used Youth Insights Survey data to investigate the proportion of Year 10 students who reported past month vaping of cannabis, smoking of cannabis and use of both modes.

Methods

The Youth Insights Survey is a biennial nationally representative survey of Year 10 students (aged 14–15 years).\(^7,8\) It was run by Te Hiringa Hauora/Health Promotion Agency as part of the New Zealand Youth Tobacco Monitor until 2018, when it was discontinued. To increase statistical precision, we pooled data from the 2016 and 2018 years (N=5,573).

Past month vaping of cannabis was based on the question: ‘During the last 30 days (one month) how often did you use e-cigarettes (e-cigs, vapes) that had marijuana or hash oil in it?’ (Never tried/I don’t know whether there was marijuana or hash oil in the vapour/In the past but not in the past 30 days/Once in the past 30 days/2–3 times/About once a week/Several times a week/ Most days).

Past month smoking of cannabis was based on the question: ‘During the last 30 days (one month) how often did you smoke marijuana (pot, weed, grass, cannabis)?’ (Never/In the past but not in the past 30 days/Once in the past 30 days/2–3 times/About once a week/Several times a week/ Most days).

Analysis was limited to participants who answered both questions (N=5,334). Descriptive statistics gave the proportion of the population, and of past month cannabis users, who vaped cannabis, smoked cannabis, vaped cannabis exclusively (ie, vaped and did not smoke cannabis), smoked cannabis exclusively and used both modes. Population estimates were adjusted for sample selection and non-response and weighted to the ethnicity and gender distribution of the Year 10 student population.
Results
As shown in Table 1, about 9% of Year 10 students reported using cannabis in the past month. Smoking remained the most common mode of administration, with over 90% of past month users reporting they smoked cannabis in the past month. However, vaping of cannabis was also relatively common, with about a quarter of past month users reporting they vaped cannabis in the past month. Those who vaped exclusively made up about 7% of past month users.

Discussion
Our findings show that, although smoking remained the dominant mode of cannabis use among Year 10 students (14–15 years) in 2016–2018, vaping of cannabis was also relatively common in this age group. About a quarter of past month cannabis users reported vaping cannabis, and about 7% of reported vaping exclusively. A limitation of the study was lack of any data on ingestion of cannabis products.

Our findings, and those from North American studies, suggest that survey questions that only ask about ‘smoking’ of cannabis are increasingly likely to underestimate cannabis use. We recommend that questions in future surveys ask about any cannabis ‘use’, with a follow-up question on product type (eg, dried herb, oils, solid concentrates, edibles) and mode of administration. Modes investigated should include: (i) smoking cannabis by itself, (ii) smoking cannabis mixed with tobacco, (iii) vaping and (iv) ingestion.

Vaporisers for cannabis use were relatively new to New Zealand in 2018 (and typically quite expensive), so use among adolescents would be expected to be low. That a quarter of past month users in this age group had vaped cannabis was therefore surprising. The proportion of adolescents vaping cannabis is likely to have grown since 2018, given the increasing availability of low-cost vaporisers and the general growth of vaping (eg, vaping of nicotine) in this age group. According to the ASH Year 10 Snapshot survey, regular e-cigarette use (monthly or more often) in New Zealand Year 10 students increased from 7% in 2018 to 12% in 2019.9

The rise in cannabis vaping also has implications for tobacco and e-cigarette research. Cannabis vaping is seldom acknowledged in such research, where questions about ‘vaping’ or ‘e-cigarette use’ seldom explicitly specify whether cannabis vaping is included in the definition.10 For example, the 2019/20 New Zealand Health Survey explicitly excluded cannabis smoking when asking

Table 1: Prevalence of past month cannabis use in Year 10 students, 2016–2018 (pooled), N=5,334.

<table>
<thead>
<tr>
<th></th>
<th>Past month cannabis use</th>
<th>Vaped cannabis</th>
<th>Smoked cannabis</th>
<th>Vaped cannabis exclusivelya</th>
<th>Smoked cannabis exclusivelyb</th>
<th>Both smoked and vaped cannabis</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>453</td>
<td>124</td>
<td>418</td>
<td>35</td>
<td>329</td>
<td>89</td>
</tr>
<tr>
<td>Year 10 population</td>
<td>Unweighted</td>
<td>8.5%</td>
<td>2.3%</td>
<td>7.9%</td>
<td>0.7%</td>
<td>6.2%</td>
</tr>
<tr>
<td></td>
<td>Weighted (95% CI)</td>
<td>8.6% (7.6, 9.6)</td>
<td>2.5% (2.0, 3.0)</td>
<td>7.9% (7.0, 8.9)</td>
<td>0.7% (0.5, 0.9)</td>
<td>6.1% (5.3, 7.0)</td>
</tr>
<tr>
<td>Past month cannabis users</td>
<td>Unweighted</td>
<td>-</td>
<td>27.4%</td>
<td>92.3%</td>
<td>7.7%</td>
<td>72.6%</td>
</tr>
<tr>
<td></td>
<td>Weighted (95% CI)</td>
<td>-</td>
<td>24.4% (19.4, 30.3)</td>
<td>93.3% (90.3, 95.5)</td>
<td>6.7% (4.5, 9.7)</td>
<td>75.6% (69.7, 80.6)</td>
</tr>
</tbody>
</table>

a Defined as past month vaping of cannabis, in the absence of past month smoking of cannabis.
b Defined as past month smoking of cannabis, in the absence of past month vaping of cannabis.
whether participants smoked tobacco, but no explicit exclusion was made in questions about vaping. As a result, there is a lack of clarity about what e-cigarette/vaping questions are measuring, since respondents may interpret them differently. Overseas research suggests that using photographs of devices to define what researchers mean by ‘vaping’ is likely to lead to more accurate estimates of use\textsuperscript{11} and that follow-up questions are needed about the substance(s) being vaped (nicotine, cannabis/THC, or neither).

In 2019, both cannabis and e-cigarette use were more common than tobacco smoking in New Zealand adolescents.\textsuperscript{12} Technologies and products are changing rapidly, necessitating careful design of surveillance surveys to capture changing substance use behaviours. Although changing the wording of questions or definitions may limit comparability with past survey years when considering trends, comparability is also compromised when question wording does not reflect the changing reality of use.

**Conclusions**

There is a need for careful population-based monitoring of substance use, particularly among young people. The discontinuation of the Youth Insights Survey in 2018 has left a gap that is yet to be filled. It is important that survey questions capture and differentiate use of differing substances (eg, nicotine and cannabis) and modes (eg, smoking, vaping and ingestion). To ensure estimates of substance use are accurate, and to aid research into evolving modes of use, both adult and youth surveys should include questions on mode of cannabis administration. Survey questions about ‘vaping’ or ‘e-cigarette use’ should explicitly include or exclude cannabis, and questions about substances vaped should be included, where relevant.
Competing interests:
Nil.

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Author information:
Jude Ball: Public Health Department, University of Otago, Wellington.
Jane Zhang: Public Health Department, University of Otago, Wellington.
David Hammond: School of Public Health Sciences, University of Waterloo, Ontario.
Joseph Boden: Department of Psychological Medicine, University of Otago, Christchurch.
James Stanley: Public Health Department, University of Otago, Wellington.
Richard Edwards: Public Health Department, University of Otago, Wellington.

Corresponding author:
Jude Ball, Public Health Department, University of Otago, Wellington,
23A Mein Street, PO Box 7343, Wellington South 6242, 04 918 6576
Jude.ball@otago.ac.nz

URL:

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Perforation of the Bladder

By D. M. Wilson, M. B., Medical Superintendent, Southland Hospital

There was reported by Dr. W. A. Anderson in the previous number of the Journal the notes on a fatal case of apparently spontaneous rupture of the urinary bladder.

The following notes on a case of traumatic perforation of the bladder may be of interest:

W.A (male, age 41 years) was admitted to hospital about 5 p.m. on 3rd May, 1921, with this history:—Two or three hours previous to admission he was descending a threshing-machine, when he was impaled by the sharp broken end of a pitchfork handle. The implement entered the perineum, and he withdrew it himself. In his opinion it must have entered at last six inches. He noticed its withdrawal was followed by a gush of water—not blood. After examination by his doctor he was ordered to hospital with a diagnosis of "suspected rupture of bladder."

On admission patient's temperature was 98 and pulse 64. He did not appear ill and there were no signs of shock, in spite of a motor run of 20 miles. There was no vomiting or nausea. There was no pain except about perineum, and this was only elicited on turning the patient over to examine him. Examination revealed a punctured wound one inch in front of anus and slightly to left of mid-line. This wound was not bleeding and there was no sign of escaping urine. A probe could only pass two inches into the wound. Per rectum—Some tenderness over the prostate, but no sign of laceration in rectal wall, nor could any damage to prostate be felt. There was no sign of blood about urethral meatus. Patient had not attempted to micturate since accident. Examination of abdomen revealed slight tenderness on deep palpation over bladder. There was neither rigidity nor guarding, and abdomen moved freely with respirations. There was no evidence of extravasation of urine into cellular tissues of lower abdominal wall. A rubber catheter passed without obstruction into bladder and seven ounces of clear urine withdrawn. There was no blood in urine. Care was taken to pass the catheter just into the bladder to avoid the chance of catheterising the peritoneal cavity, should there be an intra-peritoneal perforation.

From the patient's history it seemed evident there was a perforation of the bladder. The question immediately arose, when deciding the treatment, was perforation intra or extra-peritoneal, or both? From the position of the wound and general condition of the patient the more likely type was the extra-peritoneal, but there was the possibility of the fork handle having penetrated two walls of bladder, producing two laceration, one of each type.

The patient was advised to submit to an exploration of the wound under anaesthesia, as the probe could only pass two inches and the wound was too small to insert the finger. However, the patient was averse to this, as there was no clinical evidence, apart from his statement, that the bladder was perforated. It was therefore decided to keep him under observation.

A catheter with suction apparatus was tied into the urethra about 7 p.m. After about three ounce of clear urine had been drawn off, patient pulled out the catheter. He spent a fairly comfortable night.

When seen at 9 a.m. on the 4th his temperature was 99.2 and pulse 60. He did not complain of any pain, but on examination there was more tenderness on pressure over bladder region, but still neither rigidity nor guarding. There was no sign of extravasation of urine under the skin nor escape from perineal wound or urethra. Abdomen was examined for free fluid, but this could not be elicited, although there was dullness in left iliac fossa. Bowels acted well with enema. Bladder was catheterised and eleven ounces of urine withdrawn. This urine was quite clear except the last two or three drachms, which were blood-stained.
Patient had had no desire to pass urine and had not attempted to do so.

When seen in the afternoon his temperature and pulse were same as at 9 a.m. He was more tender over bladder and now a little guarding was elicited. The abdomen was also slightly distended. Patient now had desire to micturate, but was unable to do so. Examination of blood revealed a leucocytosis of 13,000. Free fluid in the abdomen was not definitely elicited, but the dullness in the left iliac fossa had increased. Patient was advised that operation could no longer be delayed, and this time he was quite agreeable to submit.

The signs and symptoms pointed to an intra-peritoneal tear, so a mid-line incision was made between umbilicus and pubis. On opening peritoneum free urine was found in the cavity, and inspection of the bladder revealed a gaping tear one inch long high up on the posterior surface of the bladder. The bladder still contained several ounces of clear urine, and with each respiratory movement a little urine was spilled into the abdominal cavity. The peritoneal cavity was swabbed dry and the deepest part of the pelvis inspected. The bowel was normal and a wound was seen in the peritoneum between the rectum and bladder. The lips of this wound were already becoming glued together with lymph. This lymph was the only sign of peritonitis, as there was not even any injection of the intestinal capillaries. On inspecting the bladder further it was seen to have received only one wound, and this was closed by purse-string and Lembert suture. A drain was left down to the pelvis and the abdomen otherwise closed. Before closing a rubber drain was passed into the perineal wound up to, but not through, the peritoneal wound in the pelvis. A catheter was also left in to drain the bladder.

The patient’s after-history was uneventful. The catheter was removed in 36 hours, and the two drainage tubes after 48 hours. The wounds healed practically by first intention. The patient was up in a fortnight and discharged at the end of three weeks. As soon as the catheter was removed he regained full and normal control of the bladder.

This case is interesting in one or two aspects:—(1) Entire absence of symptoms of any serious internal injury. When a traumatic rupture of the bladder occurs with other lesions the bladder condition is apt to be overlooked. (2) Text-books state that in these cases on catheterising a little blood only is withdrawn. Here several ounces of clear urine were withdrawn, and at time of operation there was still clear urine in the bladder. (3) This case is typical, in that peritonitis is of slow and gradual onset in a low form when the urine remains aseptic. Death usually occurs about the fifth of sixth day if condition is untreated. (4) The site of the perforation. The implement evidently passed between bladder and rectum and must have entered a distended bladder. Damage to prostate and seminal vesicles could not be elicited and urethra certainly was intact.
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