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Characteristics of pulmonary rehabilitation programmes in New Zealand: a survey of practice prior to and during COVID-19

Sarah Candy, Julie Reeve, Rosie Dobson, Denise Taylor

Pulmonary rehabilitation (PR) is designed to reduce symptoms and improve quality of life for people living with chronic respiratory conditions. This study aims to explore how PR services are delivered across New Zealand and how this may impact participants' ability to access services. The paper also explored how the national restrictions impacted services and has shown how programmes were able to adapt and develop new home-based services. Further work needs to be continued to develop home-based PR services which meets the needs of all our participants.

Outcomes for Māori and European patients admitted to New Zealand intensive care units between 2009 and 2018

Alice L Reid, Michael Bailey, Matire Harwood, James E Moore, Paul J Young, on behalf of the ANZICS CORE Management Committee

Despite younger age, Māori admitted to ICUs in New Zealand have more comorbidities and severe illness than their European counterparts. Barriers to accessing ICU for Māori might potentially contribute their higher illness severity by the time of ICU admission. However, the observation that Māori ICU patients are much younger than European ICU patients but still have more chronic comorbidities than they do, implies that an unequal burden of underlying conditions is one contributor to inequality in ICU outcomes.

Risk factors differ for Gram-negative surgical site infection following hip and knee arthroplasty: an observational study from a national surveillance system

Aakash V Chhibber, Sally A Roberts, Nikki Grae, Arthur J Morris

While infection following elective orthopaedic hip and knee joint replacement is uncommon in New Zealand (occurring in approximately 1.1% of procedures performed), the large volume of surgery (with over 17,000 surgeries performed each year) leads to a number of very complex surgical site infections which cause significant morbidity and these are projected to increase. There is room for improvement in our current rate of infection, and there are multi-faceted scientific approaches to achieve this. While most of the current focus is on the most common pathogen Staphylococcus aureus (vis-à-vis "anti-staphylococcal bundle"), little attention is paid to other pathogens. Here we describe and try un-pick the underlying cause of a significant minority of infections, caused by a different group of germs ("Gram-negatives infections"). We identified a number of modifiable and non-modifiable risk factors and highlight the complexity of reducing infection rates.

Infective endocarditis in patients with rheumatic heart disease: a single-centre retrospective comparative study

Ammar Alsamarrai, Cathlyna Saavedra, Aliya Bryce, Eliazar Dimalapang, Alison Leversha, Simon Briggs, Nigel Wilson, Miriam Wheeler

Patients with rheumatic heart disease, a condition that is common in New Zealand, are at risk of developing a devastating complication called infective endocarditis. This has a mortality rate of approximately one in three patients. The best way to avoid this is to prevent infective endocarditis from occurring through improved access to dental care and appropriate antibiotic use before certain procedures.

Gynaecological cancer pathway for faster cancer treatment: a repeat clinical audit

Rebekah J Cherry, Anand Gangji

People with gynaecological cancer (cancer of the female genital organs) require different tests and discussion with subspecialists before they can receive treatment, with the overall aim to receive their first treatment within 31 days of the treatment plan being made and 62 days of being referred to the gynaecology specialists. Patients being seen by Northland DHB are being seen faster compared to previous studies, with the targets being reached for more people. However, this study showed that there are still differences in wait times for Māori compared to non-Māori, as well as for those receiving treatment in Northland compared to Auckland. Māori also present at a younger age with gynaecological cancers and were sometimes considered not to be high risk for cancer when they were referred to speciality services.

Epidemiology of major trauma in New Zealand: a systematic review

Luisa Montoya, Bridget Kool, Bridget Dicker, Gabrielle Davie

This systematic review showed that the incidence of major trauma in New Zealand varies by age, sex and ethnicity. Motor vehicle crashes and falls were the most common mechanism of injury among trauma patients across all age groups. Length of hospital stay was greatest in patients with the highest Injury Severity Scores.

Characteristics of patients hospitalised with traumatic brain injuries

Maria Bentley, Pragya Singhal, Grant Christey, Janet Amey

Suffering a traumatic brain injury (TBI), either by itself or with other injuries, can have a huge impact on a person's life. Since 2012 the number of people needing hospital-level care each year has increased; and some people have to leave the region for care and rehabilitation that can't be provided closer to home. Many injuries come from transport crashes and falls. TBI does not just affect the injured person but also their whānau and wider community, sometimes for many years after the injury happened. As healthcare and rehabilitation services develop in the future, people's experiences are needed to ensure the right services and treatments are readily accessible and available to help recovery.

Is it time to ration access to acute secondary care health services to save the Aotearoa health system?

Saxon Connor

At face value, Aotearoa's health system seems to provide "cradle to the grave" universal healthcare to all New Zealanders, with the aim of allowing individuals to lead healthy and fulfilling lives. By population metrics, Aotearoa seems to do well with an overall life expectancy of 83 years, with annual increase of 0.18%.[1] On the global happiness index, of which health contributes a significant component, Aotearoa is ranked within the top ten countries in the world.[2]

The Aotearoa health system is facing increasing pressures due to unprecedented demand. In secondary care, active decisions to ration infrastructure investment, workforce training and budget spend have been made. Yet no coordinated approach to explicitly ration acute secondary care demand to match available resources has been implemented. The workforce would appear to be at breaking point. We must consider some important principles, issues and barriers if explicit rationing were to be implemented in a just and fair way.

Aotearoa's health system is required to operate within the principles of several important legal documents, including: Te Tiriti o Waitangi[3], article 25 of Universal Declaration of Human Rights (1948),[4] Right 8 of the New Zealand Bill of Rights Act (1990),[5] the New Zealand Public Health and Disability Act (2000) [6] and the Code of Health and Disability Services Consumers' Rights [7]. Importantly, these state that all people have rights to good health and access to necessary resources,[4,7] and that no one individual should be deprived of life unlawfully or inconsistently with principles of fundamental justice .[5] Such principles are to be pursued to the extent that they are reasonably achievable within the funding provided.[6,7] District health boards (DHBs) are expected to operate in a financially responsible manner and endeavour to cover all annual costs.[6] In addition, each DHB is required to be a good employer, which includes providing a good and safe working environment for its staff.[6] However, there is no mention in these documents on the process or principles to apply should underlying resources not be able to meet the previously stated requirements. Although the concept of fundamental justice is incorporated in the New Zealand Bill of Rights,[5] a clear and concise definition remains elusive.

Secondary care health services within Aotearoa would seem to be in crisis. The collective draft deficit of the country's district health boards for the 2019–2020 financial year was reported to be $885 million.[8] Fit-for-purpose functional infrastructure remains a major problem.[9–12] Numbers entering the lengthy training programmes required to produce highly specialised healthcare workforces are tightly controlled at a national level, and projections are estimating a significant shortfall of medical staff.[13] The average numbers of hours worked by medical staff are decreasing.[14] These constraints are surfacing as major workforce issues. A provisional improvement notice has been served on at least three emergency departments by nursing staff this year alone,[15] alongside nationwide industrial action. A study of Senior Medical Officers in Aotearoa reported up to 50% prevalence of burnout.[16] Burnout is an important issue in health workforce due to its association with an increase in medical errors, reduced quality of care and withdrawal of individuals from the health workforce.[16] Loss of health professionals from the public workforce leads to more pressure on those remaining and becomes a vicious cycle.[16]

It seems clear there is a burning platform. Is it acceptable to continue to have unrestricted access to a hospital or service that has exceeded sustainable working conditions?

Active decisions have been made to ration the fiscal, infrastructure and workforce pillars required for a functioning secondary care health system. Yet there is not an explicit coordinated approach to rationing demand. The attempt to

meet all healthcare needs would overwhelm any country's resources, including the need for other social goods, such as education or law and order.[17] Therefore, rationing in the public healthcare system is necessary to ensure a balance of social goods can be provided to optimise the overall wellbeing rather than just the underlying health of a society.

Rationing has long been part of Aotearoa's health system. Widely publicised and respected examples include PHARMAC, access to solid organ transplantation and surgical waiting lists. There have also been efforts to prioritise health funding.[18] However, the current workforce pressures in secondary care are being created by the acute demand. Patients presenting acutely currently benefit from a passive approach to rationing using a combination of the principles "first in, first out" or "sickest first" (Table). Yet resources in secondary care are in the main shared by elective services and in most public hospitals elective service means urgent and cancer-based conditions. Thus, those classified as "elective patients" are having their care rationed without following ethical process for scarce resource allocation.[19] The current passive approach exacerbates waste and current inequities of the health system through lost opportunity and by favouring those with streamlined access to the system.

So why is acute demand not being explicitly rationed and whose responsibility is this? For individual health professionals, the fear of being vulnerable to criticism from society, colleagues or regulatory bodies means many take the path of erring on the side of intervention. Within the medical fraternity there is wide variation in acceptance of rationing. Some perceive a conflict with the Hippocratic oath. Individual clinicians may feel conflicted: should they advocate for the individual patient or the sustainability of the health system? Thus, a collective approach from society is required to tackle this issue. Even with a collective approach from society, the process itself may still fail, as participating individuals may remain uncomfortable with the moral responsibility of the role and prefer the decisions to remain implicit or have the appearance of randomness. Such an approach allows for unwanted variation and bias resulting in increased inefficiency and waste within the health system, further exacerbating the underlying problem. It leaves individuals within the workforce vulnerable to being held accountable for the expected outcomes of a flawed system.

There are several principles (Table) that have been suggested as ways of rationing healthcare, each with its own strengths and weaknesses.[17,20-22] Mostly these have been applied as individual principles or in descending order to break stalemates between equivalent patients. There seems to be little literature on a multi-principle-weighted approach to rationing across the spectrum of acute healthcare. Western cultural values are often at the forefront of discussions, and there is a need in the context of Aotearoa's health system to incorporate the principles of Te Tiriti o Waitangi.[19] Western societies often place the individual at the centre of decision-making, whereas other cultures may centre decision-making around extended family or societal relationships.

If principles considering prognosis are to be included, consideration as to which metric should be used. Frailty scores may help provide estimates of remaining life expectancy[23] and, potentially, may help ration by more than simply age.[24] However, careful consideration would be needed if this were applied to the Aotearoa population, given the delayed presentation and potential worse prognosis at presentation of Māori and Pacifica populations. How to risk adjust or incorporate this into the decision-making would need to be addressed to avoid systemic bias. In a multi-principle-weighted model, a weighting for potential resources consumed either by time, cost or workforce should be considered.

Rationing has recently received increased attention due to the COVID-19 pandemic. Whether this refocused attention can subsequently be translated to help health systems beyond the pandemic is yet to be seen.[25] Removing the taboo around such discussions in healthcare are critical if we are to achieve a fair, just and sustainable system.[25] In terms of the principles of implementation, several authors stress the importance of following fair processes in such high stakes decisions.[17,21,26] These include the need for a legitimate institution, transparent decision-making, reasoning according to information available, a plurality of principles that help address differing stakeholders' values, a process for appeals and meaningful public engagement.[17,21,26]

In terms of a legitimate institution, it would seem important for this to be independent of political, lobbyist or interest group interference.[27] Consideration should also be given to a body that oversees resource use within the health sector specifically aiming to identify areas of "waste" within either system processes or medical interventions.

Table: Principles of rationing that could be applied to healthcare.

Principle	Benefits or weakness
Egalitarian: each person should have equal opportunity	
Lottery	This system is simple to administer and hard to corrupt but would be hard to consistently apply in emergency healthcare setting. Likely lead to some decisions that would be morally challenging to accept at an individual patient level.
First in, first out principle	Can occur passively in most systems but favours those with power and influence and can lead to corruption and inequities due to manipulation of the system. Can have flow on effects by creating inequity in other parts of the health system due to lost opportunity.
Prioritarian: favouring those individuals with a specific health attribute	
Sickest first	This prioritises those who worst off right now but ignores potential prognosis or likely outcome. It finds favour in humans' psychological responses to people near death in that they wish to intervene no matter how small the chance of success or likely benefit. It leads to ignoring those who may become sick but don't yet qualify and hence may have worse prognosis when finally meet criteria for intervention.
Youngest first	Prioritises young over old to give all individuals equal opportunity to live a normal life span. Can be considered as prioritising those who likely to be most benefit to society in future.
Utilitarian: maximising benefits	
Maximising total number lives saved	Aims to save the most lives, thus benefiting the greatest number but does not consider the quality or prognosis of those lives.
Maximising prognosis or total life years saved.	Maximises life years produced to the system, including accounting for quality or disability adjusted life years. Therefore, may sacrifice several people for benefit of one individual. Potentially biases against the elderly.
Social value: based on past or potential future perceived social usefulness	
Instrumental value	Places preference or priority on those who have a perceived future value to society. Is open to manipulation and likely favours the powerful.
Reciprocity	Rewards those who are deemed to have added value to society in the past. This is open to manipulation and abuse.

Gaining consensus of the lay population, ethicists and medical professionals will be important. Although there is evidence of common ground, there is also evidence suggesting that these three groups may differ in their priorities of the guiding relevant principles.[28] Building consensus and having a process that allows differences to be acknowledged while still finding a way forward will be important. A possible forum is the use deliberative democracy in form of citizen juries, which were trialled during Aotearoa's euthanasia debate.[29] Potentially this is where the use of a multi-criteria decision-analysis support tool, such as 1000minds, could be advantageous.[30] Such a tool allows patients to be prioritised according to defined criteria, with individual weightings, and for stakeholder preferences to be incorporated. It is possible lay stakeholders would engage in the above processes if there was a wider understanding of the extent of the total healthcare spend being used within the last 1,000 days of life. Currently, in the United Kingdom, one-third of the total healthcare cost is spent within the last 1,000 days of life.[31] In Aotearoa, in-patient costs in the last year of life are eight-times higher in comparison to costs for age equivalent individuals who did not die in same time-period.[32]

At a pragmatic level, understanding how this could be implemented in an acute inpatient setting is challenging. For example, could patients be pre-emptively categorised? Moosa et al proposed such a system for the use of dialysis in a middle-income country.[25] Category 1 were patients eligible for full treatment. It was agreed the cap on dialysis would increase to meet this need. Patients in Category 3 were offered compassionate care alone. And patients in Category 2 were all patients in between. Category 2 patients were treated if resource was available at the time they required treatment. The cap, however, was not extended to enrol them in treatment. Could this be applied to a population such that predetermined Category 3 patients would not be admitted to secondary care but instead be offered compassionate care at home or in residential care. How such an approach could translate across a whole spectrum of emergency specialties and disorders is unknown.

The explicit and systematic application of rationing could better help Aotearoa society understand the limitations currently faced by the health system. It would allow people to think ahead and potentially reconsider how they plan to use their wealth as they age. It may stimulate the government to think about creating an equivalent of a "Cullen fund" for health. At a micro-allocation level, by pre-emptively and explicitly making these decisions at a population level, the burdens and bias associated with individuals making such decisions are removed. It would have the advantage of removing unwanted variation in clinical decision-making and reduce the frequency of futile treatment. Both of which are expensive hidden costs within the current health system.

These conversations would allow Aotearoa to reconsider the purpose of the health system. Is "cradle to the grave" philosophy still appropriate, sustainable or affordable? Should the purpose be to provide equity of healthcare access and outcomes to a certain point? For those individuals privileged enough to live beyond the agreed outcome, self-funding would be required. This is accepted with other social goods. Should health be any different?

These are challenging conversations that many don't wish to have. However, by avoiding them unwanted variation and bias flourish within the AHS. Is it morally and ethically acceptable for a generation of health privileged individuals to leave a legacy of financial debt and a decimated workforce in pursuit of delaying an inevitable death at any cost?

COMPETING INTERESTS
Nil.

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Characteristics of pulmonary rehabilitation programmes in New Zealand: a survey of practice prior to and during COVID-19

Sarah Candy, Julie Reeve, Rosie Dobson, Denise Taylor

ABSTRACT

BACKGROUND: Pulmonary rehabilitation (PR) is a core component in the management of symptoms for people living with chronic lung disease. Access to PR is a barrier for many people, which results in low uptake and completion. Differences exist in the structure, organisation and content of PR services both nationally and internationally. Developing an understanding of service provision in Aotearoa New Zealand is important for future developments which aim to reduce barriers to access.

AIM: The primary aim of this survey was to develop an understanding of current pulmonary rehabilitation practices in New Zealand. The onset of a COVID-19 lockdown in New Zealand in March 2020, shortly after completion of the initial survey, enabled a follow-up survey to determine how services had adapted in response to the global pandemic.

METHODS: A cross-sectional observational design using two sequential purpose designed online surveys administered before (Survey 1) and after COVID-19 lockdowns (Survey 2) in New Zealand.

RESULTS: Survey 1 was completed by 36 PR services across New Zealand and showed homogeneity in the content and structure of services provided. PR was primarily funded by district health boards, run by a multi-disciplinary team of health professionals and included participants with a range of chronic respiratory conditions. All programmes completed pre- and post-PR assessments, were a minimum of eight weeks in duration and included exercise and education. Survey 2 showed that, during level 4 and level 3 COVID-19 restrictions, 11 (40.7%) of services paused PR programmes, with 16 (59%) adapting the service to provide home-based rehabilitation via telephone or teleconference facilities.

CONCLUSION: PR programmes in New Zealand report following Australian and New Zealand PR best practice guidelines and are homogenous in content and structure, but COVID-19 restrictions highlighted the need for services to provide more diverse options for service delivery. Future service development should focus on providing a range of delivery options allowing increased access to PR, tailoring therapy to meet individual needs and ensuring services are engaging for all participants to optimise participation.

Pulmonary rehabilitation (PR) is an evidence-based, multidisciplinary intervention that is a key component in the management of people living with a chronic respiratory disease, including COPD.[1] PR is a formalised, highly structured programme that includes exercise, self-management, education and behaviour-change support with health professional supervision. PR has been clearly demonstrated to improve breathlessness and health-related quality of life (HRQoL) and to reduce hospital admissions for exacerbations of COPD.[2,3] Clinical guidelines strongly recommend the uptake of PR by all people with COPD, particularly following hospital admissions.[1] Despite this, the uptake of, and sustained engagement with, PR programmes in New Zealand is poor, with estimates that less than 1% of all people with COPD participate in PR, and that only 38% of participants referred to PR complete the programme.[4,5] Reasons for low attendance and adherence include transportation difficulties, lack of perceived benefit, depression and the interruption to the patient's daily routines.[4,6–8]

The structure and organisation of PR services has been shown to influence attendance and completion rates.[9] Several international PR programme surveys published in recent years[10–14] have shown variability in the organisation, structure and content of programmes both within and across different countries.

The primary aim of this study was to develop an understanding of what PR service provision

looks like across New Zealand, and how this complied with best practice guidelines. The initial survey (Survey 1) sought to describe the characteristics, organisation, structure and content of PR programmes across the country. In March and August 2020, the global COVID-19 pandemic prompted significant changes in the way healthcare was being delivered in New Zealand, resulting in PR services needing to adapt in order to meet the needs of their population. Therefore, a second survey (Survey 2) was conducted following the level 4 and level 3 COVID-19 restrictions to (1) determine the impact of COVID-19 restrictions on PR services in New Zealand and (2) assess differences in pre- and post-COVID-19 PR programme delivery and content in New Zealand. Furthermore, both Survey 1 and Survey 2 aimed to identify any gaps in PR service provision and areas for development to enhance accessibility and uptake of PR for people living with a chronic respiratory condition in New Zealand.

Methods

Study design

A cross-sectional observational design, including two sequential purpose designed surveys administered online, was utilised. Ethics approval was granted from Auckland University of Technology Ethics Committee (AUTEC) on 21 May 2019, and an amendment was granted for Survey 2 on 21 August 2020. Data for Survey 1 were collected between July and September 2019 and for Survey 2 between August and September 2020.

Inclusion criteria

Programmes met the inclusion criteria if their service was consistent with the American Thoracic Society (ATS) (2016) definition for PR. See Box 1.

Box 1: PR services must include the following:

1. Programme delivered by exercise physiologist or physiotherapist
2. Minimum duration of six weeks
3. Included functional assessment (eg, six minute walk test (6MWT))
4. Included a measure of health-related quality of life
5. Included a measure of health-related quality of life

For Survey 1, programmes were required to have had a PR programme operating within the last six months. Only services which responded to Survey 1 were invited to participate in Survey 2. Respiratory support groups or maintenance groups were excluded.

Survey tool

The two surveys used a purposefully designed instrument developed by SC, JR, RD and DT. The survey was uploaded to REDcap software for administration. The survey was designed to represent the New Zealand context. Questions were developed based on other PR surveys conducted internationally[10,12–14] and adapted to the New Zealand context, which includes questions specific to the New Zealand district health board (DHB) structure, the healthcare professionals delivering PR in New Zealand and the different cultural groups seen across the country. Secondly, taking knowledge already known about PR programmes in New Zealand from previous studies,[1] and updating and extending this knowledge. Both surveys were piloted with two clinicians working in PR to enhance content validity; neither was included in the final administration of the study, but their PR services were included. Feedback from pilot was minor and the survey was modified to improve readability. Survey 1 consisted of 72 questions over five sections, taking approximately 30 minutes to complete. Survey 2 involved 25 questions over three sections and took ten minutes to complete.

Procedures

Potential PR programmes throughout New Zealand were identified through:

1. Invitations posted in physiotherapy respiratory special interest group newsletters.
2. Contacting physiotherapy professional leads at each New Zealand DHB and requesting forwarding the survey invitation to clinicians coordinating the PR programme.
3. Internet searches for PR programmes in New Zealand.
4. Utilising professional networks.

Only one respondent per service was invited to take part in the survey.

All identified PR programme co-ordinators were sent an email inviting them to participate and outlining the aims of the survey along with

a participant information sheet. Interested participants were asked to return a written consent form via email prior to being sent the online survey link via the REDcap. One automatic reminder email and survey link was sent to all participants who did not respond within 14 days.

The second survey was administered by emailing all participants who completed the first survey and inviting them to complete Survey 2.

Data analysis

All data provided was de-identified and analysed by aggregation. A simple descriptive statistical analysis was completed. The qualitative data collated from open-ended questions were analysed using a simple general inductive thematic approach to identify common themes and meanings from the data.[15]

Results

Responses

Initial searches and advertisements identified 41 potential participants for Survey 1, who were sent participant information sheets. Two respondents did not meet the inclusion criteria. Thirty-nine survey links were sent out and 38 responses were received. Two services duplicated their responses which were checked for inter-rater reliability before duplicates were removed. Responses were analysed from 36 programmes (97.3%) for Survey 1. Survey 2 was sent to all respondents of Survey 1 and 27/36 (75.0%) responded. Response rates can be seen in Figure 1. Respondents to Survey 1 were physiotherapists (n=27; 75.0%), nurses (n=7; 19.4%) and exercise physiologists (n=2; 5.5).

Geographical distribution

New Zealand is currently divided into 16 regions for local government purposes, and 15 regions had a minimum of one respondent to Survey 1. Survey 1 was completed by 28 PR services (77.7%) in the North Island (NI), and eight (22.2%) in the South Island (SI). Survey 2 was completed by 19 PR services (70.3%) in NI and five SI (18.5%), with three respondents (11.1%) not stipulating their region.

Programme setting

The majority of respondents provided PR at one site only (n=23; 63.9%), with 13 (36.1%) offering programmes across multiple sites. The setting of the programmes surveyed can be seen in Table 1. Of note, four services (10.8%) offered home based rehabilitation prior to COVID-19 restrictions in Survey 1.

Programme organisation

The programmes surveyed reported delivery by a multi-disciplinary team with 27 programmes (75.0%) reporting that they utilised four or more different healthcare professionals directly in the delivery of the programme. The disciplines reported to be involved are listed in Table 2. The majority of programmes were funded by the public health services: 26 (72.2%) by DHBs, four (11.1%) by primary healthcare organisations (PHOs) and four (11.1%) by combined DHB/PHO funding. Two programmes (5.5%) were reported to be self-funded by participants and one service (2.8%) was funded by a combination of self-funding/insurance. Referrals to the PR services came from a variety of healthcare professionals (Table 3). Sixteen services (44.4%) undertook an annual service audit of the programme. A further four services (11.1%) reported having undertaken service audits, but not on a regular basis. A service audit had never been completed by n=16 of respondents (44.4%).

Programme structure

PR programmes were mostly eight weeks in duration and predominantly utilised group-based exercise and education classes. Respondents were asked about the format of their PR programme and the majority (69.4%) used a block/cohort programme. Block programmes require that all participants start PR on the same day, whereas a rolling programme allows participants to enrol at any time. An individual (1:1) programme was reported to be offered by one (2.7%) respondent. Twenty-four (66.7%) respondents reported having a waitlist to start the programme, with eight (22.2%) reporting the wait time for PR to be up to six months, the majority of which followed a block format programme (n=6; 75.0%). Only two services (5.5%) offered PR outside of normal working hours, with the remainder of services provided only within 9am to 5pm Monday to Friday.

Programme content

The inclusion of a pre and post programme assessment was reported by all respondents, with further follow-up assessment (>3 months post completion) included by 10 programmes (27.7%). All services included measures of exercise capacity and health-related quality of life,

Figure 1: Flow chart showing the number of participants invited and the number who completed Survey 1 and Survey 2.

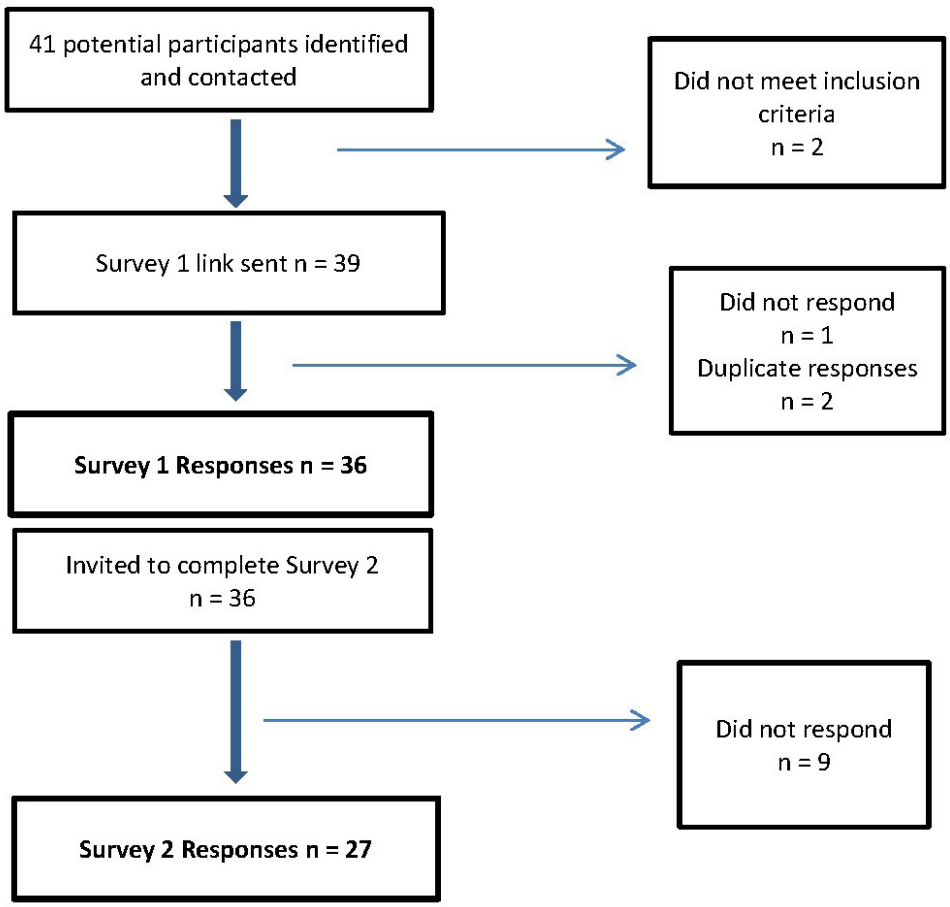

Table 1: PR programme setting (n=36).

Setting	n (%)
Hospital outpatient	19 (52.7)
Community venue	15 (41.6)
Home-based	4 (11.1)
Hospital inpatient	1 (2.7)
Church	3 (8.3)
Private facilities	3 (8.3)
Marae	2 (5.5)
Water-based	1 (2.7)
Telerehabilitation	0 (0.0)

with the different measures used shown in Table 3. Programmes included patients with a range of chronic respiratory conditions(Table 3). Only one programme (2.7%) offered multi-morbidity rehabilitation programme (ie, included participants living with multi-morbid long-term health conditions).

Respondents were asked whether they offered any adaptations to the programme for participants of different cultural backgrounds, with 22 (61.1%) reporting making adaptations to the service including: moving the location of PR to a marae (n=3; 8.3%), recruitment of healthcare professionals to reflect the different cultures in the classes (n=5; 13.8%), provision of an interpreting service (n=10; 27.7%), and provision of written material translated to different languages (n=6; 16.6%).

At the time of data collection for Survey 1, none of the services included a telerehabilitation component in their PR service. Respondents reported using digital technologies to assist in the delivery of centre-based programmes via appointment reminders through email (n=16; 44%) and/or text messaging (n=22; 61.6%). Technology was also used for delivering self-management education (n=13; 36%) in the form of videos and Microsoft PowerPoint presentations.

Survey two

Of the 27 completed Survey 2 responses, 11 centres (40.7%) stopped their PR programmes completely during the COVID-associated lockdowns (New Zealand level 3 and 4 restrictions). In the programmes that continued to operate during COVID-19 restrictions, the telephone was the most frequent modality used for completing PR assessments, delivering exercise prescription and self-management education. Some respondents utilised video-conference facilities (n =7; 25.9%) and/or text messaging (n =2; 7.4%). The content of the programmes and modalities used during the COVID-19 lockdowns is shown in Table 4. Ten services (37.0%) reported that, following COVID-19 restrictions being lifted, they planned to recommence services with the addition of telehealth options for participants, whereas five services (18.5%) reported that they would likely resume the same services as prior to COVID-19 lockdowns. Twelve services (44.4%) remained unsure of their future structure at the time of the survey.

Respondents were asked to describe the most significant barrier when trying to deliver PR during COVID-19 restrictions. The most common themes included not being able to assess participants in person (n=16; 59.2%), not being able to complete objective measures (n=15; 55.5%), a lack

Table 2: Disciplines directly involved in the delivery of PR.

Healthcare Profession	n (%)
Physiotherapist	32 (88.8)
Nurse	29 (80.5)
Dietician	21 (58.3)
Occupational therapist	15 (41.7)
Healthcare assistant	15 (41.7)
Health psychologist	10 (27.8)
Peer support / volunteer	7 (19.4)
Social worker	7 (19.4)
Pharmacist	6 (16.6)
Exercise Physiologist	5 (13.8)
Doctor (primary or secondary care)	5 (13.8)
Other *	3 (8.3)

*Others included smoke-free specialists and green prescription providers.

Table 3: Structure and content of New Zealand PR programmes (n=36).

	n (%)
Programme format	
Block programme	25 (69.4)
Rolling programme	10 (27.8)
Other (mixed n=1, individualised n=1)	1 (2.8)
Programme component	
Exercise, group education	33 (91.6)
Exercise, individual education	2 (5.5)
Other	1 (2.7)
Referrals from	
Respiratory physician	34 (94.4)
General practitioner (GP)	33 (91.6)
Physiotherapist	31 (86.1)
Nurse	31 (86.1)
Other physician	23 (63.8)
Other healthcare professional	18 (50.0)
Self-referral	12 (33.3)
Other	1 (2.7)
Participant diagnosis	
COPD	36 (100)
Interstitial lung disease	34 (94.4)
Bronchiectasis	33 (91.6)
Asthma	26 (72.2)
Post thoracic surgery	23 (63.8)
Lung cancer	19 (52.7)
Prehabilitation	18 (50.0)
Obstructive sleep apnoea	14 (28.8)
Cystic fibrosis	1 (2.8)
Breathing pattern disorders	1 (2.8)
Programme length	
<8 weeks	1 (2.8)
8 weeks	25 (69.4)
>8 weeks	10 (27.8

Table 3 (continued): Structure and content of New Zealand PR programmes (n=36).

	n (%)
Exercise test	
6MWT	30 (83.3)
1 min STS	8 (22.2)
5 rep STS	6 (16.6)
ISWT	3 (8.3)
Other (30 second sit to stand, two-minute step test, CPET)	3 (8.3)
Health-related quality of life measure	
CAT	24(66.6)
CRDQ	7(19.4)
SGRQ	5(13.8)
CCQ	3(8.3)
SF36	2(5.5)
Other (Leischer cough (2), LINQ (1),HADS (1), WHO QOL(1), EQ-5D (1))	7(19.4)
None	1(2.7)

GP: General practitioner; 6MWT: six-minute walk test; 1 min STS: 1 min sit to stand; 5 rep STS: 5 repetition sit to stand; ISWT: incremental shuttle walk test; CAT: COPD Assessment Tool; CRDQ: chronic respiratory disease questionnaire; SGRQ: St George questionnaire; CCQ: chronic COPD questionnaire; SF36: short form 36; LINQ: lung information needs questionnaire; HADS: hospital anxiety and depression index; WHO QOL: World Health Organization quality of life.

Table 4: Delivery of PR during COVID-19 restrictions (n=27).

Component of PR	Delivery modality	n (%)
Assessment	Did not complete assessment during lockdown	16 (59.2)
	Telephone	9 (33.3)
	Video conference	1 (3.7)
Exercise prescription + progression	Telephone	15 (55.5)
	Video Conference	7 (25.9)
	Paper	7 (25.9)
	Email	5 (18.5)
	Mobile apps	2 (7.4)
	Home booklet	1 (3.7)
	Not described	1 (3.7)
Self-management education	Telephone	11 (40.7)
	Paper	8 (29.6)
	Video conference	6 (22.2)
	Email	6 (22.2)
	Text messaging	3 (11.1)
	Mobile apps	3 (11.1)
	Other (web-based resources)	1 (3.7)

of digital access for participants (n= 15; 55.5%) and low digital literacy for participants and staff (n=13; 48.1%). Respondents also reported not being prepared for the restrictions, and not having the time and resources to develop alternative methods for delivering PR.

Respondents were asked whether access to national PR resources would have been helpful to the delivery of PR during COVID-19 restrictions. Twenty-one (77.8%) responded they would have liked access to resources, especially New Zealand specific exercise and self-management educational videos. Other resources respondents would have found helpful during COVID-19 restrictions are shown in Table 5.

Discussion

This study has provided valuable information on the provision of PR services in Aotearoa New Zealand and updates knowledge gained from a previous national PR survey.[5] Importantly, the study offered an opportunity to examine the impact of COVID-19 on service provision and how PR services adapted to the national restrictions and the perceived importance of maintaining this momentum in advancing the flexibility of PR service delivery.

Characteristics of PR in New Zealand

The main findings from Survey 1 showed that PR programmes demonstrate considerable homogeneity in their organisational aspects: they are largely funded by the public health system, delivered by a multidisciplinary team of healthcare professionals, and the majority include people across a range of chronic respiratory conditions. The content of PR programmes was also consistent across the regions and, importantly, mirrors best practice guidelines.[1,17] The British Thoracic Society (BTS) PR guidelines[17] recommend services complete an annual review of individual outcomes and progress. Yet our survey found this was not completed in 53% of New Zealand PR services. Developing a framework for a national audit programme, similar to that in the UK,[18] may assist smaller services to meet this recommendation and provide valuable information on service provision across New Zealand.

Provision of evidence-based PR is only part of the picture. Ensuring participants attend and complete the intervention is challenging.[4] Contributing factors have previously been identified that relate to both patient characteristics and how the service is delivered.[4,7–9,19] The current study showed New Zealand PR services have responded to some of the known barriers with the setting of PR services moving away from hospital outpatient settings and into community settings. Currently, 52.7% of PR programmes are in hospital outpatient clinics compared to 71% in 2009.[5] New Zealand has one of the highest rates of community-based programmes in the world, following Ireland, where 65% of programmes are in community venues.[20] Community-based programmes have been shown to achieve equivalent health outcomes to hospital outpatient services if delivered with a consistent format.[1] The increase in community-based services in New Zealand is an important initiative to make programmes more accessible to participants and overcome barriers associated with travel and transport. In addition, the move to community centres with cultural importance, such as marae and church facilities, demonstrate novel ways to improve engagement through making programmes more culturally engaging and meaningful to participants. Ethnicity is an important predictor of non-completion of PR.[4,18] Strategies that have been shown to assist with engagement include: the setting for PR,[21,22]

Table 5: Resources respondents reported would be helpful to deliver PR via telehealth in New Zealand (n=27).

Resources	n (%)
New Zealand-specific exercise and education videos	19 (70.3)
Televised PR programme	17 (62.9)
National telerehabilitation service	13 (48.1)
Text messaging programme	11 (40.7)
Mobile PR app	10 (37.0)
Other (written material which could be supported with telephone calls)	1 (3.7)

the staff delivering rehabilitation services,[21,23] and the use of interpreters.[24] Survey 1 demonstrated PR services in New Zealand are working towards improving cultural participation through a variety of these strategies.

Although patient barriers to uptake may have been considered, there remain several organisational and structural components of PR in New Zealand which may potentially contribute to the poor uptake and completion of PR. Most services offered only one location for PR and operated only during work hours, which limits access for people who may be unable to attend during the day. The block-style programmes were utilised by nearly 70% of the respondents, and although these programmes have been shown to be associated with improved completion rates,[9] they can also be associated with a longer waiting time to start PR. Waiting time to commencement of PR is reported as a predictor of uptake.[25] People waiting longer than 90 days are less likely to complete PR.[9] The length of waiting time is also an important consideration for people following an acute exacerbation, who are recommended to start PR promptly following discharge from hospital.[26] Survey 1 found that there were waiting lists for most PR services in NZ, which increased following the COVID-19 restrictions. Services should examine their population needs in order to determine the optimal structure to balance uptake and completion rates.

Survey 1 found the number of PR services in New Zealand offering home-based rehabilitation was low. Clinical guidelines recommend home-based PR, with regular contact, should be offered as an alternative to hospital-based PR.[1] However, it is estimated that this is offered in less than 5% of centres worldwide,[14] with Survey 1 echoing this finding for New Zealand. Emerging models to support home-based rehabilitation have been trialled internationally, including telephone support,[27] video-conferencing[28,29] and web- and mobile-based applications.[30–33] These have shown promising results. For the purposes of these surveys, home-based rehabilitation was defined as PR delivered within the participant's home with or without supervision, and telerehabilitation was defined as using information and communication technology to deliver PR from a distance.[34]Survey 1 found four services in New Zealand were using home-based rehabilitation, but no services in New Zealand were using telerehabilitation as a mode of delivery for home-based PR services prior to the emergence of COVID-19 in New Zealand.

Impact of COVID 19 restrictions on PR services

Survey 2 showed the challenge of accessing PR services was intensified with the implementation of national restrictions in response to the COVID-19 pandemic. During this time, centre-based programmes were suspended, and delivery of PR services needed to be taken to the participant in new and novel ways. Considering the low number of services offering home-based rehabilitation prior to COVID 19 lockdown, it is perhaps understandable that many services were unable to transition to new models of delivery and instead ceased services during this time. Of the services identified as offering home-based rehabilitation in Survey 1 (n=4), all continued to operate during COVID-19 restrictions.

Telephone was the PR delivery modality used most frequently by respondents who continued to provide PR throughout the lockdown periods (n= 16; 59.2%). Respondents reported the low digital literacy and access to devices for participants as one of the most challenging aspects of trying to deliver alternative PR services. Digital access and literacy have previously been reported as potential barriers to remote delivery of PR in a New Zealand study that investigated the potential for the development of technology-based PR programme.[35] Previous reports in New Zealand have shown digital exclusion can occur across all age demographics but is particularly prevalent in Māori and Pacific people,[36] who have lower access to PR programmes and poorer outcomes from chronic respiratory conditions. [37] Furthermore, international audits have shown associations between deprivation and participation in PR with people from lowest socioeconomic status having lower odds of receiving PR[38] and reduced rates of completing PR.[4,18] An Australian survey investigated computer and internet access in patients admitted to hospital with COPD in an area of high poverty, and found only 16% of patients had computer and 14% had internet access.[39] It is therefore vital that the development of alternative delivery methods for PR ensures they do not further increase inequities.

Other challenges identified in this study involved the extra staffing time required in setting up and delivering alternative programmes, such as telerehabilitation. Almost all respondents reported that having access to national resources would have assisted them in continuing to deliver PR services during the lockdown period. There are currently no evidence-based guidelines for alternative delivery methods of PR to guide clinicians. The develop-

ment of New Zealand-tailored and robustly tested resources for alternative methods of delivering PR could be helpful for overcoming known barriers to accessing traditional centre-based services by allowing rapid response to future pandemics.

Limitations

Although every effort was made to ensure all PR programmes in New Zealand were identified and included in the study, there is a possibility a programme may have been missed. A strength of Survey 1 was the high response rate. However, this was lower than expected for Survey 2, which impacts the results and may reflect the busyness of clinicians during lockdowns. Another limitation of the current surveys is that we are unable to determine capacity of PR programmes across New Zealand. Nor can we estimate the uptake of PR services for people with COPD. This survey also did not aim to look at discrepancies regarding availability of PR services across different communities, ethnicities or socioeconomic status. We realise this may influence the uptake and adherence to PR and warrants further investigation. In the future, this information may be beneficial for understanding the discrepancy between PR service referrals, uptake and completion.

Conclusion

Our study has provided important information on the structure, content, and organisation of PR services in New Zealand, and how services responded to COVID-19 lockdown restrictions. The surveys highlighted several factors which limit widespread access to PR services in New Zealand and demonstrate the potential, and the necessity, of expanding and adapting the current provision of services. PR services need to increase flexibility in the delivery options for participants, including timing, venues and modes of delivery of PR.

COVID-19 restrictions imposed in 2020 provided an unprecedented opportunity to compare how services adapted to the pandemic in New Zealand. Our surveys demonstrated that the number of home-based PR services tripled during COVID-19 restrictions, and how tele-rehabilitation programmes emerged around the country as a result. This demonstrates different models of PR can be delivered in New Zealand and shows the ability of services to be flexible in their provision of PR and to respond and rapidly adapt, but we need to maintain this momentum.

Increasing the capacity and diversity of PR options is essential to address the lack of access to programmes in New Zealand. But it is essential that these services are designed with key stakeholders to ensure they are accessible and engaging for all participants and do not increase existing disparities. Consideration in the design of services must be given to digital divide, equity and culturally engaging models. Finally, ensuring new models of care still adhere to best practice guidelines and are safe and effective is essential.

COMPETING INTERESTS
Nil.

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Outcomes for Māori and European patients admitted to New Zealand intensive care units between 2009 and 2018

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ABSTRACT

AIM: To describe characteristics and outcomes of Māori and European patients admitted to New Zealand intensive care units (ICUs) between 2009 and 2018.

METHODS: A retrospectively designed prospective cohort study. New Zealand Ministry of Health National Minimum Dataset matched to the Australia New Zealand Intensive Care Society Centre for Outcome and Resource Evaluation Adult Patient Database. The primary outcome was day-180 mortality. Secondary outcomes were ICU mortality, hospital mortality, discharge to home, ICU length of stay, hospital length of stay and survival time. We report associations between Māori ethnicity and each outcome, with European as the reference category, using regression analyses to adjust sequentially for site, deprivation status, sex, year of admission, the Charlson comorbidity index, age, admission source and type, ICU admission diagnosis, ventilation status and illness severity based on physiological parameters.

RESULTS: Māori admitted to ICU were on average 13 years younger than European patients. A total of 968 of 9,681 (10%) Māori and 2,732 of 42,871 (5.2%) European patients were admitted after trauma, and 740 of 9,681 (7.6%) and 2,318 of 42,871 (4.4%) were admitted with sepsis respectively. A total of 1,550 of 9,681 (16.0%) Māori and 6,407 of 42,871 (14.9%) European patients died within 180 days of ICU admission; odds ratio (OR) 1.08; 95% CI, 1.02 to 1.15. When adjusted for age, the OR for day-180 mortality for Māori versus European patients increased substantially. The OR decreased after adjustment for admission source and type, and after accounting for Māori having a higher comorbidity index and more severe illness than European patients. In the final model, incorporating adjustment for all specified variables, Māori ethnicity was not associated with day-180 mortality (adjusted OR 1.01; 95%CI, 0.92 to 1.10). Findings were similar for all secondary outcomes.

CONCLUSIONS: Compared to European patients, Māori were markedly more likely to be admitted to the ICU after trauma or with sepsis. Despite Māori being on average 13 years younger at ICU admission than their European counterparts, they had more co-morbidities, higher illness severity and a higher risk of dying within 180 days.

Māori have worse health outcomes than their European counterparts.[1–3] Ethnic inequalities which exist in Aotearoa New Zealand, particularly those between Māori and non-Māori, are reported consistently.[4] Reasons for these inequalities are multifactorial and complex, but likely reflect the consequences of colonisation that continue to affect Māori health.[5] There are differences in access to healthcare, and in the quality of healthcare delivery, for Māori compared to non-Māori.[6] There are also differences in broader societal issues that affect health, including housing, education, employment and socioeconomic status.[4] Despite such complexities, understanding the nature of inequalities within their own area of the health system is the first step for clinicians when developing and implementing system changes to improve health outcomes for Māori.

Māori made up 15.6% of the New Zealand population in 2013. However, the proportion of patients admitted to New Zealand intensive care units (ICUs) who are Māori has not been reported. Within ICUs, highly specialised nursing and medical teams provide healthcare for immediately life-threatening but potentially treatable acute medical and surgical conditions. ICU staff also provide post-operative care for major surgery, particularly cardiac surgery. New Zealand has a network of ICUs, including large ICUs in major cit-

ies as well as regional and rural ICUs associated with smaller hospitals.[3] It is unknown whether the outcomes of Māori and European ICU patients admitted to New Zealand ICUs differ. For ICU patients, illness severity, based on the degree of physiological derangement, as well as age, sex and chronic comorbidities, are key determinants of outcome.[7] An emergency ICU admission is generally associated with higher mortality risk than an elective post-surgical admission, and the ICU admission diagnosis is also an important outcome predictor.[7] In addition, outcomes for otherwise similar ICU patients often vary depending on the hospital they are admitted to.[7] Although a high status of deprivation does not appear to be associated with increased in-hospital mortality, it is associated with longer-term mortality[8] and is an important confounding variable to consider in an analysis evaluating outcomes by ethnicity.

In this study, we sought to describe outcomes for Māori and European patients admitted to New Zealand ICUs between 2009 and 2018. We undertook a series of analyses adjusting for potential confounders with a view to describing possible contributors to observed inequalities in health outcomes.

Methods

Study design and setting

We undertook a retrospectively designed prospective cohort study using data from the New Zealand Ministry of Health National Minimum Dataset (NMD) matched to the Australian New Zealand Intensive Care Society Centre for Outcome and Resource Evaluation Adult Patient Database (ANZICS CORE APD). This study was submitted to the Health and Disability Ethics Committee of New Zealand (20/CEN/86) and deemed out of scope due to minimal risk. The NMD is a centralised data collection system containing all New Zealand hospital admissions. The NMD is organised using patients' National Health Index numbers and administered by the New Zealand Ministry of Health.[9] The ANZICS CORE APD is an established bi-national voluntary ICU registry, which has been described previously.[10]

We used data relating to ICU admissions to New Zealand hospitals from 1 July 2009 until June 30 2018 inclusive and focused on admissions to the 17 ICUs in 16 hospitals that contributed to the ANZICS CORE APD throughout the period of interest. These included major tertiary, regional and rural public hospital ICUs in New Zealand.

Patients

All patients aged 18 years or older who were admitted to one of the 17 participating New Zealand ICUs were eligible for inclusion. Matching of patients included in the two databases of interest was performed based on six variables that were common to both databases. These variables were the name of the admission hospital, the date of hospital admission, the date of hospital discharge, age, sex and the in-hospital mortality. To account for situations where patients were transferred from one ICU to another, we linked ICU admission episodes where a particular patient was discharged from one ICU and then readmitted to another ICU on the same day. In these circumstances, descriptive baseline data were obtained from the first ICU admission and outcome data were obtained from the last ICU admission. Where a patient had multiple ICU admissions within the study period, only the first ICU admission the patient had was included. Accordingly, all ICU admissions included in our final dataset were from unique patients. Since illness severity is the key determinant of outcome for ICU patients,[7] we excluded patients where illness severity data were not available in the ANZICS CORE APD. This analysis focused on comparing the outcomes of Māori and European patients. For the purposes of this analysis, we defined patients whose ethnicity was coded as "NZ European," "European not further defined" and "Other European" as European. Patients who were neither European nor Māori were excluded from the current analysis because we plan to report outcomes for other ethnic groups separately. We ascertained long-term mortality outcomes using data from the New Zealand death registry up until June 2020.

Outcomes

The primary outcome of interest for this study was day-180 mortality. Secondary outcomes were ICU mortality, hospital mortality, discharge to home, ICU length of stay, hospital length of stay and survival time.

Outcome predictors, potential confounders and effect modifiers

To explore the extent to which Māori ethnicity is a *predictor* of adverse outcomes in the New Zealand healthcare system, we compared ethnic groupings of Māori and European using "prioritised" ethnicity classification, where each patient is allocated to a single ethnic group using prioritisation tables as used in the New Zealand Ministry of Health NMD.[11]

We specified a number of variables as *potential confounders* of the relationship between ethnicity and outcome. These variables were deprivation status, age, sex, site of admission, year of admission, chronic comorbidities as measured using the Charlson comorbidity index,[12] admission diagnosis, admission type (elective versus emergency) and source (operating theatre, emergency department, ward, transfer from another hospital and unknown), ventilation status and illness severity. Deprivation status was defined using the New Zealand Index of Deprivation (NZDep), as included in the New Zealand Ministry of Health NMD.[13] This NZDep uses data associated with postcodes obtained from the 2013 census as a surrogate for the deprivation status of individual patients. The NZDep categorises patients into deciles, from 1 (least deprived) to 10 (most deprived). Age and year of admission were calculated at the date of hospital admission. Age, sex, site of admission and year of admission we included in both study databases. However, when minor date discrepancies were encountered during merging, we used data obtained from the ANZICS CORE APD for reporting purposes. The Charlson comorbidity index[12] was calculated using pre-existing comorbidities based on ICD-10 codes included in the New Zealand Ministry of Health NMD as previously described.[14] To obtain a measure of illness severity that was independent of other potential confounders, we evaluated illness severity using only the physiological parameters included in the Acute Physiology and Chronic Health Evaluation (APACHE) III score.[15]

Statistical methods

All baseline characteristics were summarised by ethnic group using means and standard deviations for normally distributed variables, medians and interquartile ranges for other continuous variables, and counts and percentages for categorical variables. Comparisons of baseline variables by ethnic group were undertaken using Student's t-test for normally distributed variables, and Wilcoxon rank sum tests otherwise. Categorical variables were compared using chi-square tests for equal proportions.

For outcome comparisons, we evaluated the association between Māori ethnicity and outcome using European ethnicity as the reference category. For the four binomial outcomes (day-180 mortality, ICU mortality, hospital mortality and discharge home) we used logistic regression and adjusted for known covariates and baseline imbalance. These variables included: site, deprivation status, sex, year of admission, Charlson comorbidity index,[12] age, admission source and type, admission diagnosis, ventilation status and illness severity. To ascertain the individual impact of each covariate, we fitted these sequentially, with the resulting risk for Māori ethnicity (versus European) reported as odds ratios (OR), with a 95% confidence interval for each stage. An OR of more than one corresponded to a greater risk of an adverse outcome for Māori compared to their European counterparts. ICU and hospital length of stay were evaluated using a competing risk analysis adjusted for the competing risk of death, using an analogous approach to that described above with results reported at each stage as hazard ratios (HR), along with 95% CI and presented as cumulative incidence plots. For these analyses, a HR of greater than one corresponds to a shorter time to discharge alive for Māori compared to their European counterparts. Survival time to 180 days was compared using Cox Proportion Hazards regression in accordance with the approach described above, with results reported as HRs (95%CI) for each stage of model development. Proportionality assumptions for ethnicity were visually assessed using log-cumulative hazard plots. For the survival analysis, a hazard ratio of more than one corresponds to a worse outcome for Māori compared to their European counterparts because it equates to a shorter time to death.

Analyses were conducted using SAS statistical software, version 9.4 (SAS Institute).

Results

Patients

A total of 52,552 patients from 17 ICUs were included in this study (Figure 1). (The ICUs that contributed data are listed in the acknowledgments section.) A comparison of Māori and European patients in the New Zealand Ministry of Health NMD who could be matched to the ANZICS CORE APD with those could not be matched to the ANZICS CORE APD is shown in Supplementary Table 1. Of the patients included in this analysis, 9,681 (18.4%) were Māori. When patients from other (non-European) ethnic groups were included, Māori made up 15.6% of all ICU admissions. Compared to European patients, Māori patients were on average 13 years younger at ICU admission. They were more often female, had

higher deprivation status, were more likely to be admitted to ICU in an emergency, and had more severe illness (Table 1). Māori also had higher rates of some comorbidities, most notably diabetes and renal disease, and were more likely to have a Charlson comorbidity index of three or more than European patients (Table 1). Additional data on comorbidities for Māori and European patients are shown in Supplementary Table 2. Deciles of deprivation by ethnicity are shown in Supplementary Table 3. Data on admission site and year by ethnicity are shown in Supplementary Table 4.

Compared to European patients, Māori were markedly more likely to be admitted to the ICU after trauma, with sepsis, with neurological disorders and with metabolic disorders, such as complications of diabetes (Table 2).

Primary outcome

A total of 1,550 Māori (16.0%) and 6,407 (14.9%) European patients had died within 180 days of ICU admission (OR: 1.08, 95% CI, 1.02 to 1.15) (Figure 2, Table 3 and Supplementary Table 5). The effect of sequentially adjusting for potential confounding variables is shown in Table 3. Deprivation status, sex, year of admission, diagnosis and whether the patient was ventilated did not appear to be important confounders of the association between Māori ethnicity and day-180 mortality. Site had some effect, but the strongest confounder was age. Inclusion of age in the regression model increased the OR for day-180 mortality for Māori versus European patients substantially. Adjustment for the Charlson comorbidity index and for illness severity both reduced the OR for day-180 mortality for Māori versus European patients. In the final model incorporating adjustment for all specified variables, Māori ethnicity was not associated with day-180 mortality (OR 1.01, 95% CI 0.92 to 1.10).

Secondary outcomes

A total of 702 Māori (7.3%) and 2,525 (5.9%) European patients died prior to ICU discharge (OR: 1.25, 95% CI, 1.15 to 1.36), with 1,103 (11.4%) and 4,662 (10.9%) respectively dying prior to hospital discharge (OR: 1.05, 95% CI, 0.98 to 1.13). Similar proportions of Māori and European patients were discharged home (Table 3). For these outcomes, the effect of confounding variables on the associations between Māori ethnicity and outcome was similar to that observed when evaluating the relationship between Māori ethnicity and day-180 mortality, with age observed to be consistently the strongest confounder (Table 3). Site (ie, the ICU the patient was admitted to) appeared to be an important confounder of the association between Māori ethnicity and ICU mortality (Table 3). The ICU length of stay was a median of 1.5 days (IQR, 0.8–2.9 days) and 1.2 days (IQR, 0.9–2.8 days) for Māori and European patients respectively (Supplementary Figure 1). The median hospital length of stay was 7.5 days (IQR, 4.0–14.1 days) and 8.3 days (IQR, 5.1–15.0) for Māori and European patients respectively (Supplementary Figure 2). Age was the strongest confounding variable when evaluating the association between Māori ethnicity and ICU and hospital length of stay (Supplementary Table 6). In the final models, which adjusted for all specified confounders, Māori ethnicity was not an independent predictor of ICU mortality, in-hospital mortality, discharge home, ICU or hospital length of stay or survival time (Table 3, Supplementary Table 5 and Supplementary Table 6.)

Discussion

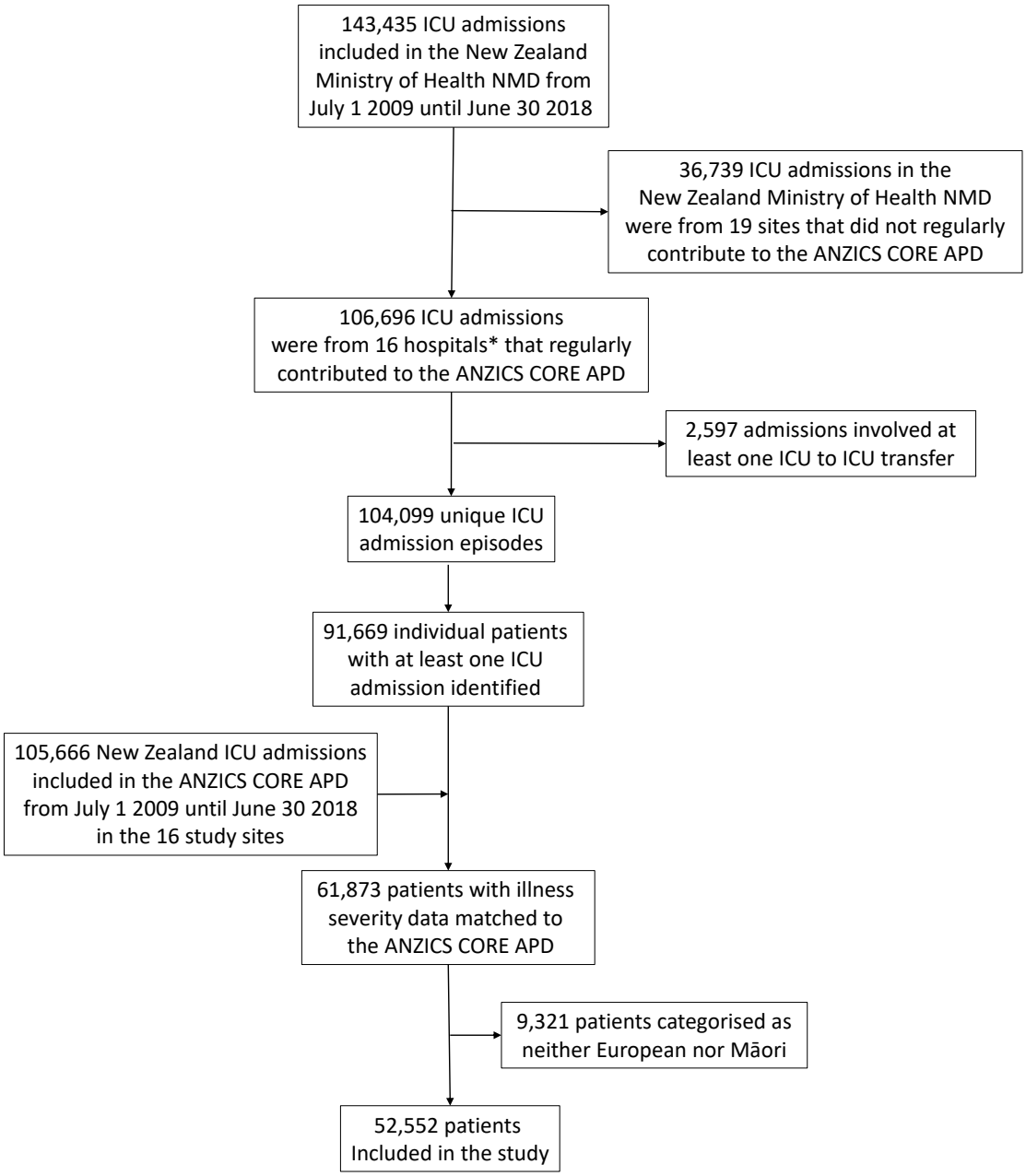
Statement of principal findings

In this retrospectively designed prospective cohort study, we compared the outcomes of Māori and European patients admitted to New Zealand ICUs between 1 July 2009 and 30 June 2018. We observed that Māori were more likely than European to die within 180 days of ICU admission. In particular, when accounting for the fact they were on average 13 years younger at ICU admission, Māori patients had a markedly higher risk of death and of other adverse outcomes. This increased risk of adverse outcomes for Māori patients appeared, in part, to be accounted for by Māori having more comorbidities, being more likely to be admitted to ICU in an emergency and having more severe illness than European patients. Deprivation status, sex, year of admission, diagnosis and whether the patients were ventilated did not appear to be important confounders of the associations between Māori ethnicity and outcomes.

Relationship to previous studies

We have previously reported that the outcomes for Māori patients enrolled in a large scale randomised controlled trial conducted in the ICU were similar to those of European patients,[17] and outcomes were also similar by ethnicity in a single ICU during the 2020 COVID-19 lockdown.[18] However, these populations are unlikely to be representative of the patients who receive ICU care in

Figure 1: Flow diagram.



*Two ICUs from a single hospital were included for a total of 17 contributing ICUs.
Abbreviations: ANZICS CORE APD: Australian and New Zealand Intensive Care Society Centre for Outcome and Resource Evaluation Adult Patient Database; ICU: intensive care unit; NMD: National Minimum Database.

Table 1: Baseline characteristics by ethnicity.*

	Māori (N=9,681)	**European (N=42,871)**
Age, yr, median [IQR]	**53 [38–64]**	**66 [54–75]**
0 to 39.9 years, n (%)	2,594 (26.8%)	4,815 (11.2%)
40 to 59.9 years, n (%)	3,761 (38.8%)	10,072 (23.5%)
60 to 79.9 years, n (%)	3,128 (32.3%)	22,418 (52.3%)
80+ years, n (%)	198 (2%)	5,566 (13%)
Male sex, n (%)	**5,382 (55.6%)**	**26,885 (62.7%)**
Weight, kg	**91.3±28.1**	**81.1±20.4**
Deprivation status†	**7.8±2.4**	**5.7±2.7**
Category of admission, n (%)		
Elective ICU admission	3,163 (32.8%)	18,765 (43.9%)
Emergency ICU admission	6,518 (67.2%)	24,106 (56.1%)
Source of ICU admission, n (%)		
Operating theatre	4,546 (47.0%)	25,054 (58.4%)
Emergency department	3,307 (34.2%)	10,252 (23.9%)
Ward	1,120 (11.6%)	5,443 (12.7%)
Transfer from another hospital	696 (7.2%)	2,069 (4.8%)
Unknown	12 (0.1%)	53 (0.1%)
Charlson comorbidity index, median [IQR]	**1 [0–3]**	**1 [0–2]**
Charlson comorbidity index 0, n (%)	3,737 (38.6%)	17,548 (40.9%)
Charlson comorbidity index 1, n (%)	2,102 (21.7%)	10,404 (24.3%)
Charlson comorbidity index 2, n (%)	1,277 (13.2%)	5,935 (13.8%)
Charlson comorbidity index ≥3, n (%)	2,565 (26.5%)	8,984 (21%)

Table 1 (continued): Baseline characteristics by ethnicity.*

	Māori (N=9,681)	**European (N=42,871)**
Common comorbidities, n (%)		
Myocardial infarction	842 (8.7%)	5,007 (11.7%)
Congestive cardiac failure	1,182 (12.2%)	3,924 (9.2%)
Diabetes without complications	1,038 (10.7%)	2,755 (6.4%)
Diabetes with complications	1,891 (19.5%)	4,864 (11.3%)
Renal disease	1,240 (12.8%)	3,406 (7.9%)
Cancer	797 (8.2%)	5,016 (11.7%)
Illness severity‡		
ANZROD	10.6±18.9	9.5±17.5
APACHE-III Physiology score	50.6±27.1	46.0±23

± values are mean±SD
* The P values for all between-group comparisons were <0.0001 except for source of ICU admission (ward), P=0.002; source of ICU admission (unknown), P=0.99; Charlson comorbidity index 2, P=0.09; ANZROD, P=0.007.
† Deprivation status was categorised in deciles from 1 (least deprived) to 10 (most deprived) using data associated with post-codes obtained from the 2013 New Zealand census.
‡The ANZROD combines physiology, age, diagnosis and comorbidities collected during the first 24 hours in the ICU to create predicted risk of death in hospital. The chronic score was not normally distributed. However, the median [IQR] was 0 [0–0] for both groups.
Abbreviations: ANZROD: Australian and New Zealand Risk of Death; APACHE: Acute Physiology and Chronic Health Evaluation; IQR: interquartile range; SD: standard deviation.

Table 2: ICU admission diagnostic categories by ethnicity.

Diagnostic category, n(%)	Māori (N=9,681)	European (N=42,871)
Cardiovascular	3,207 (33.1%)	18,401 (35.0%)
Respiratory	1,368 (14.1%)	5,713 (10.9%)
Gastrointestinal	896 (9.3%)	5,398 (10.3%)
Neurological	923 (9.5%)	3,028 (5.8%)
Trauma	968 (10.0%)	2,732 (5.2%)
Metabolic	699 (7.2%)	2,359 (4.5%)
Sepsis	740 (7.6%)	2,318 (4.4%)
Musculoskeletal	322 (3.3%)	1,318 (3.1%)
Renal/genitourinary	308 (3.2%)	998 (3.2%)
Gynaecological	181 (1.9%)	317 (1.9%)
Haematological	25 (0.3%)	127 (0.3%)
Other medical disorders	29 (0.3%)	102 (0.3%)
Unknown	15 (0.2%)	60 (0.2%)

Table 3: Key outcomes by ethnicity.

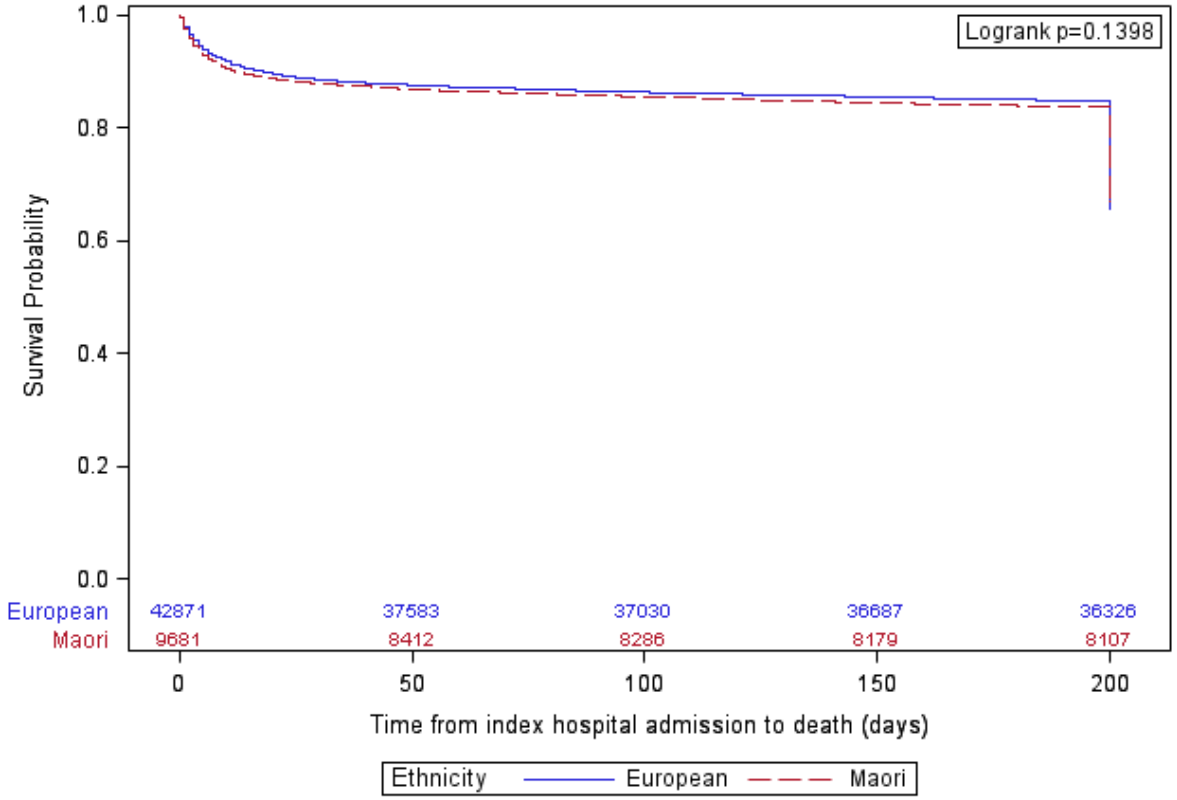
	Māori (N=9,681)	**European (N=42,871)**	**Analysis model***	**Odds ratio (95% CI)**
Day-180 mortality (primary outcome), n (%)	1,550 (16.0%)	6,407 (14.9%)	unadjusted	1.08 (1.02–1.15)
			+site	1.02 (0.95–1.10)
			+deprivation†	0.99 (0.92–1.07)
			+gender	0.98 (0.91–1.06)
			+year	0.98 (0.91–1.06)
			+Charlson comorbidity index	0.91 (0.84–0.98)
			+age	1.21 (1.12–1.31)
			+admission type‡	1.13 (1.04–1.23)
			+ICU admission diagnosis	1.11 (1.02–1.21)
			+ventilated (Y/N)	1.12 (1.03–1.21)
			+illness severity§	1.01 (0.92–1.10)
ICU mortality, n (%)	702 (7.3%)	2525 (5.9%)	unadjusted	1.25 (1.15–1.36)
			+site	1.16 (1.05–1.29)
			+deprivation†	1.13 (1.02–1.26)
			+gender	1.13 (1.02–1.25)
			+year	1.12 (1.01–1.25)
			+Charlson comorbidity index	1.10 (0.99–1.22)
			+age	1.26 (1.13–1.41)
			+admission type‡	1.13 (1.01–1.27)
			+ICU admission diagnosis	1.07 (0.96–1.21)
			+ventilated (Y/N)	1.08 (0.96–1.22)
			+illness severity§	0.96 (0.85–1.10)

Table 3 (continued): Key outcomes by ethnicity.

	Māori (N=9,681)	**European (N=42,871)**	**Analysis model***	**Odds ratio (95% CI)**
Hospital mortality, n (%)	1,103 (11.4%)	4,662 (10.9%)	unadjusted	1.05 (0.98–1.13)
			+site	0.99 (0.91–1.07)
			+deprivation†	0.97 (0.89–1.05)
			+gender	0.96 (0.88–1.04)
			+year	0.96 (0.88–1.04)
			+Charlson comorbidity index	0.91 (0.84–0.99)
			+age	1.16 (1.06–1.27)
			+admission type‡	1.08 (0.98–1.18)
			+ICU admission diagnosis	1.04 (0.95–1.15)
			+ventilated (Y/N)	1.05 (0.96–1.16)
			+illness severity§	0.92 (0.83–1.02)
Discharged home, n (%)	6,619 (68.4%)	29,295 (68.3%)	unadjusted	1.00 (0.96–1.05)
			+site	0.98 (0.93–1.04)
			+deprivation†	1.06 (1.00–1.12)
			+gender	1.07 (1.01–1.13)
			+year	1.07 (1.01–1.14)
			+Charlson comorbidity index	1.11 (1.05–1.18)
			+age	0.90 (0.84–0.95)
			+admission type‡	0.94 (0.88–1.00)
			+ICU admission diagnosis	0.96 (0.90–1.02)
			+ventilated (Y/N)	0.96 (0.90–1.03)
			+illness severity§	1.03 (0.96–1.10)

*Variables shown were added sequentially to the model.
† Deprivation status was categorised in deciles, from 1 (least deprived) to 10 (most deprived), using data associated with post-codes obtained from the 2013 New Zealand census.
‡ Admission type combined both source of ICU admission (operating theatre, emergency department, ward, transfer from another hospital and unknown) and whether the admission was categorised as elective or emergency
§ Illness severity was calculated using the physiological components of the Acute Physiology and Chronic Health Evaluation (APACHE) III score.

Figure 2: Kaplan-Meier survival plot.*



* The unadjusted hazard ratio for survival to day 180 for Māori vs European patients was 1.08 (95% CI, 1.02 to 1.14), with a hazard ratio of more than one corresponding to a worse outcome for Māori compared to their European counterparts because it equates to a shorter time to death. Data showing hazard ratios adjusted for potential confounding variables are shown in the Supplementary Table 5.

New Zealand. This study is the first large-scale national study to compare outcomes for Māori and European patients admitted to New Zealand ICUs. Our findings are consistent with a recent single-centre study conducted at Waikato Hospital that reported Māori were more likely than non-Māori to be admitted to ICU with sepsis and after major trauma.[19] Previous studies have also highlighted the high burden of serious infections[20] and diabetes[21] among Māori patients hospitalised in New Zealand. Our findings are similar to those of an Australian study, where adjusted long-term mortality and median number of potential life years lost after ICU admission were higher for Indigenous than non-Indigenous patients.[22] Our finding that Māori have higher illness severity at ICU admission than European patients has parallels with a previous study, where high illness acuity was observed in Indigenous Australians requiring ICU admission.[23]

Implications of study findings

Despite their younger age, Māori have more comorbidities and more severe illness than their European counterparts. Barriers to accessing intensive care for Māori might potentially contribute their higher illness severity by the time of ICU admission. However, the observation that Māori ICU patients are much younger than European ICU patients and yet still have more chronic comorbidities implies that an unequal burden of underlying conditions is one contributor to inequality in ICU outcomes.

Strengths and weaknesses

Our study had a number of strengths. It included data from more than 50,000 patients admitted to all major tertiary, regional and rural public hospital ICUs over a 10-year period. The only ICUs that were not included in this study were private ICUs and some small ICUs in rural and regional centres. We conducted analyses that adjusted for important variables that might potentially contribute to health inequalities in Māori patients admitted to the ICU including deprivation status and comorbid conditions. We were also able to conduct analyses that included robust adjustment for illness severity.

Our study had some limitations. Despite its large size, it only included the subset of ICU admission episodes for which we we could match patient data from the New Zealand Ministry of Health NMD to the ANZICS CORE APD. Accordingly, the patient group we studied is not representative of all patients admitted to New Zealand ICUs. We used the New Zealand Ministry of Health NMD prioritised ethnicity categories to define ethnic groups and cannot preclude the possibility that different methods for categorising ethnicity would result in different findings. Our method of categorisation of deprivation was based on data related to the post codes of patients' residences obtained from the 2013 census. Although our study did include data from ICU admissions in 2013, it is possible that the reliability of the categorisation of deprivation may be lower for patients admitted in other years. Although we captured deaths that occurred beyond hospital discharge, we only captured those deaths that were registered in New Zealand. It is possible some patients died overseas within 180 days of an ICU admission. We choose day-180 mortality as the primary end point for this study, as deaths occurring as a consequence of an acute illness episode beyond this point are rare.[24] However, our findings may have been different if we had evaluated mortality rates at a different time point. Although we undertook analyses that adjusted for ICU illness severity, data on illness severity at the time of hospital admission were not available and are likely to be a key determinant of mortality risk.

Conclusions

Compared to European patients, Māori were markedly more likely to be admitted to the ICU after trauma or with sepsis. Despite Māori being on average 13 years younger at ICU admission than their European counterparts, they had more co-morbidities, higher illness severity and a higher risk of dying within 180 days of an ICU admission.

COMPETING INTERESTS
Nil.

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Supplementary material

Supplementary Table 1: A comparison of matched versus unmatched patients.*

	Matched (N=52,597)	**Unmatched (N=26,058)**
Age (years), median [IQR]	64 [50-74]	64 [50–75]
Male sex, n (%)	32,285 (61.4%)	14,766 (56.7%)
Deprivation status†	6.07±2.76; n=52,185	6.11±2.69; n=25,878
European ethnicity, n (%)	42,909 (82%)	21,775 (84%)
Maori ethnicity, n (%)	9,688 (18%)	4,283 (16%)
Died in ICU, n (%)	3,233 (6%)	1,462 (6%)
Hours of mechanical ventilation, median [IQR]	10 [3–39]; n=34,565	0 [0–13]; n=15,970
Total ICU hours, median [IQR]	33 [22–72]	29 [19–66]
Died in hospital, n (%)	5,773 (11%)	2,471 (9%)
Hospital length of stay (days), median [IQR]	8 [5–15]	6 [3–12]
Discharged home, n (%)	35,946 (68%)	18,252 (70%)
Died by day 180, n (%)	7,967 (15%)	4,009 (15%)

± values are mean ± SD.
* P values were less than 0.0001 for all comparisons except for the comparison of deprivation status, P=0.06; died in ICU, P=0.003; Died by day 180, P=0.38. Of the 78,655 European and Māori patients with ICU admissions included the New Zealand Ministry of Health National Minimum Dataset (NMD), 52,597 were matched to the Australian and New Zealand Intensive Care Society Centre for Outcome and Resource Evaluation Adult Patient Database (ANZICS CORE APD) and 26,058 could not be matched. Because ethnicity data are not available in the ANZICS CORE APD, a comparison of patients included in the ANZICS CORE APD who were not identifiable in the NMD could not be undertaken. A total of 45 patients were matched but were not included in the analysis because illness severity data were not available.
† Deprivation status was categorised in deciles from 1 (least deprived) to 10 (most deprived) using data associated with post-codes obtained from the 2013 New Zealand census.
Abbreviations: ICU: intensive care unit; IQR: interquartile range; SD: standard deviation.

Supplementary Table 2: Additional details of comorbidities by ethnicity.*

	Māori (N=9,681)	European (N=42,871)
Peripheral vascular disease	764 (7.9%)	4,123 (9.6%)
CVA or TIA	672 (6.9%)	3,034 (7.1%)
Dementia	37 (0.38%)	221 (0.52%)
COPD	901 (9.3%)	2,701 (6.3%)
Connective tissue disease	34 (0.35%)	257 (0.60%)
Peptic ulcer disease	144 (1.5%)	506 (1.2%)
Mild liver disease	338 (3.5%)	928 (2.2%)
Moderate to severe liver disease	116 (1.2%)	579 (1.4%)
Paraplegia or hemiplegia	411 (4.2%)	1,431 (3.3%)
Metastatic cancer	313 (3.2%)	1,935 (4.5%)
HIV/AIDS	12 (0.12%)	23 (0.05%)

* P values were <0.0001 for all comparison between groups except CVA or TIA, P value=0.64; Dementia, P value=0.09; Connective tissue disease, P value=0.003, Peptic Ulcer Disease, P value=0.14; moderate to severe liver disease, P value=0.24; HIV/AIDS, P value=0.015.
Abbreviations: AIDS: Acquired immunodeficiency syndrome; COPD: chronic obstructive pulmonary disease; CVA: cerebrovascular accident; HIV: human immunodeficiency virus; TIA: transient ischaemic attack.

Supplementary Table 3: Deprivation categories by ethnicity.*

Deprivation category†	Māori (N=9,681)	European (N=42,871)
1	168 (1.7%)	3319 (7.7%)
2	242 (2.5%)	3,788 (8.8%)
3	321 (3.3%)	3,611 (8.4%)
4	408 (4.2%)	4,107 (9.6%)
5	480 (5%)	4,615 (10.8%)
6	706 (7.3%)	5,026 (11.7%)
7	1,064 (11%)	5,238 (12.2%)
8	1,213 (12.5%)	5,180 (12.1%)
9	1,966 (20.3%)	4,649 (10.8%)
10	3,080 (31.8%)	2,959 (6.9%)
Deprivation status missing	33 (0.3%)	379 (0.9%)

* P values were <0.0001 for all comparisons except for deprivation category 8, P=0.22.
† Deprivation status was categorised in deciles from 1 (least deprived) to 10 (most deprived) using data associated with post-codes obtained from the 2013 New Zealand census.

Supplementary Table 4: Admission site and year by ethnicity.

Admission hospital	Māori (N=9681)	European (N=42871)
Middlemore Hospital	853 (8.8%)	1426 (3.3%)
Christchurch Hospital	627 (6.5%)	7028 (16.4%)
Dunedin Hospital	299 (3.1%)	4384 (10.2%)
Tauranga Hospital	642 (6.6%)	2407 (5.6%)
Wellington Hospital	926 (9.6%)	4708 (11%)
Taranaki Health	95 (0.981%)	379 (0.884%)
Timaru Hospital	67 (0.692%)	1092 (2.5%)
Hawke's Bay Hospital	308 (3.2%)	592 (1.4%)
Nelson Hospital	109 (1.1%)	1,365 (3.2%)
Waikato Hospital	2,094 (21.6%)	5,401 (12.6%)
Rotorua Hospital	236 (2.4%)	346 (0.807%)
Whangārei Area Hospital	927 (9.6%)	1,446 (3.4%)
Hutt Hospital	292 (3%)	1182 (2.8%)
Auckland City Hospital	2,010 (20.8%)	9,826 (22.9%)
North Shore Hospital	196 (2%)	1,289 (3%)
Year		
2009	230 (2.4%)	1,208 (2.8%)
2010	646 (6.7%)	3,159 (7.4%)
2011	885 (9.1%)	4,113 (9.6%)
2012	1,022 (10.6%)	4,932 (11.5%)
2013	1,068 (11%)	4,991 (11.6%)
2014	1,309 (13.5%)	6,033 (14.1%)
2015	1,319 (13.6%)	5,608 (13.1%)
2016	1,207 (12.5%)	5,052 (11.8%)
2017	1,345 (13.9%)	5,285 (12.3%)
2018	650 (6.7%)	2,490 (5.8%)

Supplementary Table 5: Cox Proportional Hazards Regression for survival to day 180.

Analysis Model	Hazard ratio (95% CI)*
unadjusted	1.08 (1.02–1.15)
+site	1.02 (0.95–1.10)
+deprivation†	0.99 (0.92–1.07)
+gender	0.98 (0.91–1.06)
+year	0.98 (0.91–1.06)
+Charlson comorbidity index	0.91 (0.84–0.98)
+age	1.21 (1.12–1.31)
+admission type‡	1.13 (1.04–1.23)
+ICU admission diagnosis	1.11 (1.02–1.21)
+ventilated (Y/N)	1.12 (1.03–1.21)
+illness severity§	1.01 (0.92–1.10)

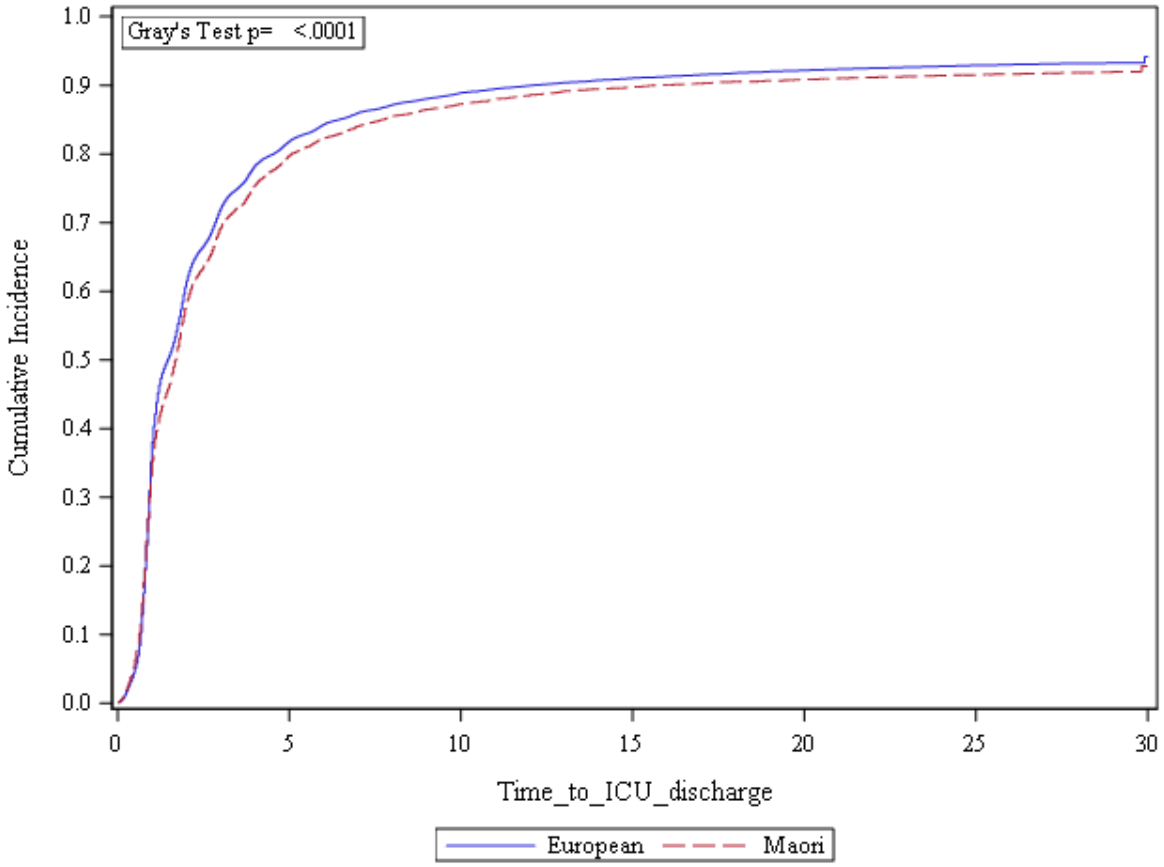
* Variables shown were added sequentially to the model. Hazard ratios show associations between Māori ethnicity and the survival time with European as the reference category; a hazard ratio of more than one corresponds to worse outcome for Māori compared to their European counterparts because it equates to a shorter time to death.
† Deprivation status was categorised in deciles from 1 (least deprived) to 10 (most deprived) using data associated with post-codes obtained from the 2013 New Zealand census.
‡ Admission type combined both source of ICU admission (operating theatre, emergency department, ward, transfer from another hospital, and unknown) and whether the admission was categorised as elective or emergency.
§ Illness severity was calculated using the physiological components of the Acute Physiology and Chronic Health Evaluation (APACHE) III score.

Supplementary Table 6: ICU length of stay and hospital length of stay by ethnicity.*

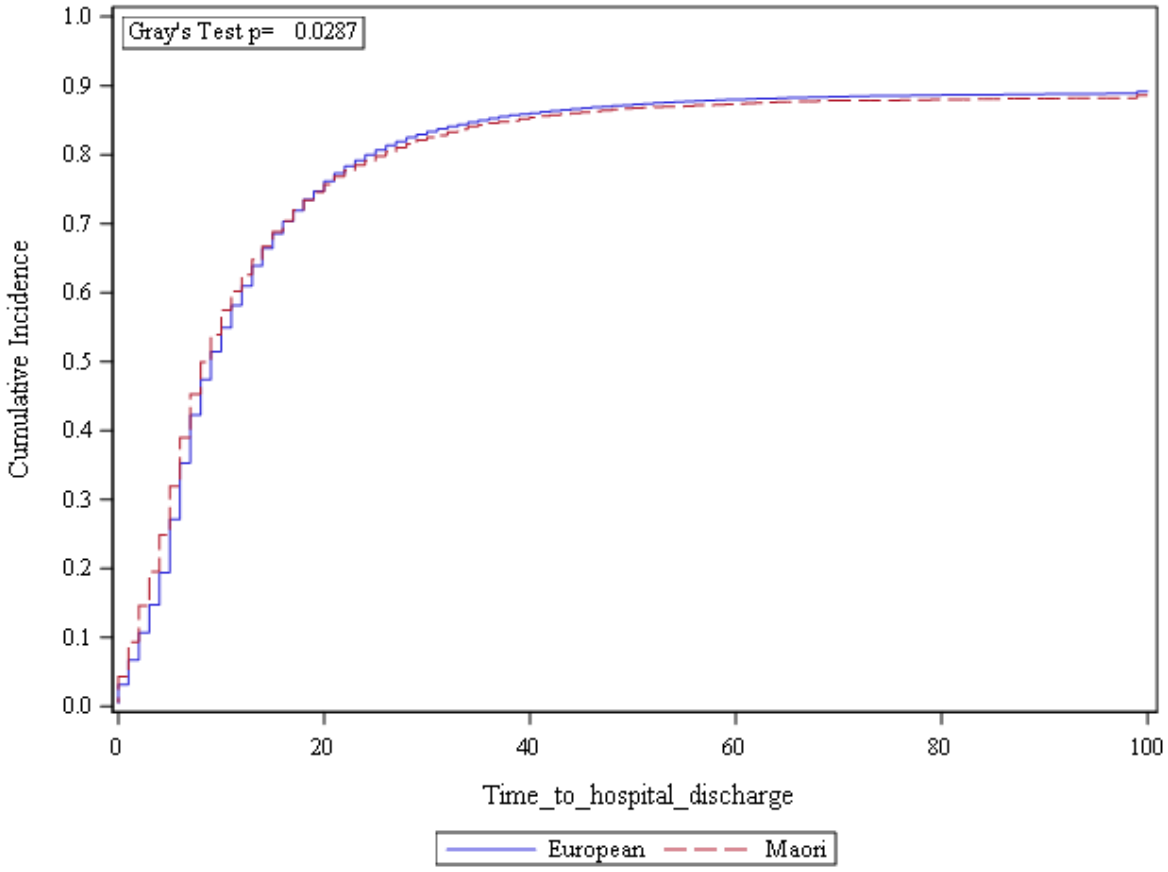
Outcome	Māori (N=9,681)	European (N=42,871)	Analysis Model	Hazard ratio (95% CI)
ICU length of stay (days) mean±SD; median [IQR]	2.9±5.2 1.5 [0.8–2.9]	2.8±5.0 1.2 [0.9–2.8]	unadjusted	1.08 (1.02–1.15)
			+site	1.02 (0.95–1.10)
			+deprivation†	0.99 (0.92–1.07)
			+gender	0.98 (0.91–1.06)
			+year	0.98 (0.91–1.06)
			+Charlson comorbidity index	0.91 (0.84–0.98)
			+age	1.21 (1.12–1.31)
			+admission type‡	1.13 (1.04–1.23)
			+ICU admission diagnosis	1.11 (1.02–1.21)
			+ventilated (Y/N)	1.12 (1.03–1.21)
			+illness severity§	1.01 (0.92–1.10)
Hospital length of stay (days) mean±SD; median [IQR]	11.4±13.9 7.5 [4.0–14.1]	12.1±13.4 8.3 [5.1–15.0]	unadjusted	1.25 (1.15–1.36)
			+site	1.16 (1.05–1.29)
			+deprivation†	1.13 (1.02–1.26)
			+gender	1.13 (1.02–1.25)
			+year	1.12 (1.01–1.25)
			+Charlson comorbidity index	1.10 (0.99–1.22)
			+age	1.26 (1.13–1.41)
			+admission type‡	1.13 (1.01–1.27)
			+ICU admission diagnosis	1.07 (0.96–1.21)
			+ventilated (Y/N)	1.08 (0.96–1.22)
			+illness severity§	0.96 (0.85–1.10)

* Variables shown were added sequentially to the model. Hazard ratios show associations between Māori ethnicity and the outcome of interest with European as the reference category. The analysis models were calculated using a competing risk analysis adjusting for the competing risk of death; hazard ratios greater than one correspond to a shorter time to discharge alive for Māori compared to their European counterparts.
† Deprivation status was categorised in deciles from 1 (least deprived) to 10 (most deprived) using data associated with post-codes obtained from the 2013 New Zealand census.
‡ Admission type combined both source of ICU admission (operating theatre, emergency department, ward, transfer from another hospital, and unknown) and whether the admission was categorised as elective or emergency.
§ Illness severity was calculated using the physiological components of the Acute Physiology and Chronic Health Evaluation (APACHE) III score.

Supplementary Figure 1: Time to ICU discharge by ethnicity category.



Supplementary Figure 2: Time to hospital discharge by ethnicity category.



Risk factors differ for Gram-negative surgical site infection following hip and knee arthroplasty: an observational study from a national surveillance system

Aakash V Chhibber, Sally A Roberts, Nikki Grae, Arthur J Morris

ABSTRACT

AIM: To describe risk factors for surgical site infection (SSI) caused by aerobic Gram-negative organisms after hip and knee arthroplasty.

METHOD: Publicly funded hip and knee arthroplasties (performed between 1 July 2013 and 31 December 2017) that developed SSIs were compared to those that did not. SSIs were grouped by causative organism: Gram-negative (*Pseudomonas* spp. or enteric Gram-negative bacilli) or staphylococcal (pure or mixed growth of *Staphylococcus* spp.). Independent risk factors in each group were identified.

RESULTS: 24,842 (54%) hip and 20,993 (46%) knee arthroplasties were performed. There were 497 (1.1%) SSIs. Staphylococci were responsible for 233 SSIs (47%) and Gram-negatives were responsible for 73 (15%). Age, sex, body mass index ≥35kg/m^2, smoking status, socioeconomic deprivation, American Society of Anesthesiologists classification, revision surgery and prophylactic antibiotic dose were all independent predictors of all-cause SSI. On subgroup analysis, socioeconomic deprivation and Pasifika ethnicity were independent risk factors for Gram-negative SSI, but not staphylococcal SSI.

DISCUSSION: In this study, socioeconomic deprivation and ethnicity were independent and novel risk factors for Gram-negative SSI following arthroplasty. Some of the SSI risk factors can be modified before arthroplasty (e.g., appropriate timing of prophylactic antibiotics, smoking cessation, weight loss). Non-modifiable risk factors can help identify high-risk procedures where additional pre- and post-operative interventions may be warranted.

Surgical site infection (SSI) following orthopaedic surgery is associated with significant morbidity.[1,2] The issue will become increasingly important with the projected increases in hip and knee arthroplasty.[3] In New Zealand, 9,169 total hip joint replacements and 8,321 total knee joint replacements were performed in 2018.[4] Deep infection is the leading cause and second highest cause of revision surgery within one year of primary knee and hip arthroplasty respectively and the leading indication for re-revision.[4]

Since 2013, the New Zealand Health Quality & Safety Commission Orthopaedic Surgical Site Infection Improvement Programme (SSIIP) has conducted national SSI surveillance for selected hip and knee procedures. The SSIIP, using a quality improvement approach, observed an association between increased adherence to key process measures (appropriate prophylactic antibiotic selection, dose and timing and use of an alcohol-based skin preparation) and a decrease in the SSI rate from 1.36% to 0.91%.[5] The most commonly isolated pathogen was *Staphylococcus aureus*, and strategies to target this pathogen are being introduced through the implementation of a preoperative anti-staphylococcal intervention bundle.[6]

Despite causing a moderate proportion of SSI, Gram-negative SSI are less well described and not specifically targeted in preventative measures like staphylococcal SSIs.[7–12] This study examined the SSIIP database to find predictors of SSI, particularly those caused by aerobic Gram-negatives, to identify modifiable risk factors amenable to quality improvement interventions.

Method

Data collection

Since 2013, the SSIIP has collected data on all publicly funded routine elective hip and knee arthroplasties through New Zealand's 20 district health boards (DHBs). Procedures between 1 July 2013 and 31 December 2017 were included in the analysis. Additional information was available through the Ministry of Health National Minimum Dataset (NMDS) (i.e., socioeconomic deprivation (New Zealand Index of Deprivation[13]), diagnosis of diabetes mellitus (type 1 and type 2), smoking status and ethnicity). Data collection methodology has been published previously.[5,14,15] Pasifika ethnicity was defined as one category. However, Pasifika contains many culturally distinct groups, with Samoan (48%), Tongan (22%) and Cook Island Māori (21%) being the most common.[16]

Regular training is provided by the SSIIP in surveillance methods and application of the SSI definitions to ensure high-quality data are recorded. Data not gathered by the surveillance system includes: antimicrobial use in the pre-admission period, presence of other comorbidities other than diabetes and smoking (such as inflammatory arthropathies, glycaemic control, anticoagulation or immunosuppression) or clinical information such as perioperative bacteraemia or bacteriuria. Of note, arthroplasties performed for fractured neck of femur are excluded.

Definitions

The Centers for Disease Control and Prevention (CDC) National Healthcare Safety Network (NHSN) SSI definitions were used. Patients were followed for 90 days after surgery.[17] Briefly, superficial incisional SSIs involve only skin and subcutaneous tissue of incision and must occur within 30 days of operative procedure. Deep incisional SSI must occur within 90 days of operative procedure and involve deep soft tissues of the incision (e.g., fascia and muscle layers), and even deeper infections are considered organ/space SSI. Superficial SSIs managed outside hospital were not part of surveillance.

All-cause SSIs were analysed. This included all culture positive and culture negative SSIs. For subgroup analysis, SSIs were categorised by the pathogen(s) isolated from microbiological samples. "Staphylococcal SSI" had either pure growth of a *Staphylococcus* sp. or mixed *Staphylococcus* spp.. Partly informed by previous literature,[10] the "Gram-negative SSIs" were defined as due to either *Pseudomonas* spp. or organisms from the order Enterobacterales, commonly called "enteric" Gram-negatives (e.g., *Escherichia coli*, *Klebsiella* spp., *Proteus* spp.) either isolated pure or mixed with each other. SSIs with other Gram-negative organisms or other Gram-positive organisms isolated were excluded from subgroup analysis. Examples of organisms isolated from microbiological samples of SSIs that were not included in subgroup analysis were: *Candida* spp., *Acinetobacter* spp., *Streptococcus* spp., *Enterococcus* spp. and *Corynebacterium* spp..

Appropriate dose of cefazolin prophylaxis was defined as 1g for patients <80kg, 2g if 80–120kg and 3g if >120kg. Lower doses were defined as underdosed. Antibiotic surgical prophylaxis administered within 60 minutes before incision was considered "on time," and prophylaxis given >60 minutes before or after incision was defined as "not on time."

Statistical analysis

All statistical analyses were conducted using STATA version 13.0 (StataCorp, College Station, TX, USA). Each stratum had the same statistical methodology.

For univariate analysis, age, sex, BMI (kg/m$^{2)}$, weight, duration of surgery, ethnicity, smoking status, diabetes, socioeconomic status (New Zealand Index of Deprivation), whether the procedure was a revision procedure, the use of alcohol containing skin antiseptic, American Society of Anesthesiologists classification (ASA class), perioperative exposure to various antibiotics (gentamicin, cefazolin, cefuroxime) and timing and dose of standard cefazolin prophylaxis were cross tabulated against procedures that developed SSI and those that did not at 90-day follow-up. Categories with fewer than five events in any single cell were reviewed before proceeding to analytical statistics.

A time-to-failure (SSI) Cox regression analysis was performed, where entry into the analysis occurred on the day of surgery and exit from analysis occurred at day of SSI, or end of 90-day follow-up, or date of death (if available), whichever occurred first. Univariate Cox analysis was performed, and variables that had p-value <0.2 on univariate analysis entered the reverse stepwise multivariate Cox regression. Then one at a time, the variable with the highest p-value was removed and the model re-run. This was repeated until all variables remaining within the model had a p-value less than 0.05. At this stage, because

of its clinical importance, age was re-entered into the model to verify no statistically significant effect on the final model.

Robustness of relationships was checked by sorting all variables by Likelihood Ratio (LR) chi-square test values (from univariate analysis) and then consecutively entry (one at a time) into a forward stepwise Cox regression and with variables exiting the model if at any iteration the p-value was >0.05. At this stage age was re-entered into the model for the reasons described above.

Ethical considerations

Under New Zealand Health and Disability Ethics Committee guidelines, formal Ethical Committee review was not needed for this type of quality-improvement-related audit.

Funding

This work is self-funded. The authors had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

Over the study period, there were 45,835 arthroplasties comprised by 24,842 (54%) hip and 20,993 (46%) knee procedures. There were 497 SSIs (1.1%): 233 staphylococcal SSIs (47%) and 73 Gram-negative SSI (15%). Enterobacterales contributed a majority of the Gram-negative SSI (n=54, 74%), and *Pseudomonas* spp. (all *P. aeruginosa*, except one) contributed (n=19, 26%). SSIs that were excluded from sub-analyses either had no specimen for microbiology taken (n=31, 6%) or were cultured negative (n=61, 12%) or had other positive culture results that did not meet study definitions (n=99, 20%). There were 301 (61%) and 196 (39%) hip and knee SSIs, respectively. Hip procedures had an SSI rate of 1.2% and knee procedures an SSI rate of 0.9%. Deep SSI accounted for majority of SSI (n=206, 41%) and the remainder were either organ space (n=129, 26%) or superficial (n=162, 33%). There was no significant relationship between the depth of infection and SSI organism group (data not shown). Perioperative exposure to different prophylactic antibiotics (gentamicin, cefazolin, cefuroxime) had no association with SSI on univariate or multivariate analysis (data not shown). Rates of early (<30 days) and late (30–90 days) SSI were not different when comparing Gram-negative and staphylococcal SSI (p=0.13, data not shown).

The cohort demographics are included in Table 1. Male sex, BMI, weight, surgery duration ≥2 hours, smoking status, deprivation, revision arthroplasty, ASA class, cefazolin timing and dosing of prophylaxis were associated with an increase in risk of all-cause SSI on univariate analysis. After adjustments for confounders, independent risk factors for all-cause SSI were age (as continuous variable), male sex, BMI, revision arthroplasty and deprivation in the fifth quintile, ASA class ≥3, cefazolin underdosing and smoking status (Table 2).

On univariate analysis of staphylococcal SSI, male sex, BMI, weight, surgery duration ≥2 hours, diabetes, revision arthroplasty, ASA class, antibiotic timing and cefazolin underdosing were risk factors of statistical significance (Table 1). On multivariate analysis male sex, BMI, revision arthroplasty, ASA class, prophylaxis timing and duration of surgery remained significant (Table 2).

On univariate analysis Gram-negative SSI risk factors were BMI, weight, surgery duration ≥2 hours, ethnicity, deprivation, revision arthroplasty, ASA class and cefazolin underdosing (Table 1). A low number of Gram-negative SSI events were not administered prophylaxis on time (n=2), from New Zealand Index of Deprivation quintile 1 (n=3) and ASA class 1 (n=3). However, these were retained acknowledging this as a limitation of further analyses. On multivariate analysis BMI, revision arthroplasty, deprivation and ethnicity remained as independent risk factors. The risk factors identified conferred higher hazard ratios for Gram-negative infection, with New Zealand Index of Deprivation quintiles 4 and 5 having eight times the SSI risk, BMI of ≥40kg/m^2 four times the SSI risk, and Pasifika ethnicity (not associated with other SSI groups) more than doubled the risk of SSI (Table 2).

Maori and Pasifika people with a BMI of ≥40kg/m^2 are more frequently underdosed than non-Māori non-Pasifika of similar BMI (Table 3). Underdosing was not associated with deprivation quintile (data not shown).

Those with higher BMI have longer procedures. However, within each BMI category, Pasifika people were more likely to have longer procedures, as were Maori with BMI of ≥40kg/m^2 (Table 4).

Prevalence of SSI risk factors within the entire cohort by ethnic group is presented Table 5. Māori had a statistically significant higher crude rate of SSI when compared directly to non-Māori non-Pasifika (1.4% and 1.0% respectively, p-value 0.049), while Pasifika did not (1.1%, p-value 0.923). Māori

Table 1: Univariate Analysis of 45,835 hip and knee arthroplasties performed between 2013 and 2017.

	No SSI	All-cause SSI	Staphylococcal SSI	Gram-negative SSI
	(n=45,835)	(n=497)	(n=233)	(n=73)
Age category	*Reference*	*p=0.926*	*p=0.324*	*p=0.982*
< 65 years	15,127 (98.9%)	165 (1.1%)	84 (0.6%)	24 (0.2%)
≥65 years	30,708 (98.9%)	332 (1.1%)	149 (0.5%)	49 (0.2%)
Sex	*Reference*	*p=0.001*	*P<0.001*	*p=0.793*
Female	25,035 (99.1%)	235 (0.9%)	90 (0.4%)	41 (0.2%)
Male	20,788 (98.8%)	262 (1.2%)	143 (0.7%)	32 (0.2%)
BMI category, kg/m²	*Reference*	*p<0.001*	*p<0.001*	*p<0.001*
BMI<30	20,555 (99.2%)	157 (0.8%)	78 (0.4%)	19 (0.1%)
30≤BMI<35	10,608 (99.1%)	100 (0.9%)	53 (0.5%)	9 (0.1%)
35≤BMI<40	6,526 (98.6%)	94 (1.4%)	45 (0.7%)	9 (0.1%)
BMI≥40	3,695 (97.8%)	84 (2.2%)	33 (0.9%)	20 (0.5%)
Weight	*Reference*	*p<0.001*	*p<0.001*	*p<0.001*
<80kg	16,239 (99.2%)	132 (0.8%)	63 (0.4%)	18 (0.1%)
80-120kg	22,952 (98.9%)	247 (1.1%)	118 (0.5%)	33 (0.1%)
>120kg	1,876 (97%)	58 (3%)	25 (1.3%)	11 (0.6%)
Duration of surgery	*Reference*	*p<0.001*	*p<0.001*	*p=0.004*
≥2hours	6,507 (98.1%)	123 (1.9%)	65 (1%)	19 (0.3%)
<2hours	39,328 (99.1%)	374 (0.9%)	168 (0.4%)	54 (0.1%)
Ethnicity	*Reference*	*p=0.143*	*p=0.198*	*p=0.001*
Non-Māori non-Pasifika	39,470 (99%)	416 (1%)	193 (0.5%)	54 (0.1%)
Māori	4,655 (98.6%)	64 (1.4%)	32 (0.7%)	12 (0.3%)
Pasifika	1,481 (98.9%)	16 (1.1%)	7 (0.5%)	7 (0.5%)
Smoking status	*Reference*	*p=0.017*	*p=0.376*	*p=0.198*
Non-smoker	42,585 (99%)	448 (1%)	213 (0.5%)	65 (0.2%)
Smoker	3,250 (98.5%)	49 (1.5%)	20 (0.6%)	8 (0.2%)

Table 1 (continued): Univariate Analysis of 45,835 hip and knee arthroplasties performed between 2013 and 2017.

	No SSI	All-cause SSI	Staphylococcal SSI	Gram-negative SSI
	(n=45,835)	(n=497)	(n=233)	(n=73)
Diabetes	*Reference*	*p=0.098*	*p=0.028*	*p=0.924*
No	40,649 (99%)	429 (1%)	196 (0.5%)	65 (0.2%)
Yes	5,186 (98.7%)	68 (1.3%)	37 (0.7%)	8 (0.2%)
NZ Deprivation Quintiles	*Reference*	*p=0.017*	*p=0.073*	*p=0.032*
1 (least deprived)	6,521 (99.1%)	58 (0.9%)	22 (0.3%)	3 (0%)
2	8,366 (99.1%)	75 (0.9%)	44 (0.5%)	10 (0.1%)
3	9,418 (98.9%)	100 (1.1%)	41 (0.4%)	14 (0.1%)
4	11,343 (98.9%)	125 (1.1%)	60 (0.5%)	26 (0.2%)
5 (most deprived)	10,072 (98.7%)	137 (1.3%)	65 (0.6%)	20 (0.2%)
Revision arthroplasty	*Reference*	*p<0.001*	*p<0.001*	*p<0.001*
No	42,241 (99.1%)	402 (0.9%)	188 (0.4%)	55 (0.1%)
Yes	3,594 (97.4%)	95 (2.6%)	45 (1.2%)	18 (0.5%)
Alcohol containing skin preparation	*Reference*	*p=0.375*	*p=0.747*	*p=0.476*
No	313 (98.4%)	5 (1.6%)	2 (0.6%)	0 (0%)
Yes	45,074 (98.9%)	483 (1.1%)	229 (0.5%)	73 (0.2%)
ASA class	*Reference*	*p<0.001*	*p<0.001*	*p=0.001*
1	3,848 (99.5%)	20 (0.5%)	11 (0.3%)	3 (0.1%)
2	26,845 (99.2%)	219 (0.8%)	99 (0.4%)	31 (0.1%)
≥3	14,446 (98.3%)	245 (1.7%)	116 (0.8%)	38 (0.3%)
Antibiotic prophylaxis timing	*Reference*	*p=0.002*	*p=0.001*	*p=0.884*
On time	43,726 (99%)	463 (1%)	214 (0.5%)	69 (0.2%)
Not on time	1,141 (98%)	23 (2%)	14 (1.2%)	2 (0.2%)
Dose of cefazolin prophylaxis	*Reference*	*p<0.001*	*p<0.001*	*p<0.001*
Appropriate	36,018 (99%)	356 (1%)	169 (0.5%)	48 (0.1%)
Under dosed	1,905 (97.4%)	51 (2.6%)	23 (1.2%)	10 (0.5%)

Shown p-values are for chi-square tests comparing No SSI vs SSI subgroups.

Table 2: Multivariate Cox regression of risk factors for SSI following hip and knee arthroplasty.

	All-cause SSI			Staphylococcal SSI*			Gram-negative SSI*		
	Hazard Ratio	**95% CI**	**p-value**	**Hazard Ratio**	**95% CI**	**p-value**	**Hazard Ratio**	**95% CI**	**p-value**
Age (continuous)	1.01	1.00–1.03	0.012	-	-	-	-	-	-
Sex									
Female	1	1.00–1.00	ref	1	1.00–1.00	ref	-	-	-
Male	1.42	1.15–1.75	0.001	2.02	1.52–2.70	<0.001	-	-	-
BMI category, kg/m^2									
BMI<30	1	1.00–1.00	ref	1	1.00–1.00	ref	1	1.00–1.00	ref.
30≤BMI<35	1.16	0.88–1.53	0.298	1.26	0.89–1.80	0.197	0.85	0.38–1.88	0.682
35≤BMI<40	1.77	1.32–2.36	<0.001	1.7	1.16–2.48	0.006	1.24	0.56–2.79	0.596
BMI≥40	2.62	1.86–3.69	<0.001	2.05	1.34–3.14	0.001	4.28	2.18–8.40	<0.001
Revision arthroplasty									
No	1	1.00–1.00	ref	1	1.00–1.00	ref	1	1.00–1.00	ref
Yes	2.55	1.92–3.37	<0.001	2.29	1.52–3.46	<0.001	2.99	1.46–6.10	0.003
NZ Index of Deprivation									
1 (least deprived)	1	1.00–1.00	ref	-	-	-	1	1.00–1.00	ref
2	1.11	0.74–1.66	0.619	-	-	-	6.64	0.84–52.47	0.073
3	1.29	0.88–1.89	0.199	-	-	-	5.84	0.74–46.17	0.094
4	1.23	0.85–1.79	0.268	-	-	-	8.65	1.15–65.03	0.036
5 (most deprived)	1.55	1.08–2.24	0.019	-	-	-	8.48	1.12–64.10	0.038

Table 2 (continued): Multivariate Cox regression of risk factors for SSI following hip and knee arthroplasty.

	All-cause SSI			Staphylococcal SSI*			Gram-negative SSI*		
	Hazard Ratio	**95% CI**	**p-value**	**Hazard Ratio**	**95% CI**	**p-value**	**Hazard Ratio**	**95% CI**	**p-value**
Ethnicity									
Non-Māori non-Pasifika	-	-	-	-	-	-	1	1.00–1.00	ref
Māori	-	-	-	-	-	-	1.65	0.83–3.29	0.15
Pasifika	-	-	-	-	-	-	2.52	1.06–5.97	0.036
ASA class									
1	1	1.00–1.00	ref	1	1.00–1.00	ref	-	-	-
2	1.5	0.85–2.66	0.165	1.04	0.56–1.96	0.892	-	-	-
≥3	2.38	1.32–4.28	0.004	2.05	1.09–3.86	0.026	-	-	-
Antibiotic dose									
Appropriate	1	1.00–1.00	ref	-	-	-	-	-	-
Under dosed	1.47	1.03–2.10	0.035	-	-	-	-	-	-
Prophylaxis timing									
On time	-	-	-	1	1.00–1.00	ref.	-	-	-
Not on time	-	-	-	1.83	1.02–3.28	0.042	-	-	-

Table 2 (continued): Multivariate Cox regression of risk factors for SSI following hip and knee arthroplasty.

	All-cause SSI			Staphylococcal SSI*			Gram-negative SSI*		
	Hazard Ratio	**95% CI**	**p-value**	**Hazard Ratio**	**95% CI**	**p-value**	**Hazard Ratio**	**95% CI**	**p-value**
Duration of surgery									
<2 hours	-	-	-	1	1.00–1.00	ref	-	-	-
≥2 hours	-	-	-	1.48	1.03–2.11	0.032	-	-	-
Smoking status									
Non-smoker	1	1.00–1.00	ref	-	-	-	-	-	-
Smoker	1.61	1.14–2.27	0.007	-	-	-	-	-	-

*Forcing age into this model did not change these relationships.
- not statistically significant on multivariate analysis.
ref = reference group for comparison.
Shown p-values are for multivariate Cox regression within respective SSI subgroup. For example, only for all-cause SSI, procedures that had antibiotics under dosed had HR 1.47 (p value = 0.035) of SSI compared to appropriately dosed procedures.

Table 3: Relationship between BMI, ethnicity and cefazolin dosing.

BMI (kg/m²)	Ethnicity	Cefazolin underdosed	Total	
BMI ≥40	Non-Māori non-Pasifika	570 (26.3%)	2,171	*reference*
	Māori	244 (30.9%)	789	p-value 0.012
	Pasifika	133 (32.7%)	407	p-value 0.008
All	Non-Māori non-Pasifika	1394 (4.3%)	32,641	*reference*
	Māori	374 (9.1%)	4,122	p-value <0.001
	Pasifika	183 (13.2%)	1,382	p-value <0.001

BMI data available for 41,823 procedures (91%).
Procedures missing ethnicity data, n=230.
Procedures not administered cefazolin, n=3,347.
Procedures with weight unavailable for dose calculation, n=4,655.
Shown p-values are for chi-square tests comparing ethnicity head to head (with non-Māori non-Pasifika as the reference group) within each respective BMI category. For example, for BMI ≥40, Pasifika, compared to non-Māori non-Pasifika, had a significantly greater proportion of procedures that had cefazolin underdosed (p=0.008).

Table 4: Relationship between BMI, ethnicity and duration of surgery.

	Ethnicity	Non-Māori non-Pasifika		Māori		Pasifika	
BMI (kg/m²)	Duration of Surgery	n (%)	p-value	n (%)	p-value	n (%)	p-value
BMI<30	2 or more hours	2,279 (11.9%)	ref	153 (12.1%)	0.87	38 (16.4%)	**0.038**
	<2 hours	16,830 (88.1%)		1,113 (87.9%)		194 (83.6%)	
30≤BMI<35	2 or more hours	1,092 (12%)	ref	173 (13.9%)	0.053	66 (20.4%)	**<0.001**
	<2 hours	7,993 (88%)		1,068 (86.1%)		258 (79.6%)	
35≤BMI<40	2 or more hours	792 (15.4%)	ref	182 (17.2%)	0.15	82 (20.6%)	**0.007**
	<2 hours	4,347 (84.6%)		876 (82.8%)		317 (79.4%)	
BMI≥40	2 or more hours	448 (18%)	ref	195 (22.8%)	**0.002**	118 (27.8%)	**<0.001**
	<2 hours	2,045 (82%)		659 (77.2%)		307 (72.2%)	

Shown p-values are for chi-square tests comparing ethnicity head to head (with non-Māori non-Pasifika as the reference group) within each respective BMI category. For example, for BMI ≥40, Pasifika, compared to non-Māori non-Pasifika, had a significantly higher proportion of surgeries lasting greater than 2 or more hours (p <0.001).

and Pasifika ethnicities are consistently overrepresented in the higher risk groups (Table 5).

Discussion

Overall, in our cohort, Gram-negative SSI contributed significant morbidity accounting for 15% of all SSIs. In other studies Gram-negatives contribute between 9% and 43% of SSIs.[8–12] *Pseudomonas* spp. contributed 26% of Gram-negative infections, agreeing with previous literature (between 10% and 40%).[8–11]

New Zealand Index of Deprivation confers a modest but significant increase in risk for all-cause SSI (Table 2). However, the most deprived are at an eight-fold increase in risk of Gram-negative SSI. There is a paucity of high-quality evidence to accurately describe the effect of poverty on risk of SSI following orthopaedic infection, with conflicting studies that often use proxy measurements such as health insurance type.[18–21] Unfortunately, SSI has not been an outcome of interest in orthopaedic studies that purposefully measure income and poverty levels.[22,23] Although the New Zealand Index of Deprivation does not measure an individual's poverty level, it is a well-established and comprehensive measure of socioeconomic deprivation of the area in which people reside[13] and is considered a more meaningful representation of a person's socioeconomic environment than any single parameter, such as income.

The link between ethnicity and SSI risk could foreseeably be confounded by BMI, deprivation and co-morbidity. However, we found Pasifika ethnicity was an independent risk factor for Gram-negative SSI after controlling for these. Again, there is a paucity of high-quality evidence to link ethnicity to SSI, with past studies having conflicting outcomes in different settings.[18,21] DeKeyser et al have discussed the role of education level and genetics in SSI risk in an ethnically homogenous Utah study population.[20] Although genetic predisposition is possible, we consider modifiable factors to also be implicated, either at an environmental or systems level, and that health literacy may be a confounder not measured in the present study. Māori have a significantly higher crude rate of SSI compared to non-Māori and non-Pasifika (Table 1). However, Māori ethnicity was not an independent risk factor on multivariate analysis, suggesting that this is mediated through other known risk factors in the model. For example, 17% of Māori patients were smokers compared to 11% of Pasifika and 6% of non-Māori non-Pasifika (Table 5). Importantly, Māori and Pasifika are over-represented in the most deprived areas of New Zealand.[24] Social, cultural and economic factors are well established determinants of overall health in New Zealand,[25] but until now this has not been associated with SSI directly, which raises concern regarding equitable health outcomes following hip and knee arthroplasty. Duration of surgery has been acknowledged as an important SSI risk factor for orthopaedic surgery previously.[8,26,27] On sub-analysis (Table 4), it became clear that ethnicity and BMI were intertwined into procedure duration. Further research is needed to explain why, within a BMI group, certain ethnicities have longer surgeries.

Although large-scale health system reform and altering social deprivation are beyond the scope of quality improvement programmes, ensuring key performance measures are attained equally for all ethnicities is important from an equity perspective. This current study showed that, even after being controlled for BMI, a known confounder,[28,29] Māori and Pasifika were still more frequently underdosed cefazolin prophylaxis (a key process measure of the SSIIP).

Cefazolin prophylaxis is more frequently underdosed in obese patients.[29,30] A majority of Pasifika ethnicity (31%) in this cohort studied had a BMI of 40kg/m^2 or more. Targeting this highest BMI category for intervention, in which Pasifika and Māori are over-represented, could correct this modifiable risk factor.

Knowledge of the sites of staphylococcal colonization informs interventions such as intra-nasal decolonization and antiseptic skin washes in pre-operative and intensive care settings.[6,31] Gram-negative bacteria inhabit the lower gastrointestinal tract and occasionally the urinary system and the risk of inpatient colonization increases with disease severity and longer hospitalisation.[32,33] Aboltins et al suggested Gram-negative colonization or contamination of the skin around the hip and groin area cause Gram-negative SSI.[34] If this is true, antiseptic wipes included in interventions to reduce perioperative carriage of *S. aureus* may be helpful to reduce the risk of Gram-negative SSI.

Patients with multiple risk factors could be targeted for intensive care pathways[35] that include pre-operative conditioning for weight reduction, smoking cessation, medical optimisation, skin decolonization, rigid adherence to antibiotic surgical prophylaxis guidelines and culturally appropriate wound care instructions before and after the procedure.

Table 5: Risk factors for SSI by ethnicity.

		Non-Māori non-Pasifika	Māori	Pasifika
Meets criteria for SSI	No SSI	39,472 (99%)	4,657 (98.6%)	1,481 (98.9%)
	SSI	416 (1%)	64 (1.4%)	16 (1.1%)
	p-value	ref	**0.049**	**0.923**
BMI category (kg/m^2)	BMI<30	19,109 (53.3%)	1,266 (28.6%)	232 (16.8%)
	30≤BMI<35	9,085 (25.4%)	1,241 (28.1%)	324 (23.5%)
	35≤BMI<40	5,139 (14.3%)	1,058 (23.9%)	399 (28.9%)
	BMI≥40	2,493 (7%)	854 (19.3%)	425 (30.8%)
	p-value	ref	**<0.001**	**<0.001**
Duration of surgery	2 or more hours	5,469 (13.7%)	785 (16.6%)	339 (22.6%)
	<2hours	34,419 (86.3%)	3,936 (83.4%)	1,158 (77.4%)
	p-value	ref	**<0.001**	**<0.001**
Smoking status	Non-smoker	37,573 (94.2%)	3,918 (83%)	1,339 (89.4%)
	Smoker	2,315 (5.8%)	803 (17%)	158 (10.6%)
	p-value	ref	**<0.001**	**<0.001**
Diabetes	No	35,891 (90%)	3,875 (82.1%)	1,108 (74%)
	Yes	3,997 (10%)	846 (17.9%)	389 (26%)
	p-value	ref	**<0.001**	**<0.001**
NZ Index of Deprivation	1 (least deprived)	62,32 (15.7%)	246 (5.2%)	73 (4.9%)
	2	7,784 (19.6%)	455 (9.6%)	158 (10.6%)
	3	8,606 (21.6%)	694 (14.7%)	173 (11.6%)
	4	9,866 (24.8%)	1,216 (25.8%)	343 (23.1%)
	5 (most deprived)	7,326 (18.4%)	2,108 (44.7%)	741 (49.8%)
	p-value	ref	**<0.001**	**<0.001**

Table 5 (continued): Risk factors for SSI by ethnicity.

		Non-Māori non-Pasifika	Māori	Pasifika
ASA class	1	3,382 (8.6%)	362 (7.8%)	105 (7%)
	2	23,487 (59.8%)	2,625 (56.5%)	814 (54.6%)
	3 or more	12,391 (31.6%)	1,663 (35.8%)	571 (38.3%)
	p-value	ref	**<0.001**	**<0.001**
Type of SSI	Deep	175 (42.1%)	25 (39.1%)	6 (37.5%)
	Organ/space	98 (23.6%)	26 (40.6%)	4 (25.0%)
	Superficial	143 (34.4%)	13 (20.3%)	6 (37.5%)
	p-value	ref	**0.001**	**0.986**
Timing of antibiotic prophylaxis	On time	38,089 (97.5%)	4,480 (96.9%)	1,402 (96.6%)
	Not on time	970 (2.5%)	142 (3.1%)	49 (3.4%)
	p-value	ref	**0.016**	**0.033**
Dose of cefazolin prophylaxis	Appropriate	31,247 (95.7%)	3,748 (90.9%)	1,199 (86.8%)
	Under-dosed	1,394 (4.3%)	374 (9.1%)	183 (13.2%)
	p-value	ref	**<0.001**	**<0.001**

ref = reference.
Shown p-values are for chi-square tests comparing ethnicity head to head (with non-Māori non-Pasifika as the reference group) within each respective category. For example, Māori, compared to non-Māori non-Pasifika, had a significantly higher proportion of procedures performed on those with a diagnosis of diabetes ($p < 0.001$).

This study has a number of limitations. *Pseudomonas* SSI events were low in number and had to be grouped with the Enterobacterales. Glycaemic control, particularly in the post-operative period, may be more important than a mere diagnosis of diabetes alone.[36,37] We had not collected information on some well-described risk factors for SSI, preventing their inclusion for analysis (e.g., history of inflammatory arthropathy, malnutrition, choice of anticoagulation, intraoperative wound irrigation).[36] To the best of our knowledge, no study has analysed all known SSI risk factors. Future work needs to focus on systematic data collection of all known risk factors for SSI to accurately describe risk and measure impacts of interventions. Ideally this information needs to be collected prospectively and stored electronically to allow its extraction. While the dataset used in the current study is unique to New Zealand, particularly the relationship between ethnicity and socioeconomic status, the impact health inequity on risk of SSI is of relevance to other high-income countries. Temporal changes in data across the study period were outside the scope of this study, and indeed previous stewardship efforts by the SSIIP may already be addressing the risks identified (e.g., antibiotic timing and dose).[14,15] SSIs that did not require hospitalisation were not captured by the surveillance system, and therefore incidence, distribution and burden caused by Gram-negative organisms are all unknown. Additionally, individual surgeon procedure volume data were not available, and therefore its impact on SSI risk is unable to be quantified.

This study set out to understand current risk factors for SSI, particularly those modifiable by quality improvement interventions, with a novel focus on Gram-negative SSI. We found a number of risk factors for SSI following arthroplasty. However, not all of the risk factors identified are modifiable (e.g., age, male sex, revision arthroplasty, ASA class, social deprivation, duration of surgery). Smoking, BMI, time and dose of antibiotic prophylaxis were identified as modifiable risk factors. SSI improvement programmes must incentivise equitable health outcomes when monitoring adherence to key process measurements. Prevalence of risk factors is not uniform across all ethnicities. Therefore, modifiable risk factors (e.g., correct prophylaxis dosing in overweight patients) may be of increased importance to specific ethnicities. Lastly, SSIs of different etiologies also appear to have unique risk factors, and the usual pooled analysis approach may fail to recognise subtle relationships, therefore hampering the development of appropriate interventions that can be implemented within quality improvement programmes.

COMPETING INTERESTS
Nil.

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Infective endocarditis in patients with rheumatic heart disease: a single-centre retrospective comparative study

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ABSTRACT

AIMS: We reviewed the baseline characteristics and outcomes of patients with infective endocarditis (IE) and compared those with and without rheumatic heart disease (RHD).

METHODS: We retrospectively reviewed patients ≥15 years with IE treated at Auckland City Hospital between January 2016 and December 2018 and excluded device-related IE and complex congenital heart disease. RHD status was based on echocardiographic features or previous history of rheumatic fever with valvular disease. Microbiologic and echocardiographic results, treatment modalities and complications were recorded. Demographics and outcomes were compared based on RHD status.

RESULTS: There were 155 patients with IE. Twenty-two had RHD. The mean age at admission was 45 years for RHD patients, which was 19 years younger than for non-RHD patients. There were significantly more Pacific patients with RHD (55% vs 14%). Previous IE and prosthetic valve endocarditis (PVE) were more common in RHD patients (27% vs 5%, and 77% vs 29%, respectively). After a median follow-up of 29 months, there was no significant difference in all-cause mortality between the two groups. However, 25/155 patients (16%) had died from IE-related causes (septic or cardiogenic shock post cardiac surgery, or embolic complications), with a significantly higher mortality in patients with RHD (7/22 (32%) patients, HR: 2.5) on univariate analysis. On multivariable analysis, PVE, heart failure, *Staphylococcus aureus* infection, diabetes, stroke and cardiac abscess were all associated with increased mortality, whereas RHD was not independently associated with increased mortality.

CONCLUSIONS: In this retrospective single-centre audit, patients with RHD experienced IE at a younger age, had a higher incidence of prosthetic valve endocarditis and a prior history of IE. Although there was no difference in all-cause mortality, mortality in patients with RHD was almost exclusively secondary to complications of IE. This highlights the need for prevention strategies against endocarditis in the RHD population, including use of antibiotic prophylaxis, accessible dental health care and a high clinical suspicion for IE in RHD by healthcare providers.

Infective endocarditis (IE) remains a challenging clinical entity and carries a significant risk of morbidity and mortality. In developed countries, IE now affects increasingly older populations, with higher rates of nosocomial infection than seen in earlier studies. In developing countries, IE continues to affect younger populations, which is more consistent with epidemiological reports from developed countries last century. This is in part due to the persistent burden of rheumatic heart disease (RHD) in developing countries, which is now rare in most developed countries with improved access to healthcare and improved living conditions.[1]

Historically, RHD was the most common risk factor for IE. [2] Although for many years the burden of Group A streptococcal disease and RHD has been diminishing in most developed countries due to access to healthcare, the increasing use of penicillin to treat streptococcal pharyngitis and improved living conditions.[3] RHD remains prevalent at significant rates in the developing world, in the Pacific and in populations in New Zealand and Australia, where RHD almost exclusively affects Māori, Pacific and Aboriginal populations and those from a low socioeconomic backgrounds.[3,4] The true burden of RHD in New Zealand is difficult to establish, due to the lack of population

screening and because, unlike acute rheumatic fever (ARF), RHD is not a notifiable condition. Although a documented history of ARF is helpful in confirming rheumatic valvular changes seen on echocardiography, some patients with RHD have no known history of ARF, and the diagnosis is made on echocardiography alone, or occasionally at the time of cardiac surgery, when typical findings of leaflet thickening and retraction, and mitral chordal thickening, are seen. The World Heart Federation published a guideline in 2012 defining possible and definite echocardiographic findings of RHD to improve standardisation in reporting.[5]

There are few studies that have assessed the burden and outcome of IE complicating RHD in the modern era of improved diagnostics and surgical treatment.[6] Therefore, the aim of this study was to compare the clinical features of IE in rheumatic versus non-rheumatic heart disease, and to compare demographics and outcomes between these two groups.

Methods

Study design

A retrospective case series of adult patients admitted to Auckland City Hospital who received a discharge diagnosis of IE (using International Classification of Disease coding) between 1 January 2016 and 31 December 2018. Exclusion criteria included patients <15 years of age, those with a history of complex congenital heart disease (patients with isolated lesions such as bicuspid aortic valve or small ventricular septal defect were not excluded), and cases of cardiac implantable electronic device endocarditis (patients with valvular endocarditis and concurrent, non-infected devices were not excluded). Follow-up was for a median of 29 months (range 0–41 months). For patients referred from outside New Zealand, follow-up was censored to the date of the last documented healthcare encounter.

Our institution (Auckland District Health Board, Auckland, New Zealand) serves a population of 545,640 people that reside within the locality. Tertiary cardiac surgical services are provided to patients from a larger total population (children and adults) of >2 million people (all patients within the wider Auckland and Northland regions and patients from neighbouring Pacific Islands). We expected IE patients requiring cardiac surgery to be over-represented in this study, with adult patients managed medically in the larger total population not being captured. All cases of cardiac surgery are managed by a multidisciplinary heart team, and the decision regarding surgery is by way of consensus between cardiologists, cardiac surgeons, cardiac anaesthetists and cardiac intensive care specialists, in keeping with international recommendations.[7,8]

Data collection and definitions

Patients were classified as having definite or possible IE according to the Modified Duke Criteria.[9] Regarding major criteria, transthoracic and transoesophageal echocardiography reports for each patient were reviewed and pertinent findings recorded including presence of vegetation, valve involvement, cardiac abscess and left ventricular ejection fraction. Electrocardiography was performed on all patients during admission, and significant findings were recorded. Peripheral blood cultures were reviewed and considered significant if the microbiology was consistent with IE or if an organism was persistently cultured with no other focus found. Peripheral blood cultures were obtained within our institution and cultured at an onsite microbiological laboratory using standard microbiological techniques (n=71), or they were obtained within other localities (n=84). Prosthetic valve endocarditis (PVE) was defined as IE affecting a bioprosthetic or metallic heart valve. Patients were classified as having nosocomial IE if symptoms/signs of IE started more than 48 hours after hospitalisation. The diagnosis of RHD was based on echocardiographic features consistent with the World Heart Federation criteria for definite RHD[5] or a previous history of ARF with valvular disease. Patients with prosthetic valves with no documentation of prior rheumatic valvular disease were not included in the RHD group.

Baseline clinical data including demographics and medical comorbidities were retrospectively retrieved from electronic medical records. Ethnicity was self-defined and categorised as New Zealand European, Māori, Pacific, Asian or Other. Pacific ethnicity included people from the Cook Islands, Fiji, Niue, Norfolk Island, Samoa, Tahiti, Tonga and Tuvalu. Chronic kidney disease was defined as a documented estimated glomerular filtration rate of <60 mL/min/1.73m^2 prior to the index admission. Recent invasive procedure was defined as any invasive procedure that occurred within 60 days prior to onset of symptoms. The outcomes of interest were the occurrence of valve vegetation, intracardiac abscess (aortic root abscess or other site), stroke, non-stroke systemic

embolisation (screening for asymptomatic systemic embolism was at the discretion of the treating clinician), conduction abnormality, cardiac surgery and death. IE-related death was defined as death that occurred due to embolic stroke or intracranial haemorrhage from a mycotic aneurysm, sepsis, heart failure, cardiogenic shock, or death secondary to multi-organ failure or shock post cardiac surgery.

Ethics

Institutional ethical approval was gained from the Auckland District Health Board Research Review Committee for a low-risk audit with research methodologies not meeting criteria for formal independent ethics approval.

Statistical analysis

Continuous variables were reported as mean with standard deviation (SD) or median with interquartile range (IQR), and categorical variables were reported as absolute values with percentages. Comparison between RHD and non-RHD groups was performed by Mann-Whitney U test for continuous variables and Chi-square or Fisher's exact test for categorical variables where appropriate. Kaplan-Meier curves were plotted to demonstrate survival from IE-related death and all-cause death. Multivariate analysis using Cox proportional hazards model (stepwise method) was undertaken to calculate the hazard ratio (HR) with 95% confidence interval (95% CI) and included factors that had a $p<0.10$ in the univariate analysis. Statistical analysis was undertaken using IBM SPSS Version 24 and SAS 9.4 (SAS Institute Inc, Cary, NC, USA).

Results

Demographic characteristics

Over the three-year study period, a total of 155 patients with a discharge diagnosis of IE were identified, of which 22 (14%) had RHD (Table 1). The mean age at presentation was younger in those with RHD: 45.2 years (SD 15.3) in the RHD group compared with 63.9 years (SD 15.8) in the non-RHD group ($p<0.01$). There was a significant difference in ethnicity, where the largest self-reported ethnic group was Pacific (55%) in the RHD group and New Zealand European (48%) in the non-RHD group. Māori made up five (23%) of the RHD group and 16 (12%) of the non-RHD group. Most of the cohort were New Zealand residents (142 patients (92%)).

Clinical characteristics

Patients with RHD had a significantly higher rate of previous IE (six patients, 27%) compared with the non-RHD group (six patients, 5%) ($p<0.01$), as well as higher rates of PVE (17 patients, 77%) compared with the non-RHD group (39 patients, 29%) ($p<0.01$). Nineteen patients (12%) had a recent (<60 days prior) invasive procedure, of which there were eight surgical operations or procedures, five dental procedures, four cardiac valve operations (representing early PVE) and two cardiac catheterisations. According to Modified Duke criteria, 123 (79%) patients were classified as having definite IE and the remainder as having possible IE.

Microbiology

Staphylococcus aureus was the most common causative organism in both groups, followed by viridans group streptococci and *Enterococcus* species (Table 2). There was no significant difference in causative organisms between the two groups.

Clinical outcomes and survival analysis

Stroke occurred in eight patients (36%) in the RHD group compared with 24 (18%) in the non-RHD group, although this difference was not statistically significant (Table 3). Non-stroke systemic embolisation was common in both RHD and non-RHD groups (27% and 40% respectively). The rates of heart failure, conduction abnormalities and cardiac abscess were not significantly different between the two groups. Surgical treatment was undertaken in 14 patients (64%) in the RHD group (with the majority requiring multi-valve surgery) compared with 71 patients (53%) in the non-RHD group.

After a median follow-up duration of 29.4 (IQR 7.4–40) months, 41 patients died: eight (36%) in the RHD group and 33 (25%) in the non-RHD group. Kaplan-Meier survival demonstrated no significant difference in overall mortality between the two groups (Figure 1). During the same follow-up period, 25 patients met the definition for an IE-related death: seven (32%) in the RHD group and 18 (14%) in the non-RHD group. In the RHD group, three deaths were from multi-organ failure following cardiac surgery, three deaths were from intracranial haemorrhage secondary to embolic complications, and one death was from a stroke while awaiting cardiac surgery. In the non-RHD group, nine deaths were from multi-organ failure post cardiac surgery, six deaths from sepsis, two deaths from intracranial haemorrhage

Table 1: Baseline clinical characteristics and disease factors of patients with infective endocarditis.

Characteristics	Total (n=155)	Non-rheumatic heart disease (n=133)	Rheumatic heart disease (n=22)	P-value
Demographics				
Age				
Mean age	61.3 (17.0)	63.9 (15.8)	45.2 (15.3)	<0.01
Under 18 years	0	0	0	
18–30 years	11 (7%)	5 (4%)	6 (27%)	
31–45 years	16 (10%)	11 (8%)	4 (18%)	
46–60 years	41 (26%)	33 (25%)	9 (41%)	
Over 60 years	87 (56%)	84 (63%)	3 (14%)	
Male	105 (68%)	93 (70%)	12 (55%)	0.15
Ethnicity				
New Zealand European	67 (43%)	64 (48%)	3 (14%)	<0.01
Māori	21 (14%)	16 (12%)	5 (23%)	
Pacific	31 (20%)	19 (14%)	12 (55%)	
Asian	14 (9%)	13 (10%)	1 (5%)	
Other	22 (14%)	21 (16%)	1 (5%)	
New Zealand residency	142 (92%)	124 (93%)	18 (82%)	0.09
Medical history				
Diabetes	31 (20%)	30 (23%)	1 (5%)	0.08
Chronic kidney disease	28 (18%)	23 (17%)	5 (23%)	0.55
Dialysis dependent	6 (4%)	5 (4%)	1 (5%)	1.00
Cancer	17 (11%)	15 (11%)	2 (9%)	1.00
Current intravenous drug use	3 (2%)	3 (2%)	0	1.00
Previous infective endocarditis	12 (8%)	6 (5%)	6 (27%)	<0.01
Invasive procedure within 60 days	19 (12%)	15 (11%)	4 (18%)	0.49
Implanted cardiac device [a]	9 (6%)	7 (5%)	2 (9%)	0.62
Immunosuppression	7 (5%)	7 (5%)	0	0.59

Table 1 (continued): Baseline clinical characteristics and disease factors of patients with infective endocarditis.

Characteristics	Total (n=155)	Non-rheumatic heart disease (n=133)	Rheumatic heart disease (n=22)	P-value
Disease characteristics				
Duke's definite	123 (79%)	103 (77%)	20 (91%)	0.25
Duke's possible	32 (21%)	30 (23%)	2 (9%)	0.25
Prosthetic valve endocarditis	56 (36%)	39 (29%)	17 (77%)	<0.01
Duration of symptoms [b]				
<1 week	72 (46%)	59 (44%)	13 (59%)	0.19
1–4 weeks	26 (17%)	25 (19%)	1 (5%)	0.13
>4 weeks	35 (23%)	31 (23%)	4 (18%)	0.78
Community acquired	150 (97%)	128 (96%)	22 (100%)	1.00
Nosocomial	5 (3%)	5 (4%)	0	1.00

[a] Patients had valvular endocarditis and not device-related endocarditis.
[b] Data not available in 22 patients.

Table 2: Causative organisms of infective endocarditis.

Causative organism	Total (n = 155) [a]	Non-rheumatic heart disease (n=133)	Rheumatic heart disease (n=22)
Staphylococcus aureus	51 (33%)	42 (32%)	9 (41%)
Coagulase-negative staphylococci	6 (4%)	6 (5%)	0
Viridans group streptococci	26 (17%)	24 (18%)	2 (9%)
Streptococcus gallolyticus	4 (3%)	4 (3%)	0
Other *Streptococcus* species	13 (8%)	10 (8%)	3 (14%)
Enterococcus species	21 (14%)	20 (15%)	1 (5%)
HACEK group [b]	12 (8%)	7 (5%)	5 (23%)
Polymicrobial	3 (2%)	3 (2%)	0
Other organisms	14 (9%)	13 (10%)	1 (5%)
Culture negative	5 (3%)	4 (3%)	1 (5%)

[a] There was no statistically significant difference between the distribution of causative organisms between the two groups.
[b] HACEK: *Haemophilus* species, *Aggregatibacter* species, *Cardiobacterium hominis, Eikenella corrodens, and Kingella kingae*.

and one death from ischaemic bowel. Kaplan-Meier survival demonstrated a significantly higher IE-related death rate in patients with RHD (p=0.03) (Figure 2). On multivariate analysis, factors associated with increased risk of IE- related death included PVE, heart failure, *Staphylococcus aureus* endocarditis, diabetes, stroke and cardiac abscess (Table 4).

Discussion

One in three RHD patients with IE in this study had an IE-related death within 20 months of diagnosis, which was twice the IE-related death rate of non-RHD patients at the same duration of follow-up. This high IE-related death rate in the RHD group is comparable to the reported IE-related death rate in low- and middle-income countries.[10] Overall, the outcomes in our study are similar to contemporary series. The European Infective Endocarditis study (2019) prospectively enrolled 3,116 patients across 40 countries. In-hospital outcomes included heart failure in 14% and surgical treatment in 51%, and the overall in-hospital death rate was 17%. Underlying rheumatic heart disease incidence was not specified.[11]

In addition to the higher mortality rate in the RHD group, the near 20-year age difference between the two groups implies a very significant reduction in life expectancy in the RHD group. The increased IE-related death rate in patients with RHD may have been contributed to by the higher rate of PVE, which was also the strongest predictor of death.

In the present study, 14% of patients with IE had a diagnosis of RHD, which contrasts with estimates for the community prevalence of RHD; echocardiography screening studies in high-risk groups in Auckland have shown approximately 5% of young Pacific adults and 2.5% of Māori and Pacific children have RHD changes on echocardiography.[12,13] The over-representation of RHD patients in the total number of patients with IE is still apparent even when compared to a publication from the 1980s for the same region (where 45% of the cohort had RHD), despite clear evidence for modifiable risk factors for ARF and national guidelines for management of sore throats.[14]

We observed a significant difference in the rate of previous IE between the RHD and the non-RHD groups; a quarter of the RHD group had a previous episode of IE, compared with only 5% of the non-RHD group. A significantly higher incidence of PVE was seen in the RHD group compared to the non-RHD group. Heart valve surgery early in life in patients with RHD, a condition often affecting multiple valves, exposes them to high cumulative risk of developing PVE over their lifetime. This supports a notion of a vicious cycle which can emerge from the combination of RHD, prosthetic heart valves and episodes of IE, which create a host that is at an exceedingly high risk of recurrent IE and complications thereof. In this regard, New Zealand and Australian IE prophylaxis guidelines recommend several measures to prevent the occurrence of IE, including continued recognition of the role of prophylactic antibiotics prior to invasive procedures in patients with RHD.[15–17] This contrasts with the guidelines of the European Society of Cardiology and the American Heart Association,[8,18] which do not specifically list people with RHD as part of the high-risk populations that require antibiotic prophylaxis. The specific recognition of RHD in New Zealand and Australian guidelines reflects the higher prevalence of this condition in these regions. Our finding that PVE and previous IE were common in the RHD group supports the recommendation to include these patients in the high-risk populations that require antibiotic prophylaxis. In the present study, PVE was associated with a near tenfold increase in the hazard of death compared to native valve IE. This increased risk of death may be because the management of PVE is characterised by high rates of surgical intervention and technically challenging operations and that there are significant rates of recurrent IE with the need for future redo surgery in this patient group.[19]

Given the mortality risk and complications of IE, high-risk patients with valvular heart disease (in particular, patients with a prosthetic valve replacement, patients with previous IE and patients with RHD) should have regular dental reviews. Funded dental treatment options should be available for those who are unable to have regular dental reviews due to financial reasons. Patients should also be provided with "Infective Endocarditis" wallet cards, such as those produced by the New Zealand Heart Foundation,[20] and advised of symptoms that should prompt urgent medical review. Experience from most of the developed world indicates that the eradication of ARF and RHD is possible, and therefore ongoing efforts to reduce the incidence of ARF within Indigenous populations are essential. A focus on adequate provision of safe, healthy housing and funded access to healthcare, including dental services for high-risk populations, is required.

Table 3: Complications, surgical treatment and outcomes of patients with infective endocarditis.

	Total (n=155)	**Non-rheumatic heart disease (n=133)**	**Rheumatic heart disease (n=22)**	**P-value**
Complications				
Vegetation [a]	118 (76%)	98 (74%)	20 (91%)	0.11
Aortic valve	42 (27%)	38 (29%)	4 (18%)	
Mitral valve	77 (50%)	60 (45%)	17 (77%)	
Tricuspid valve	15 (10%)	14 (11%)	1 (5%)	
Intra-cardiac abscess	23 (15%)	20 (15%)	3 (14%)	0.86
Aortic root	18 (12%)	15 (11%)	3 (14%)	
Other site [b]	5 (3%)	5 (4%)	0	
Stroke	32 (21%)	24 (18%)	8 (36%)	0.08
Non-stroke systemic embolisation [c]	59 (38%)	53 (40%)	6 (27%)	0.26
Conduction abnormality or arrhythmia [d]	34 (22%)	29 (22%)	5 (23%)	0.67
Heart failure	17 (11%)	16 (12%)	1 (5%)	0.47
Surgery	85 (55%)	71 (53%)	14 (64%)	0.37
Aortic valve repair or replacement [e]	42 (27%)	33 (25%)	9 (41%)	
Mitral valve repair or replacement [e]	47 (30%)	36 (27%)	11 (50%)	
Tricuspid valve repair or replacement [e]	11 (7%)	6 (5%)	5 (23%)	
Multi-valve surgery	16 (10%)	8 (6%)	8 (36%)	
Outcomes				
Median follow-up in months	29 (7.4–40)	32 (16–41)	20 (0.07–36)	0.11
IE-related in-hospital death	20 (13%)	15 (11%)	5 (23%)	0.16
IE-related death at 30 days	22 (14%)	16 (12%)	6 (27%)	0.06
IE-related death during follow-up	25 (16%)	18 (14%)	7 (32%)	0.05
All-cause death during follow-up	41 (26%)	33 (25%)	8 (36%)	0.26
Recurrent IE	7 (5%)	7 (5%)	0	0.59

Abbreviations: IE, infective endocarditis.
[a] Indicates number of patients affected, as some patients had multiple valve vegetations.
[b] mitral annulus, interventricular septum, or left ventricular outflow tract.
[c] Includes cerebral abscess, meningitis, meningoencephalitis, epidural abscess, discitis, transient ischaemic attack, splenic embolism, renal embolism, mesenteric ischaemia, liver abscess or infarcts, osteomyelitis, muscle abscess, septic arthritis, endophthalmitis, septic pulmonary emboli, limb artery embolism and Janeway lesions.
[d] Includes sinus bradycardia, first degree heart block, complete heart block, bundle branch block, atrial fibrillation or flutter, junctional arrhythmia and ventricular tachycardia.
[e] Includes cases of redo valve surgery and multi-valve surgery.

Figure 1: Kaplan-Meier survival free from all-cause death based on rheumatic heart disease (RHD) status.

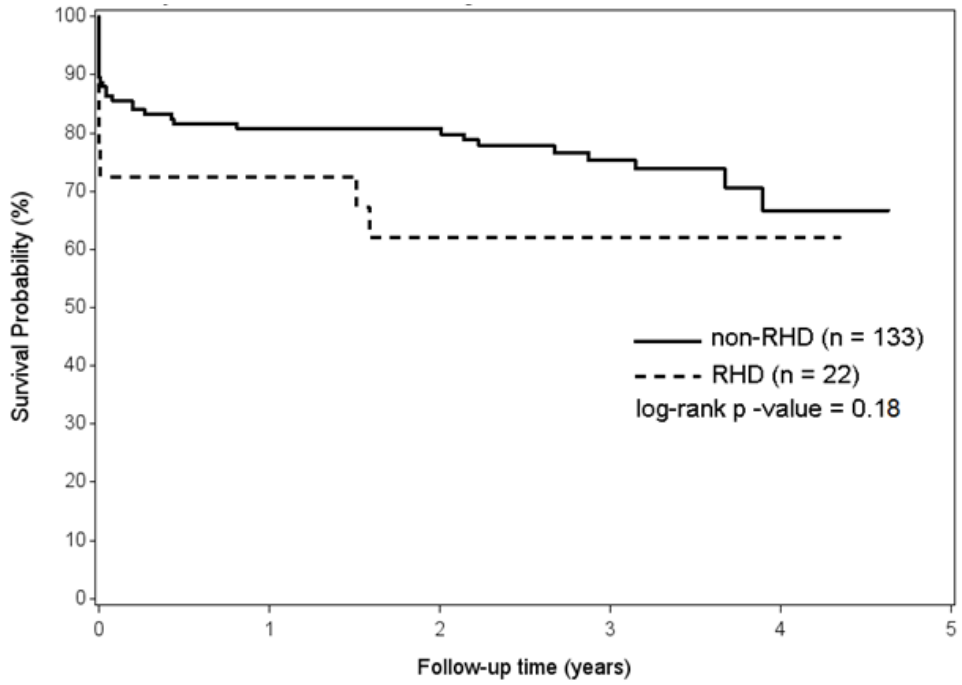

Figure 2: Kaplan-Meier survival free from infective endocarditis-related death based on rheumatic heart disease (RHD) status.

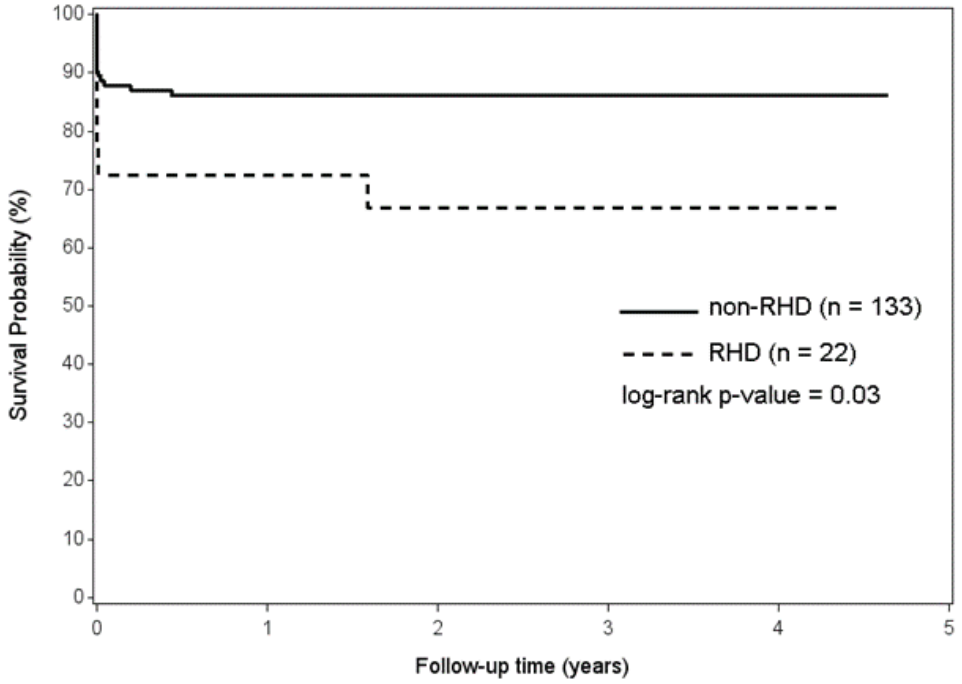

Table 4: Cox univariate and multivariate analyses of factors for association with infective endocarditis-related mortality.

Factor	Univariate		Multivariate	
	Hazard ratio (95% CI)	**P-value**	**Hazard ratio (95% CI)**	**P-value**
Prosthetic valve endocarditis	2.8 (1.2–6.2)	0.01	9.5 (3.2–28.5)	<0.01
Heart failure	2.8 (1.1–6.9)	0.03	6.3 (2.0–19.4)	<0.01
Staphylocccus aureus infective endocarditis	3.2 (1.5–7.2)	<0.01	4.1 (1.8–9.7)	<0.01
Diabetes	2.4 (1.1–5.4)	0.04	3.9 (1.6–9.9)	<0.01
Stroke	2.7 (1.2–5.9)	0.02	2.8 (1.2–6.5)	0.02
Cardiac abscess	2.8 (1.2–6.5)	0.02	2.4 (1.0–5.6)	0.049
Rheumatic heart disease	2.5 (1.0–6.0)	0.04	Not significant	
Chronic kidney disease	2.7 (1.2–6.1)	0.02	Not significant	
Age	1.0 (0.9–1.0)	0.68		
Cancer	1.2 (0.3–3.8)	0.82		
Cardiac operation	1.1 (0.5–2.3)	0.90		
Male gender	1.0 (0.4–2.3)	0.99		
Previous infective endocarditis	1.7 (0.5–5.6)	0.51		
Vegetation	1.0 (0.4–2.5)	0.99		
Ethnicity				
New Zealand European	Reference			
Māori	2.7 (1.0–7.1)	0.053		
Pacific	1.3 (0.4–3.8)	0.66		
Asian	1.1 (0.2–4.9)	0.95		
Other	0.7 (0.2–3.2)	0.65		

This study has a number of limitations. It is retrospective and based on a single centre. Further, we were not able to include patients treated non-surgically from the other centres that referred patients for cardiac surgery, and therefore there is a risk that referral bias may have affected the results. A small number of patients were included having been referred from the Pacific, and follow-up data were also limited for these patients, which contributes to the referral bias.

Conclusion

This study has shown that patients with underlying RHD are at risk of developing IE. Patients with RHD experienced IE at a significantly younger age and had higher rates of previous IE and prosthetic valves. Although there was no difference in all-cause mortality, mortality in patients with RHD was almost exclusively secondary to IE- related factors. Prevention strategies to reduce the risk of endocarditis in the RHD population are important, including the use of antibiotic prophylaxis as per the New Zealand Heart Foundation Guidelines, accessible dental healthcare and a high clinical suspicion for IE by healthcare providers. Efforts to eradicate ARF should also continue for this preventable disease.

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COMPETING INTERESTS
Nil.

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Gynaecological cancer pathway for faster cancer treatment: a repeat clinical audit

Rebekah J Cherry, Anand Gangji

ABSTRACT

AIMS: This clinical audit aimed to review cancer management pathways for patients with gynaecological cancers in Northland in order to evaluate whether there has been an improvement compared to previous audit periods and look for differences between ethnicities.

METHODS: 186 Northland patients with a new diagnosis of gynaecological cancer were discussed at the Auckland gynaecology-oncology multidisciplinary meeting (MDM) between 1 January 2018 and 31 December 2020. Patient demographics and data pertaining to cancer care was collected and compared to datapoints set out in the original audit, derived from the Ministry of Health Faster Cancer Treatment (FCT) targets and standards of service provision.

RESULTS: 89.2% of patients had their first treatment within 31 days of treatment decision, and 66.9% had their first treatment within 62 days of referral, an improvement compared to previous audit periods. Wait times were shorter but there were still delays in obtaining histology, MDM discussion and receiving treatment. There were also differences between treatment locations, as well as between Māori and non-Māori.

CONCLUSIONS: There has been an overall improvement in gynaecological cancer service provision for Northland patients. However, outcomes still fall short of the national FCT targets and there are on-going disparities between Māori and non-Māori.

Gynaecological cancers are a diverse group of cancers arising from the female reproductive tract, encompassing malignancies of the uterus (including endometrium), ovary, fallopian tube, cervix, vagina and vulva, alongside tumours of variable malignant behaviour such as borderline ovarian tumours and persistent gestational trophoblastic neoplasia.[1] 10% of all cancer cases in New Zealand are gynaecological, the most common of which is endometrial, followed by ovarian and cervical. They also constitute 10% of all cancer deaths among New Zealand women.[1] There are inequitable outcomes between ethnicities, with Māori and Pacific Island patients having higher incidences of and mortality from endometrial and cervical cancers compared to non-Māori/non-Pacific Island.[1]

The Ministry of Health *Standards of Service Provision for Gynaecological Cancer Patients* introduced in 2012 aim to ensure that all elements of gynaecological cancer care are provided in an efficient, sustainable and equitable fashion.[1] These standards align with the national Faster Cancer Treatment (FCT) targets.[2]

Gynaecological cancer services are regionally organised. In Northland District Health Board (DHB), all cases of suspected or confirmed gynaecological cancer are discussed at the Auckland multidisciplinary meeting (MDM), a tertiary level gynaecology-oncology service. The location of treatment is determined by the MDM depending on the complexity of disease and type of treatment required. Patients requiring radiotherapy or surgical treatment by gynaecology-oncology subspecialists receive treatment in Auckland, and others receive treatment in Northland. The above targets provide auditable standards to ensure consistency across centres.[1] However, there is still the potential for inequitable access between different DHBs.

Between June 2014 and June 2015, an audit evaluating Northland DHB's performance regarding these standards identified significant delays across all elements in the assessment and management of patients with gynaecological cancers.[3] A repeat audit between January and December 2016 demonstrated an overall improvement, but it also showed that Northland DHB was still falling

short of the Ministry of Health targets. Inequities in service provision between Māori and non-Māori patients were also identified.[4]

This repeat audit aims to:

1. Assess how Northland DHB is performing with regards to the targets defined in the *Standards of Service Provision for Gynaecological Cancer Patients* and the FCT targets.
2. Ascertain whether there has been an improvement in service provision following initiatives implemented since the previous audit period.
3. Identify where delays are occurring along the cancer care pathway.
4. Assess equity of service provision between ethnicities, namely Māori and non-Māori.

Methods

The study population for this audit consisted of all patients with gynaecological cancer referred by Northland DHB to the Auckland gynaecology-oncology MDM between 1 January 2018 and 31 December 2020. Patients were identified from MDM meeting minutes held by the gynaecology and colposcopy outpatients clinical nurse specialist. 295 patients were identified, of which 109 were excluded for the following reasons: MDM referral outside of timeframe, recurrent disease, benign histology, non-gynaecological cancer, MDM referral from private practitioners/external DHBs, treatment completed outside the region, or patient declining further investigation/treatment. For the remaining 186 patients, data were collected from electronic documents (discharge summaries, clinic letters, operation notes, MDM summary documents, radiology/histology requests and reports) stored in the electronic collection system Concerto, as well as from physical patient notes and email correspondence. Information regarding patient age, ethnicity, cancer type, referral source and triage category were also collected from the same electronic sources. Patient ethnicities were then prioritised as per

Table 1: National FCT targets, gynaecological tumour standards/good practice points.

National Faster Cancer Treatment (FCT) targets[2]
1. Treatment should begin within 31 days of a decision being made that they will have that treatment.
2. Patients receive their first cancer treatment within 62 days of the hospital receiving their referral (when the doctor receiving the referral believes there is a high suspicion of cancer and that they should be seen within 2 weeks).
Standards of Service Provision for Gynaecological Cancer Patients[1]
Standard 1:
• Women referred urgently with a high suspicion of gynaecological cancer have their first specialist assessment (FSA) within 14 days.
• Women with a confirmed diagnosis of gynaecological cancer receive their first treatment within 31 days of the decision to treat.
• Women referred urgently with a high suspicion of gynaecological cancer receive their first cancer treatment within 62 days.
Standard 6:
• Women with a new diagnosis of gynaecological malignancy are offered an appointment for radiological investigations required for treatment planning that falls within two weeks of the date of receipt of that referral.
Standard 12:
• The MDM discussion takes place within 14 days of referral (provided referral criteria are met).
Pathology Review Good Practice Point 3.3:
• Provisional or final pathology reports are communicated with the lead clinician within 10 working days of the specimen being taken.

the Ministry of Health Ethnicity Data Protocols for the purposes of statistical analysis.[5] The data were then collated in a Microsoft Excel spreadsheet and simple statistics were performed to calculate the percentage of patients who met each target, as well as the minimum, mean and maximum waiting times.

The datapoints for this audit were defined using the same definitions as the original audit (Table 2),[3] derived from the standards and good practice points from the *Standards of Service Provision for Gynaecological Cancer Patients* and national FCT targets (Table 1).[1,2]

The standards forming datapoints 1 and 6 specify "women referred urgently with a high suspicion of cancer." However, not all patients with gynaecological cancer are deemed to be "high suspicion" at initial triage. Therefore, the outcomes for these two datapoints were only calculated for those who had their outpatient referral triaged as "urgent with a high suspicion of cancer" or were seen as inpatients. There were also patients triaged as urgent for reasons other than cancer, semi-urgent and routine, and their triage status documented accordingly. These patients were not initially tracked by the FCT pathway until after their FSA. There is no national target for time from referral to FSA for those deemed to require an urgent (non-cancer) or semi-urgent out-patient review. Northland aims to see urgent, non-cancer referrals within 10 working days, semi-urgent within four weeks and routine within four months. To assess the waiting times for radiological investigations across all imaging modalities, datapoints 2a, 2b and 2c were combined to create datapoint 2. Datapoints 3a and 4b were defined in the benchmark audit after discussion with local clinicians as an extrapolation of good practice point 3.3 and standard 12 respectively,[1] and were thus reproduced compare the current performance with previous audit periods.[3] For datapoints 4b, 5 and 6, the date of decision to treat was the date this decision was discussed with the patient and their whānau following the final MDM plan, in line with the FCT definitions.[3]

Results

Patient demographics

Over the three-year period, there were 186 patients with a confirmed diagnosis of new gynaecological cancer. The average age at diagnosis was 61.7 (22–88). Of these 186 patients, 92 were New Zealand European (49.5%), 73 Māori (39.2%), 14 other European (7.5%), two other Asian (1.1%), two Chinese (1.1%), one South East Asian (0.5%), one Fijian (0.5%) and one European not further defined (0.5%). This equates to 113 non-Māori (60.8%) and 73 Māori (39.2%).

Referral and triage information

The majority of referrals came from general practice (68.8%), with the remaining referred by the emergency department (10.2%), other inpatient (14%) or outpatient (5.4%) specialties or from the private sector (1.6%). 59.7% of patients were triaged as urgent with a high-suspicion of cancer, 2.2% as urgent, 11.3% as semi-urgent (11.3%) and 4.3% as routine. 21% of patients were seen as inpatients.

Cancer type

The most common cancer type was endometrial, followed by cervical and malignant ovarian. For 186 patients, there were a total of 189 cancer diagnoses, with three patients having both endometrial and ovarian primaries. The category "other" encompasses gestational trophoblastic disease, other cancers of the Mullerian tract, or where the primary cancer type was not completely determined, most commonly labelled as "primary peritoneal vs tubo-ovarian." Of interest, the most common cancer types among Māori patients were the most prevalent gynaecological cancers (endometrial, cervical, ovarian), with fewer patients being affected by more rare cancer types (Table 3).

Standard of service provision

Datapoint 1 stipulates that women deemed to be "high suspicion of gynaecological cancer" have their first specialist assessment (FSA) within 14 days of referral.[1] This target was met for 90.7% of patients, an improvement on 85.4%[4] and 65%[3] in previous audits. The waiting times were shorter, with a mean time from referral to FSA of 6.7 days (0–33), compared to 12.0 days[4] and 10.5 days.[3]

Datapoint 2 stipulates that radiological investigations are to be completed within 14 days of receiving the request.[1] This target was met in 90.4% of cases across all imaging modalities, with a mean time of 7.8 days (0–76). The biggest improvement was seen for MRI scans (2c), with 95.1% of MRIs being performed within 14 days, compared to 75.0%[4] and 73%.[3] Wait times were shorter, with a mean time of 6.5 days (0–25) compared to 11.2 days[4] and 10.6 days.[3] The target was met for 82.3% of ultrasounds, with an average wait time of 6.7 days (0–33). Fewer CT scans were performed within target (91.9% compared

Table 2: Audit datapoints and target timeframe with their respective standard of service provision.

Datapoint	Target [days]	Standard of service provision
1. Time from referral → FSA	≤ 14 days	Standard 1a: women referred urgently with a high suspicion of gynaecological cancer have their first specialist assessment within 14 days.[1]
2. Time from imaging requested → imaging performed	≤ 14 days	Standard 6: women with a new diagnosis of gynaecological malignancy are offered an appointment for radiological investigations required for treatment planning that falls within 2 weeks of the date of receipt of that referral.[1]
2a. USS wait time	≤ 14 days	
2b. CT wait time	≤ 14 days	
2c. MRI wait time	≤ 14 days	
3a. Time from decision to take histology → histology reported	≤ 14 days	Datapoint set by the benchmark audit.[3] Derived from Good Practice Point 3.3 after discussion with local clinicians.[1]
3b. Time from histology taken → histology reported	≤ 10 working days	Good Practice Point 3.3: provisional or final pathology reports are communicated with the lead clinician within 10 working days of the specimen being taken.[1]
4a. Time from MDM referral → first MDM meeting	≤ 14 days	Standard 12: the MDM discussion takes place within 14 days of the referral (provided referral criteria are met).[1]
4b. Time from MDM referral → decision to treat	≤ 14 days	
5. Time from decision to treat → first treatment	≤ 31 days	Standard 1a: treatment should begin within 31 days of a decision being made that they will have that treatment.[1]
6. Time from referral → first treatment	≤ 62 days	Standard 1c: women referred urgently with a high suspicion of gynaecological cancer have their first cancer treatment within 62 days.[1] As of June 2017, this should be met by 90% of patients.

Table 3: Final histological cancer diagnosis (stratified by Māori vs non-Māori).

Cancer type	Total cases		Māori		Non-Māori	
	Number	%	Number	% of Māori	Number	% of non-Māori
Endometrial	85	45.0%	37	50.0%	48	41.7%
Cervical	30	15.9%	14	18.9%	16	13.9%
Ovarian, malignant	22	11.6%	10	13.5%	12	10.4%
Ovarian, borderline	11	5.8%	5	6.8%	6	5.2%
Other uterine	9	4.8%	3	4.1%	6	5.2%
Vulval	10	5.3%	1	1.4%	9	7.8%
Vaginal	3	1.6%	1	1.4%	2	1.7%
Other	19	10.1%	3	4.1%	16	13.9%
Total	**189**		**74**		**115**	

Figure 1: Percentage of patients meeting the target for each datapoint compared to previous audit periods, in reference to the 90% target set by the Ministry of Health.

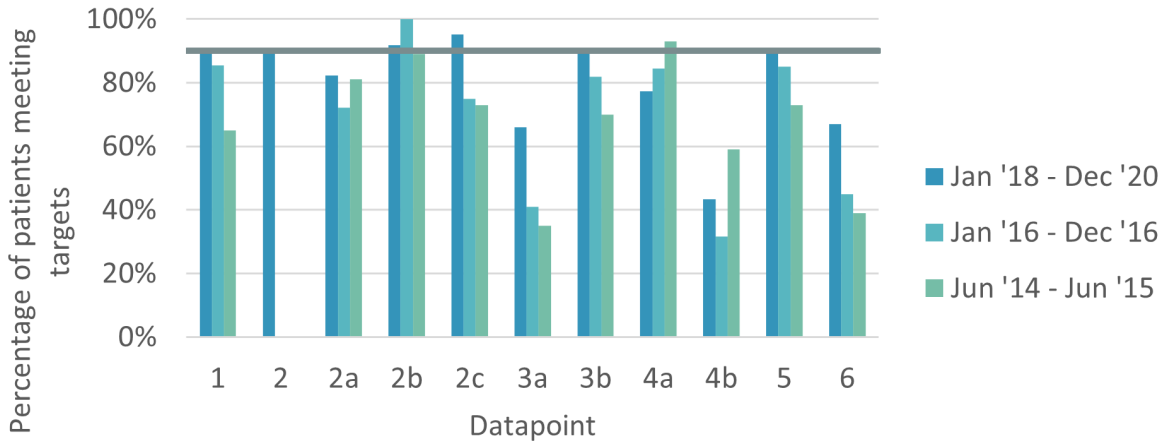
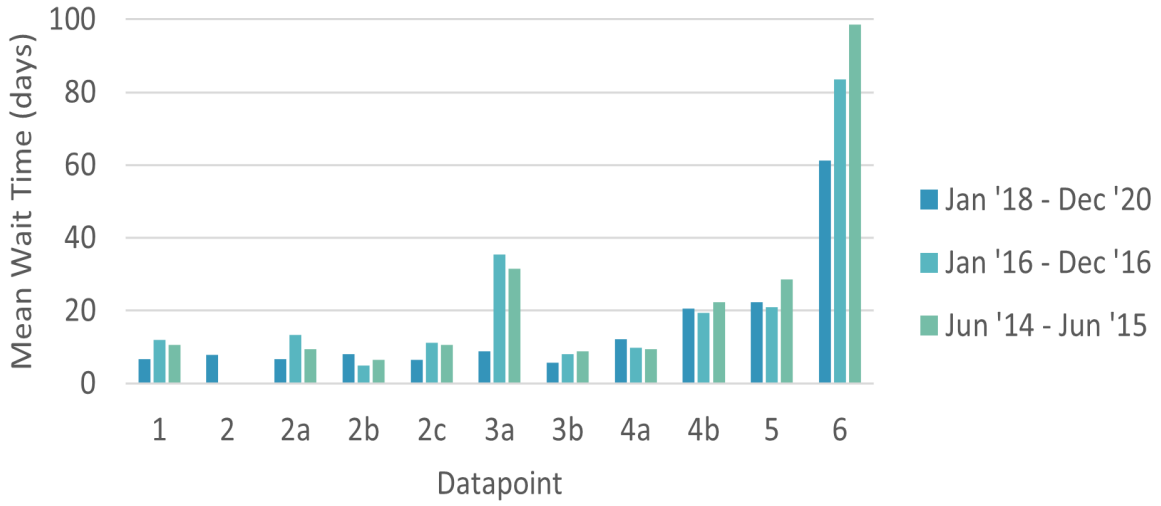


Figure 2: Mean wait times for each datapoint compared to previous audit periods.



to 100% in 2016), with slightly longer wait times, too (8.1 days compared to 5.0 days).[4]

Datapoint 3a stipulates that the time from decision to take histology to histology being reported should be 14 days or less.[3] This is comprised of two components: the time from decision to collect histology to histology collection, and the time from collection of histology to histology report (datapoint 3b). The target for datapoint 3a was met in 66.0% of cases, with a mean wait time of 8.9 days (0–29). This is an improvement compared 40.9%[4] and 35%[3] in previous audit periods. Stratifying by histology collection method, the longest wait times were for those who required an operation for histology collection, most notably hysteroscopy, with only 22.4% of patients requiring a hysteroscopy meeting the target, waiting a mean time of 28.6 days. However, the wait times were substantially shorter compared to 2014–2015, where the mean wait time for hysteroscopy was 52.0 days.[3] Shorter waiting times were seen across all histology collection methods.

Datapoint 3b stipulates that a provisional or final histology report should be communicated with the lead clinician within 10 working days.[1] This was met in 88.2% of cases, an improvement on 81.8%[4] and 70%[3] previously. The mean time for histology reporting was also shorter than previous periods at 5.7 working days.

Datapoint 4a stipulates that the first MDM discussion should occur within 14 days of the MDM referral (provided the referral criteria are met).[1] Given that the date of first MDM discussion and date of treatment decision may not be the same, datapoint 4b was created and stipulates that a treatment decision should be made and discussed with the patient within 14 days of MDM referral.[3] Datapoint 4a was met in 77.4% of cases, a smaller proportion compared to previous audit periods at 84.4%[4] and 93%.[3] The wait times for MDM discussion were longer, with a mean time of 12.1 days (2–49) compared to 9.82 days[4] and 9.5 days.[3] Datapoint 4b was the worst performing outcome in this audit, with only 43.3% meeting the target, though this is an improvement on 31.6% in last audit period.[4] The mean time from MDM referral to treatment decision was 20.5 days (0–109), similar to previous.[3,4]

Datapoint 5 stipulates that patients with confirmed gynaecological cancer should receive their first treatment within 31 days of treatment decision,[1] aligning with the 31-day FCT target.[2] This target was met by 89.2% of patients (an improvement on 85%[4] and 73%[3] previously), with a mean time of 22.3 days (0–151). Stratifying by treatment location, this target was met by 98.8% of those receiving treatment in Auckland, compared to 81.6% of those receiving treatment in Northland. There were statistically significant differences in wait times between treatment locations, with those receiving treatment in Auckland waiting an average of 9.4 days less than those receiving treatment Northland (Table 4).

Datapoint 6 stipulates that patients referred urgently with a high suspicion of cancer should receive their first treatment within 62 days of referral,[1] aligning with the 62-day FCT target. As of June 2017, this target should be met by 90% of patients.[2] This target was met by 66.9% of patients, with a mean time of 61.3 days (1–398), a significant improvement compared to previous periods at 45%[4] and 39%.[3] The target was met by 70.6% of those receiving treatment in Auckland, compared to 63.4% in Northland, with mean wait times of 57.3 days and 64.9 days respectively; however, the difference in wait times between treatment locations was not statistically significant (Table 4).

Results by ethnicity

There was a statistically significant difference in age at presentation of gynaecological cancers between Māori and non-Māori, with Māori presenting an average of 6.9 years younger for gynaecological cancers overall (Table 5). Stratifying by cancer subtype, there was also a statistically significant difference in the age at presentation for endometrial cancer, with Māori presenting an average of 7.1 years younger, at a mean age at presentation of 60.4 years old (95% CI 56.6–64.2), compared to 67.5 years old (95% CI 65.0–70.0) for non-Māori.

Māori patients with cancer were less likely to be triaged as urgent with a high suspicion of cancer or to be seen as inpatients, and were more likely to be triaged as semi-urgent or routine compared to non-Māori (Table 6).

Compared to non-Māori, Māori were less likely to have their CT scans performed within 14 days (datapoint 2b), have a treatment decision within 14 days of MDM referral (datapoint 4b), or receive their first treatment within 31 days of treatment decision (datapoint 55) and 62 days of initial referral (datapoint 6) (Figure 3).

Māori had longer wait times for most datapoints, though these differences were not statistically significant (Figure 4). The largest difference was for datapoint 3a, with Māori patients waiting on average 4.5 days longer compared to non-

Table 4: Datapoints 5 and 6 by treatment location.

Datapoint	Treatment location	Number meeting target	Percentage meeting target	Mean wait time (days) [95% CI]	Range (days)
5. Treatment decision to first treatment ≤31 days	Overall	166/186	89.2%	19.0 [15.–22.2]	0-151
	Auckland	81/82	98.8%	13.8 [12.1–15.5]	0-34
	Northland	84/103	81.6%	23.2 [17.7–28.7]	0-151
	Private	1/1	100%	16.0	-
6. Referral to first treatment ≤62 days	Overall	101/151	66.9%	61.3 [53.7–68.9]	1-398
	Auckland	48/68	70.6%	57.3 [50.1–77.5]	14-172
	Northland	52/82	63.4%	64.9 [52.3–77.5]	1-398
	Private	1/1	100%	38.0	-

Table 5: Mean age at presentation for all gynaecological cancers for Māori and non-Māori.

Ethnicity	Mean age (years) [95% CI]	Range (years)
Māori	57.5 [54.5–60.5]	24–84
Non-Māori	64.4 [61.9–66.8]	22–88
All cancers	61.7 [59.7–63.6]	22–88

Table 6: Percentage of Māori and non-Māori for each triage category

Triage category	% of Māori	% of non-Māori	% of all patients
Inpatient	19.2%	22.1%	21.0%
Urgent with a high suspicion of cancer	54.8%	62.8%	59.7%
Urgent	2.7%	1.8%	2.2%
Semi-urgent	12.3%	10.6%	11.3%
Routine	8.2%	1.8%	4.3%
Not triaged	2.7%	0.9%	1.6%

Figure 3: Percentage meeting each datapoint target by ethnicity, in reference to the 90% target set by the Ministry of Health.

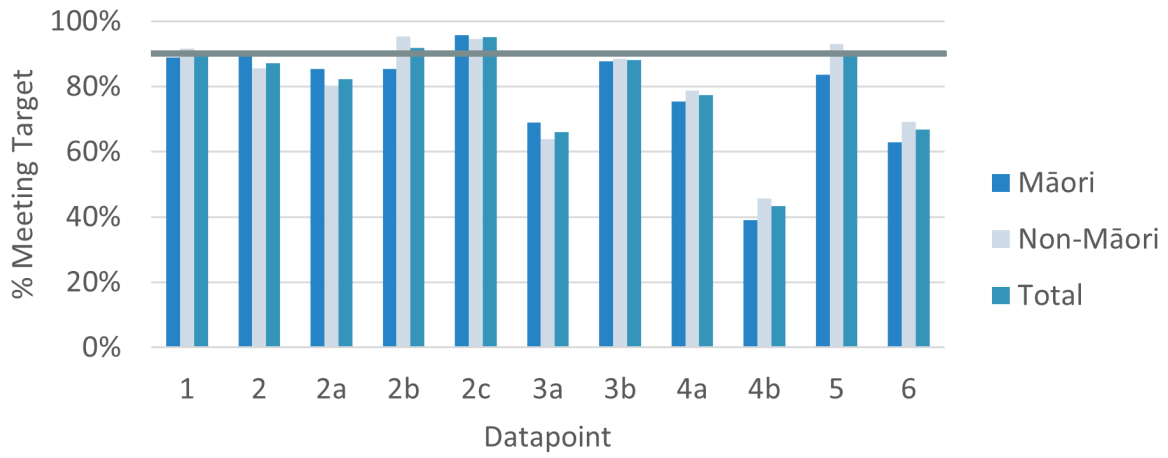
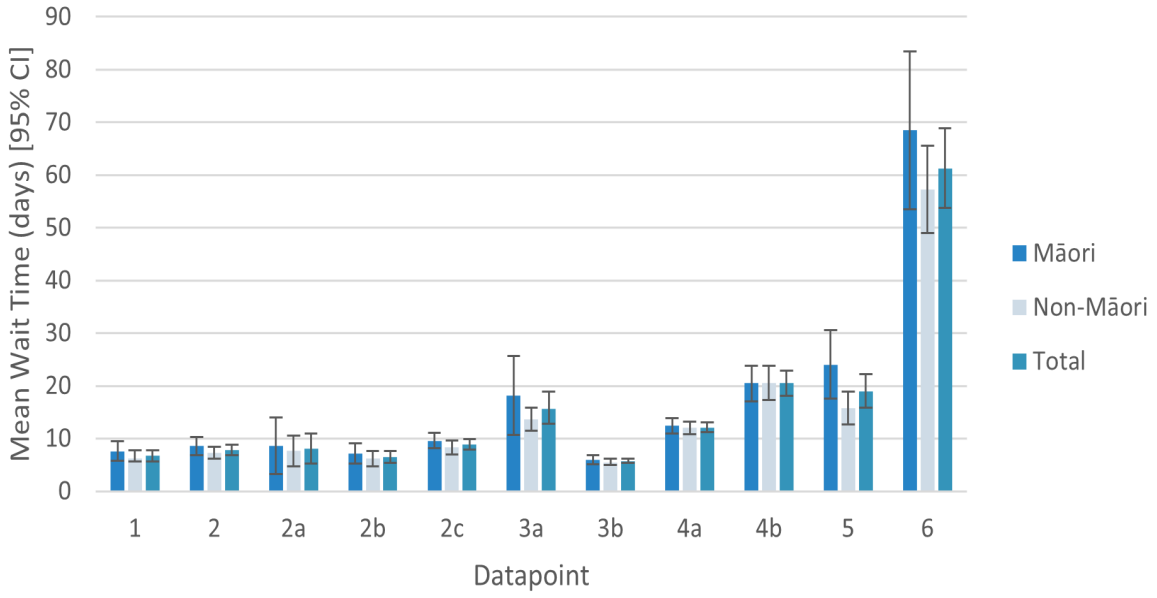


Figure 4: Mean wait times by ethnicity (with 95% confidence intervals).



Māori; with similar wait times for datapoint 3b, this is due to a delay in collecting histology. Looking specifically at hysteroscopy, Māori waited almost twice as long from decision for hysteroscopy to hysteroscopy being performed compared to non-Māori (27.6 days compared to 15.0 days). Compared to the previous audit period, there has been an improvement in equity of service provision, with a higher proportion of both Māori and non-Māori met the 31- and 62-day targets (datapoints 5 and 6), alongside a reduction in wait times for both groups (Table 7).

Discussion

The introduction of tumour-specific national standards as part of the Ministry of Health's FCT programme have improved service delivery and clinical practice for all elements of cancer care.[1] However, while the standards provide a framework for the provision of cancer care, the overall target of 62 days from referral to first treatment is difficult to achieve, with only 66.9% of patients meeting this target. Although this is a substantial improvement compared to previous audit periods, it is still far from the 90% target set by the Ministry of Health and is only a marginal improvement on baseline performance established by the Ministry of Health in 2014 of 65%.[3] With 89.2% of patients receiving treatment with 31 days of decision to treat, most of the delays in cancer care occur during the investigation and discussion processes that lead to a treatment decision.

The best performing area in this audit was radiological investigations, with 90.4% of all imaging being performed within the 14-day target. The most notable improvement was in MRI, with 95.1% of MRI scans being performed within the target. This is a reflection of Northland DHB's increased MRI capacity, with urgent MRI now being performed on Saturdays.

There are ongoing delays in obtaining histology, with 66.0% of patients having their histology reported within 14 days from decision to collect histology. This is largely confined to those requiring an operative procedure (most commonly hysteroscopy), a reflection of the inadequacy of theatre resources, preventing timely investigation and management for cancer patients across all specialties. The deficits identified in the benchmark audit led to the implementation of an additional weekly gynaecology operating list, for which patients with suspected or confirmed malignancy are prioritised. There has subsequently been substantial improvement in the proportion of patients meeting the 14-day target compared to this audit (66.0% vs 35%), with a decrease in average wait times from 31.5 days to 8.9 days. As it stands, hysteroscopies are almost always performed under general anaesthetic; implementation of outpatient hysteroscopies is being considered as a way of improving access, but this is yet to be implemented.

Centralised MDMs are now the standard of care for gynaecological cancer as they have been shown to improve patient outcomes.[6] Unfortunately, this audit shows it is also one of the rate-limiting steps in initiating treatment, with fewer patients having their first MDM discussions within 14 days of referral, and waiting longer from MDM referral to MDM discussion compared to previous audits. Treatment decisions are often further delayed due to the need for multiple discussions and for additional investigations requested by the MDM. Once a decision is made, patients were able to access treatment within a reasonable timeframe, suggesting that the delays during the MDM process contribute the delays seen in the overall time from referral to gynaecological services to first treatment. Unfortunately, results pertaining to the MDM process may be inaccurate; MDM referrals are submitted via email correspondence between

Table 7: Datapoints 5 and 6 by ethnicity compared to 2016 audit period.

		% meeting target		Mean wait time (days)	
Datapoint	**Ethnicity**	**Jan '18–Dec '20**	**Jan '16–Dec '16**	**Jan '18–Dec '20**	**Jan '16–Dec '16**
5	Māori	83.6%	76.9%	24.0 (0–151)	21.0 (0–64)
	Non-Māori	92.9%	87.9%	15.8 (0–125)	21.1 (0–63)
6	Māori	63.0%	27.3%	68.5 (13–398)	111.5 (0–310)
	Non-Māori	69.1%	51.7%	57.3 (1–315)	73.0 (0–269)

individual clinicians and are often submitted pending completion of investigations. There is no formal documentation of when referrals are sent or deemed complete, meaning that the date of MDM referral used for statistical analysis was often a best guess. We have suggested the date of referral be included in the MDM meeting minutes to improve the accuracy of future audits.

It is a shame to see ongoing inequities between patients depending on treatment location, with patients receiving treatment in Auckland having significantly shorter wait times once a treatment decision has been made and minimal improvement compared to previous audit periods. Patients living in Northland already face immense geographical barriers to accessing specialist services, with Northland DHB covering a land area of 13,286km^2 compared to Auckland's 1,086km^2.[7] These barriers are compounded by socioeconomic status, with a high proportion of Northland people living in the most deprived quintile.[8] The inequities that exist are a reflection on the immense strain on surgical services in Northland, with small secondary-level services catering for a population of 193,170.[7] These differences are compounded by the comparatively larger operating capacity that the subspecialty gynaecology-oncology service has. In addition, patients deemed suitable for surgical treatment in Northland tend to have earlier stage and less aggressive disease, making treatment somewhat less time sensitive.

Māori and Pacific Island women have higher incidences of and mortality from gynaecological cancers and evidence shows that Māori women have poorer access to healthcare and worse survival rates.[1] Māori were over-represented in this audit, comprising 39.2% of patients with gynaecological cancer, compared to 35.8% of the Northland population.[8] Compared to non-Māori, Māori patients are waited longer for histology collection—particularly hysteroscopy—as well as for their first treatment, from both decision to treat (datapoint 5) and initial referral (datapoint 6). There has been an improvement in these two datapoints compared to the last audit period, but a difference remains. Of interest were the disparities in triage category: Māori patients with cancer were much more likely to be triaged as routine, with a relative risk of 4.6 (95% CI 1.0–22.4) compared to non-Māori. Triaging of referrals is currently performed by a designated senior medical officer (SMO) based on the clinical information provided by the referrer. For those with cancer, a triage category of semi-urgent or routine causes significant delays in time to FSA, with Northland DHB aiming to see patients within four weeks and four months of referral, respectively. This subsequently delays access to appropriate treatment. However, due to the wording of *Standards of Service Provision for Gynaecological Cancer Patients*, these delays are not reflected in the outcomes for datapoints 1 and 6, as these patients are not deemed to have a high suspicion of cancer at the initial referral. If we look at the mean time from referral to first treatment for all patients with a confirmed cancer diagnosis, it increases from 68.5 to 93.8 days for Māori, and from 57.3 to 69.0 days for non-Māori—a much larger disparity than the outcomes for datapoint 6 would suggest. One possible explanation for these disparities may be the younger age at diagnosis for Māori patients with gynaecological cancer, notably endometrial cancer occurring in premenopausal women. As a result of this audit, Northland DHB plans to take into consideration the fact that Māori women present younger with gynaecological cancer when triaging referrals, with the aim to address the delays in accessing appropriate treatment for these women.

This audit is one of the first to comment on equity of service provision for patients with gynaecological cancer between ethnicities, and although it demonstrates some statistically significant differences between Māori and non-Māori, the sample size was too small to definitively comment on the statistical significance of many of the potential inequities highlighted. An audit with a larger sample size over a longer period of time would be of use to further investigate these differences.

COMPETING INTERESTS
Nil.

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Supplementary material

Supplementary Table 1: Percentage of patients meeting each target and mean wait times for each datapoint compared to previous audits.

Datapoint		% meeting target			Mean (days) [range]		
		Jan '18–Dec '20	Jan '16–Dec '16	Jun '14–Jun '15	Jan '18–Dec '20	Jan '16–Dec '16	Jun '14–Jun '15
1	Referral → FSA ≤14 days	90.7%	85.4%	65%	6.7 [0–33]	12.0 [0–84]	10.5 [0–60]
2	Imaging (all modalities)	90.4%	-	-	7.8 [0–76]	–	–
2a	USS wait time ≤14 days	82.3%	72.2%	81%	6.7 [0–33]	13.4 [0–65]	9.5 [0–101]
2b	CT wait time ≤14 days	91.9%	100%	89%	8.1 [0–76]	5.0 [0–14]	6.5 [0–26]
2c	MRI wait time ≤14 days	95.1%	75.0%	73%	6.5 [0–25]	11.2 [3–20]	10.6 [0–23]
3a	Decision for histology → histology reported ≤14 days	66.0%	40.9%	35%	8.9 [0–29]	35.4 [2–253]	31.5 [0–140]
3b	Histology taken → reported ≤10 days	88.2%	81.8%	70%	5.7 [0–18]	8.1 [2–22]	8.9 [0–29]
4a	MDM referral → first MDM ≤14 days	77.4%	84.4%	93%	12.1 [2–49]	9.82 [0–23]	9.5 [5–27]
4b	MDM referral → treatment decision ≤14 days	43.3%	31.6%	59%	20.5 [0–109]	19.3 [7–46]	22.3 [5–162]
5	Decision to treat → first treatment ≤31 days	89.2%	85%	73%	22.3 [0–151]	21 [0–64]	28.5 [0–161]
6	Referral → first treatment ≤62 days	66.9%	45%	39%	61.3 [1–398]	83.6 [0–310]	98.5 [5–525]

Epidemiology of major trauma in New Zealand: a systematic review

Luisa Montoya, Bridget Kool, Bridget Dicker, Gabrielle Davie

ABSTRACT

BACKGROUND: Physical injuries are one of the major causes of disability and death worldwide and have an immense impact on population health. In New Zealand, an estimated 8% of total health loss from all causes is attributed to injuries.

AIM: To describe the incidence and characteristics of major trauma in New Zealand.

METHODS: A systematic review based on a MEDLINE search strategy was performed using the databases PubMed, EMBASE, CINAHL and Scopus. Search terms included: "Wounds and Injuries," "Fatal Injuries," "Injury Severity Score," "Major Trauma," "Severe Trauma," "Injury Scale," "Epidemiology," "Incidence," "Prevalence" and "Mortality." Studies published in English up to September 2021 reporting the incidence of major trauma in New Zealand were included. The quality of studies was assessed using the GATE LITE™ tool.

RESULTS: Thirty-nine studies fulfilled the inclusion criteria. The majority of studies were descriptive observational studies (n=37). The incidence of fatal trauma was highest among those injured from motor vehicle crashes (MVCs) or falls, Māori males and those sustaining head injuries. The incidence of non-fatal major trauma was highest among young Māori males. MVCs and falls were the most common mechanism of injury among trauma patients across all age groups. Length of hospital stay was greatest in patients with the highest Injury Severity Scores.

CONCLUSIONS: The incidence of major trauma varies by age, sex and ethnicity. This review highlights the need for further analytical studies that can explore factors that may impact survival from major trauma.

Trauma, defined as any serious physical injury to the body that requires medical attention,[1] is one of the major causes of disability and death worldwide.[2,3] More than one quarter of the five million global deaths from physical injuries annually are the result of motor vehicle crashes (MVCs).[4] New Zealand (NZ) is a high-income country with a population of approximately 5.1 million.[5] Māori, the Indigenous people of New Zealand, account for 16.5% of the total population.[6] Around 50,000 people are hospitalised as a result of injury in New Zealand annually, with an economic cost estimated at NZ$10.2 billion per year.[7] An additional NZ$5.7 million is the estimated economic burden per fatality.[8] The New Zealand Ministry of Health (MoH) reported in 2016 that an estimated 8% of total health loss from all causes was attributed to injuries.[3] However, little is known about the incidence of injuries that have the potential to cause death or long-term disability (major trauma).[9]

Major trauma is commonly defined in terms of injury severity. Although there is not an internationally recognised definition of major trauma,[10] it has been variably defined as an Injury Severity Score (ISS) greater than 15, which is associated with a mortality risk of 10%.[11–14] Since the introduction of the Abbreviated Injury Scale (AIS) AIS-2005-Updated 2008, an ISS>12 is also considered as major trauma.[10,15–17]

In order to reduce morbidity and mortality resulting from major trauma, it is important to understand how major trauma is distributed in terms of time, geographic location and population groups. Therefore, this systematic review of the literature aimed to describe the incidence and characteristics of major trauma in New Zealand.

Methods

Inclusion criteria

Studies describing the incidence of major trauma in New Zealand published up to September 2021 were included. For the purposes of this review, "major trauma" was defined as death or an ISS greater than 12 or greater than 15, depending on the AIS version used at the time the injuries were coded.[11,17] The AIS is an anatomical scoring system used internationally to rank the severity of individual injuries by body region on a scale of 1 (minor) to 6 (un-survivable injury).[18,19] The AIS is the basis of the ISS, which is used to determine the

overall severity of multiple injuries.[20–23] The ISS is "the sum of the squares of the highest AIS grade in each of the three most severely injured areas"; its maximum score is 75, which is considered as the worst prognosis.[11,24] For the purposes of this review, in studies where ISS was not provided but the study included fatal and non-fatal cases, the deaths were assumed to be major trauma and thus were included.

The review considered all injury intents, all age groups, injuries resulting in admission to hospital, prehospital injury deaths and injury deaths occurring in hospital. Studies focusing on treatment injuries were excluded. Non-physical injuries that could not be scored by ISS such as drownings, poisonings and asphyxiations were also excluded (note codes for these three mechanisms were introduced in AIS 2005[25]).

Search strategy

Bibliographic computerised searches based on a MEDLINE search strategy were conducted in the following databases: PubMed, EMBASE, CINAHL and Scopus. Medical Subject Headings (MeSH) and keyword search terms used to identify published articles included: "Wounds and Injuries," "Fatal Injuries," "Injury Severity Score," "Major Trauma," "Severe Trauma," "Injury Scale," "Epidemiology," "Incidence," "Prevalence" and "Mortality." Additional electronic databases, the Te Hononga Whētuki ā-Motu, the National Trauma Network (formerly Major Trauma National Clinical Network (MTNCN)) website and the reference lists of all included studies were examined to identify any potentially relevant articles missed by the electronic search.

Limitations of English language, human population and New Zealand studies were applied. Searches were not restricted by date. LM conducted the initial search, LM and BK independently reviewed the title and abstracts.

Data extraction and appraisal

Duplicates were identified and removed before the titles and abstracts were screened by LM and BK. Full versions of studies potentially meeting the inclusion criteria were then reviewed, and ineligible studies excluded. The following information was abstracted from included studies: study design, information sources, study population, case definitions and main findings. The quality of studies was assessed using the GATE LITE™ critical appraisal form (www.epiq.co.nz).[26] The PRISMA guidelines were followed during data extraction, analysis and reporting.[27]

Results

The initial search identified 239 studies. Based on the title and abstract, 61 were considered potentially relevant. Of these, 39 studies fulfilled the inclusion criteria (Figure 1).

Study characteristics

The review period included studies published between 1987 and 2021. Out of the 39 studies included in this review, 19 were based on trauma registry data,[28–46] 11 were based on hospital or emergency medical services (EMS) records[47–57] and nine involved routinely collected national morbidity and mortality data from the MoH.[58–66]

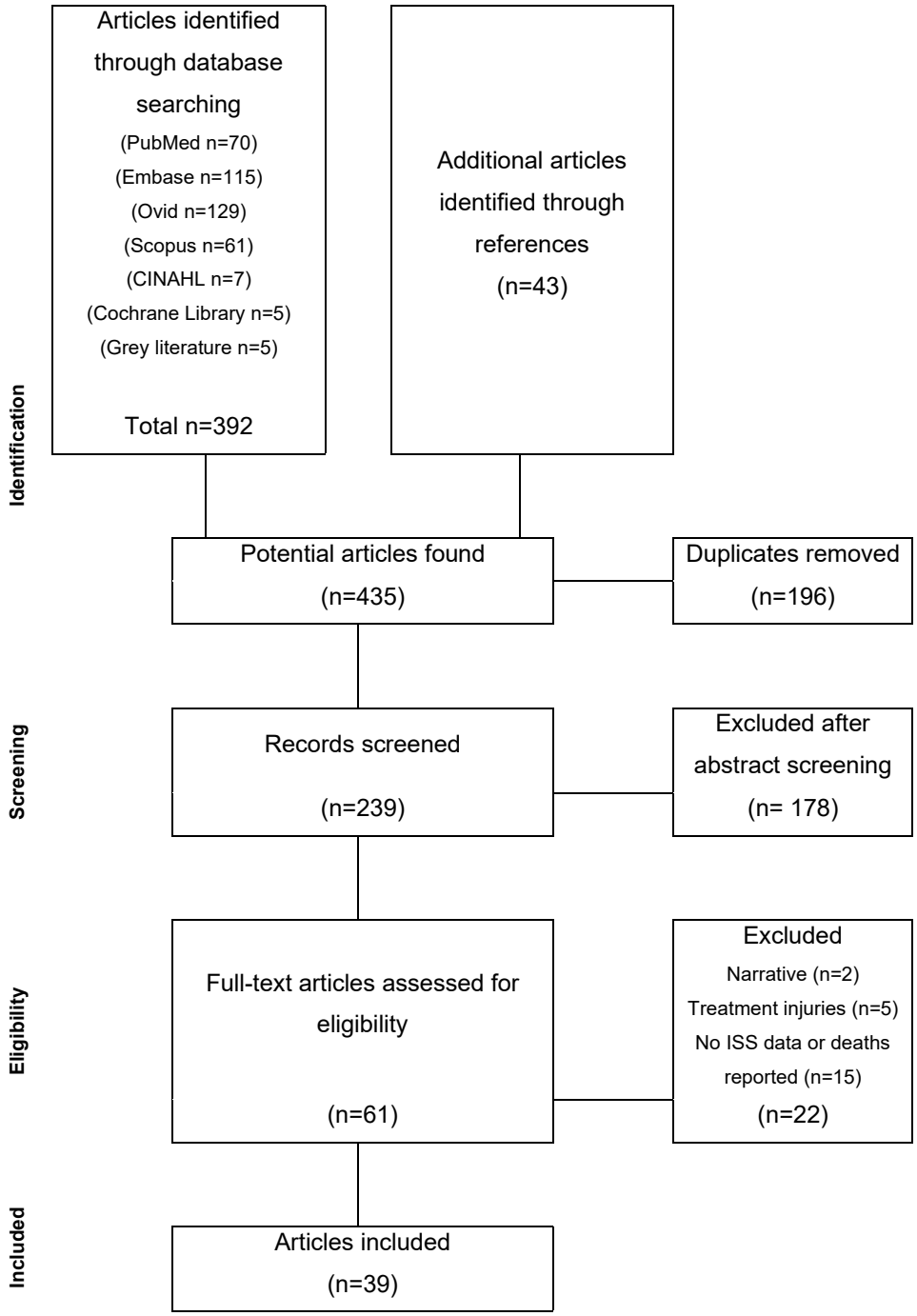
The majority of studies were descriptive observational studies (n=37), two were population-based cohort studies using prospectively gathered trauma database information from the Auckland region.[30,31] Twenty-one studies included people of all ages (Table 1), 11 included adults only (Table 2) and seven included children only (under 16 years) (Table 3). Five of the seven studies focusing on children focused on single mechanisms of injuries.[33,48,53,62,64]

The majority of studies included patients admitted to hospital following injury (n=16),[29–32,35–38,40,44,46,47,50,54–56] with two studies describing trauma admissions to the intensive care unit (ICU).[51,52] Four studies considered trauma due to all-terrain vehicles as a primary focus,[33,39,48,64] three studies included injuries occurring at home,[62,63,65] three studies limited to a particular injury type,[49,57,66] two studies considered penetrating trauma[28,45] and two studies described bicycle injuries.[34,58] Other single mechanisms of injury focused studies included pedestrian injuries,[53] motorcycle crashes,[59] work-related injuries,[41] animal-related injuries,[43] livestock-related injuries,[42] aircraft crashes[60] and river rafting injuries.[61]

The definition of major trauma was an ISS>12 in nine studies,[33–38,40,42,47] an ISS>15 or death in 16 studies[29–32,39,41,43,44,50–56,64] and death in 10 studies,[28,45,46,58,59,61–63,65,66] seven of which did not include information of ISS.[58,59,61–63,65,66] Four studies did not provide a clear definition of major trauma but reported data on ISS.[48,49,57,60]

Only 13 studies provided a full description of the characteristics of major tra uma.[30,31,35–37,46,47,55,58,59,61–63] The remaining stud-

Figure 1: Summary of study selection (PRISMA flow diagram).



ies presented information about the incidence of major trauma in trauma populations and the characteristics of trauma in general.

Due to the heterogeneity of included studies, it was not possible to explore trends in the characteristics and incidence of major trauma over the period reviewed.

Incidence of major trauma

Paediatric trauma

Among studies that described paediatric trauma, the proportion of major trauma cases among studies that focused on single mechanisms of injuries[33,48,53,62,64] ranged from 7%[48] for quad bike injuries to 95%[53] for pedestrian injuries (Table 3).

In contrast, the study that included all types of paediatric injuries that resulted in admission to hospital reported a prevalence of major trauma of 63%.[32] Studies that focused on a particular injury type showed a similar proportion of major trauma (5% for liver injury[57] and 6% for pelvic fractures[49]).

The study by Creamer et al analysed 2004 trauma registry data (all ages) from the Auckland region and reported a major trauma (ISS≥16) rate for children aged less than 15 years of 17/100,000, the lowest rate among all age groups.[30] Kool et al in their analysis of hospitalisations (2000–2009) and deaths (1999–2008) due to head injury reported that the lowest trauma rates were among children aged 5–9 (2.3/100,000).[66] However, Collins et al, in their review of pedal bicycle injuries among all ages resulting in death and hospitalisation (1979–1988), found that boys aged 10–14 had the second highest trauma rate (2.3/100,000).[58]

The studies reviewed showed that boys are more affected by major trauma than girls.[32,33,48,53,62,64] The review of national morbidity and mortality data by Collins et al found that boys aged 5–9 years and those aged 10–14 years had a higher incidence of major trauma (2.0/100,000 and 2.3/100,000 person-years respectively) than girls (0.6/100,000 and 1.3/100,000 respectively).[58] Kool et al found similar results where the incidence of major trauma was higher in boys than in girls aged 5–9 (2.7/100,000 cf. 1.9/100,000) and among those aged 10–14 (4.3/100,000 cf. 2.6/100,000).[66] Additionally, Creamer et al found that injury rates among boys aged 0–14 were approximately twice that of girls (23/100,000 cf. 12/100,000).[30]

Adult trauma

The proportion of major trauma cases among the total trauma cases reported in the adult population ranged from 4%[41] to 89%[51] in the studies reviewed (Table 2). A review of trauma registry data from the Auckland region (2004 data) by Creamer et al reported an overall major trauma (ISS≥16) incidence rate of 34/100,000 per year, with rates highest among young adults (15–29 years; 60/100,000) and older adults (≥75 years; 50/100,000).[30]

The studies reviewed showed that major trauma occurs most commonly among males.[40,41,44,45,47,51,61] The study by Gardiner et al of adult ICU trauma admissions to Auckland Hospital over a 10-year period (1988–1997) found that males had a significantly higher incidence of trauma than females (53.8 cf. 16.7 per 100,000 person-years).[51] These findings are consistent with a review of trauma registry records of work-related injuries in the Midland region (2012–2015) by Kool et al, who reported that rates among male workers were approximately five times greater (238/100,000 workers) than among females (44/100,000 workers).[41]

Additionally, the review of pedal bicycle injuries among all ages resulting in death and hospitalisation by Collins et al found that males aged 80 years or more had the highest trauma rate (3.5/100,000). However, the authors recommended treating this finding with caution because of the small number of fatalities in this group.[58]

Trauma among Māori

Although more than 35% of paediatric major trauma cases occurred among children of European origin[33,48,53,64] (range from 38%[53] to 89%[33]), Māori experienced the highest trauma rates (Table 3).[31,53] The review of trauma registry data of injured child pedestrians (<15 years) admitted to Auckland Hospital (1986–1989) by Roberts et al. reported higher trauma rates among Māori children (13.2/100,000) than children of European origin (4.2/100,000).[53] These findings are consistent with the population-based study of trauma registry data by Creamer et al, who reported that injury rates among Māori males aged 0–14 years were higher (50/100,000 per year) than among other ethnicities combined (12/100,000 per year).[31] However, the same study showed that for females aged 0-14 years, the incidence rate among Pacific children was almost double the rate among Māori children (35/100,000 cf. 19/100,000).[31]

Adult trauma rates were higher among Māori than other ethnicities.[31,51,58] The population-based study by Creamer et al of trauma registry data reported higher major trauma (ISS≥16) rates

among Māori (61.4/100,000 per year) and Pacific people (39/100,000 per year) compared to people of NZ European and other ethnicities combined (29/100,000 per year).[31] Gardiner et al found similar results among adult ICU trauma admissions, where the rates for Māori and Pacific patients were greater (123/100,000 and 70/100,000 respectively) than for NZ European patients (36/100,000).[51]

For all age groups, the review of major trauma admissions for Māori in the Canterbury region (2006–2018) by Kandelaki et al showed that 9% of major trauma cases occurred among Māori, with Māori males the most affected (75%).[35] It also reported similar incidence rates among Māori and other ethnicities (57.9/100,000 cf. 57.3/100,000).[35]

Although trauma incidence rates among males[40,41,44,45,47,51,61] and Māori[31,51,58] were highest in most studies reviewed, a review by O'Leary et al of older adult (≥65 years) trauma cases from the Midland trauma registry between 2012 and 2014 found that injury rates were higher among females (608/100,000) than males (557/100,000) and non-Māori than Māori (594/100,000 cf. 460/100,000).[40]

Mechanism of injury

Blunt trauma accounted for more than 80% of all trauma-related admissions among all ages in the studies reviewed (Table 1).[32,42,51,54–56] MVCs and falls were the most common mechanism of injury among trauma patients across all age gro ups.[31,32,36–38,40,47,51,54,59] The review of Midland trauma registry data by Kool et al reported that contact with machinery (26%) and falls (19%) were the most common cause of work-related injuries.[41] Couch's review of trauma records of 82 children (<15 years) admitted to two child emergency departments (ED) over one-year period found that MVCs accounted for 57% of all trauma, of which 61% involved pedestrians. Additionally, falls and other mechanisms in this age group (including non-accidental injury) accounted for 34% and 12% of injuries, respectively.[32]

This review found that, although major trauma due to falls is common across all age groups in New Zealand, the incidence is highest in older adults (≥65 years).[40,52,67] The review of older adult trauma cases in the Midland trauma registry published by O'Leary et al found that among older major trauma (ISS≥13) patients, the prevalence of MVCs was higher than the prevalence of falls in this age group (43% cf. 39%).[40]

Among the studies that analysed trauma due to pedal cycles, motorbikes or all-terrain vehicles, the main mechanisms of injury were falls from the vehicle and collisions with motor vehicles.[39,48,58,64] Wood et al reviewed data from the Waikato Hospital trauma registry on major trauma patients (ISS>15) with quad-bike related injuries between 2007 and 2011 and found that the main mechanism of injury was rollovers (37%).[39]

Studies analysing animal and livestock-related injuries reported that falls from horses (81%) and being hit by cattle, sheep, pigs or goats were the most common cause of injuries, respectively.[42,43] Penetrating injuries were uncommon.[28,45]

Severity

The head was the most commonly injured body region in major trauma patients in the studies included in this review.[32,39,40,48,51,53,56,58,66] The prevalence of head injuries ranged from 26%[48] in a review of quad bike injuries in children to 100%[66] in a study of incidence and mortality due to head injury. Pearce's review of paediatric ICU (PICU) records found that, in children under 16 years of age admitted to Starship Children's Hospital between 2007 and 2014 with head injuries due to a quad bike incident, the mean ISS was 19.4 (range 5–43), which was slightly higher in those who were not wearing helmet at the time of the injury (mean ISS 21.8; range 9–43).[48]

Upper and lower extremity injuries were common among major trauma cases. However, these did not represent life threatening injuries.[33,34,41–43] Singh et al found that 52% of cycling-related injuries involved extremities.[34] A study of major work-related trauma by Kool et al,[41] and a study of injuries due to animals by Johns et al[43], which reviewed trauma registry data, found similar proportion of extremity injuries (48%[41] and 49%[43] respectively).

A study by Civil et al of 114 patient hospital records over a six-month period found that 40% of patients with major injuries admitted to hospital had an ISS between 16 and 24, and that no patients with an ISS≥50 survived.[55] Safih et al, in their review of Auckland Hospital ICU records, found no difference in the mean ISS between younger (<65 years) and older adult (≥65 years) patients (26 cf. 25).[52] Similar results from among patients with liver injuries were reported by Wakeman et al, who did not find difference in the mean ISS (17.5 cf. 17.0) between paediatric (0–17 years) and adult population (≥18 years).[57] However, the study of Starship PICU records by Pearce et al found that ISS was higher in children under 5 years of age (mean ISS 22.3) compared to children aged 5–10 years of age (mean ISS 10.5).[48]

In terms of ethnicity, the study by Wood et al that examined data from 101 Waikato Hospital trauma registry cases with quad-bike related injuries found that Māori had a significantly higher mean ISS compared to their NZ European counterparts (16.8 cf. 10).[39]

Three of the studies reviewed reported an association between length of hospital stay (LOS) and ISS.[43,47,50] Czuba et al, in a cohort of 112 patients with major trauma (ISS≥12) from two hospitals in Auckland, found that the median LOS was greater in patients with higher ISS. The results of this study showed that patients with an ISS≤25 stayed in hospital for a maximum 10 days, whereas patients with an ISS>25 were in hospital between 22 and 25 days.[47]

Deaths occurring among major trauma patients

The proportion of deaths among major trauma patients in the studies reviewed ranged from 1%[39] to 30%.[55] An age gradient was evident in some studies, with an in-hospital case fatality rate approximately twice as high in older patients (≥65 years) compared to younger (<65 years) patients (28% cf. 13%; p<0.001).[29,52] The review of national morbidity and mortality data (1989 to 1998) by Gulliver et al, where they examined injuries sustained in the home among young children (<5 years of age), found that mortality rates reduced as age increased. Annualised mortality rates among children aged 0–11 months were 28/100,000 compared with 5/100,000 among children aged 48–59 months.[62] Collins et al, in their review of pedal bicycle injuries resulting in death and hospitalisation (1979–1988), found that 39% of the fatalities occurred in children between 5 and 14 years old.[58] However, in their review of head injuries resulting in death (1999–2008) and hospitalisation (2000–2009), Kool et al found that only 4% of the fatalities occurred in children between 5 and 14 years old.[66]

The study by Langley et al which reviewed national mortality data relating to motorcycle crashes (1978–1987) reported a mortality rate of 3.5/100,000 persons per year for all age groups, with males experiencing higher rates than females in those aged 15–24 years (3.4/100,000 cf. 2.0/100,000).[59] Similarly, in their study of people aged 25–59 years who died as a result of unintentional falls at home, Kool et al found the fatality rate for males was three-times higher than the female rate (0.63/100,000 cf. 0.20/100,000).[63]

Mortality rates in the studied reviewed also varied by ethnicity. Although Māori accounted for less than 30% of all trauma-related deaths[31,59,65] (range from 9%[59] to 25%[65]), this group experienced the highest fatality rates. The Auckland regional study by Creamer et al of trauma registry data (ISS>15) reported higher injury mortality rates among Māori (28.4/100,000 per year) and Pacific (16.4/100,000 per year) compared to NZ European and other ethnicities combined (11.9/100,000 per year).[31] Kool et al found similar results in patients aged 20–64 years for unintentional injuries that occurred at home, with fatality rates of 5.4/100,000 among Māori and 3.0/100,000 for NZ European.[65] However, the review of major trauma admissions for Māori conducted by Kandelaki at al showed that the proportion of deaths was lower for Māori compared to other ethnicities (5% cf. 11%).[35]

The main causes of death in major trauma patients in the studies reviewed were MVCs[30,31,46,58] (range 32%[46] to 88%[58]) and falls[30,31,46,63,65] (range 10%[46] to 23%[31]). The study of unintentional injuries occurring at home resulting in death (1998–2007) or hospitalisation (2000–2009) conducted by Kool et al found that over a 10-year period burns were one of the main mechanisms of injury resulting in death (12%).[65]

In relation to the nature of injuries sustained, head injuries were common (60%–100%) among fatal injury cases.[58,66]

Impact of COVID-19 in major trauma admissions

Coronavirus disease 2019 (COVID-19) has changed the live and daily routine of many people around the world. Due to its rapid spreading, the World Health Organization (WHO) declared it as a global pandemic on 11 March 11 2020.[68] Two weeks later, on 25 March at 11:59pm, New Zealand moved to level 4 (lockdown), the highest level of a four-level alert system announced by the New Zealand Government, in order to eradicate the virus and avoid overburdening the healthcare systems.[36,37,69] Although the effects of the lockdown are yet unknown, some studies conducted in New Zealand have shown a significant impact on the number of major trauma admissions.[36–38]

The study conducted by Christey et al of trauma patients admitted to a level one trauma centre in New Zealand pre-lockdown (5–18 March 2020) and during lockdown (26–April 8 March 2020) showed a reduction of 50% in all major trauma admissions. This study also found that it was a decrease in the number of trauma admissions for males (50% reduction), children aged 0–14 years (48%

reduction) and Māori (39% reduction). Although it was a significant reduction in the number of trauma admissions due to falls and MVCs (48% and 74%, respectively), these continue being the most common mechanism of injury during lockdown in New Zealand.[38] Similarly, in their study of major trauma patients admitted to Christchurch Hospital before (22 February–25 March), during (26 March–27 Arpil) and after lockdown (28 April–30 May), Fan et al found a 42% reduction in the number of major trauma admissions during lockdown in all sex and age groups. The most common mechanism of injury before and after lockdown was transport-related injuries. However, during lockdown falls were the most common injury (48%). Road and home were the most common places of injury across all periods.[37]

The study by McGuinness et al, which reviewed major trauma registry data in the Northern Region (16 March–8 June 2020, and in the same period in 2019), reported a decreased in major trauma admissions of 25% in 2020 compared to 2019. Although it was a reduction in age, gender, mechanism of injury, type of injury and injury intent, the differences were not statistically significant. An increase in the number of injuries occurring at home was observed in 2020 compared to 2019 (35% cf. 20%).[36]

Discussion

The aim of this review of the published literature was to describe the incidence and characteristics of major trauma in New Zealand. Thirty-nine studies met the review eligibility criteria. The studies included were mainly descriptive observational studies that had analysed routinely collected data from trauma registries, hospital records or national morbidity and mortality data. The proportion of major trauma reported in the studies reviewed was variable, ranging from 4%[41] to 95%.[53] This in part reflects the heterogeneous case definitions used, and the different populations studied (eg, trauma registry data cf. MoH morbidity and mortality data).

The results demonstrate that differences in trauma rates exist in New Zealand by sex, ethnicity and age. This review found rates of major trauma are highest among young adults (15–29 years) and older people (≥75 years), and lowest among children aged 0–14 years.[30,58] These findings are consistent with a review of Japan's trauma registry data by Kojima et al, which found that moderate to major trauma (ISS≥9) occurs most commonly among elderly people aged 60 years or older (53%), and less common among children (9%).[70]

This review also showed that in both the paediatric and adult populations, males[32,33,40,41,44,45,47,48,51,53,61,62,64] and Māori[31,51,53,58] are the subgroups most affected by major trauma in New Zealand. These results are consistent with data from annual report (2018–2019) of the New Zealand Major Trauma Registry & National Clinical Network (MTNCN), which showed the incidence of major trauma was higher among males in all age groups, and that Māori experienced higher major trauma rates (56/100,000) than non-Māori (43/100,000).[71]

Blunt trauma due to MVCs and falls were the main mechanisms of trauma resulting in hospitalisation and death in New Zealand in this rev iew.[30–32,36–38,40,42,46,47,51,54,56,58,59,63,65] For the paediatric population, these findings are consistent with a review of five years of data from a Swiss trauma registry, which found blunt trauma represented 92% of all admissions and that 42% of the patients had major injuries (ISS>15), of which 76% were males with injuries primarily due to falls (40%) and MVCs (34%).[72]

Chico-Fernández et al reported that 79% of the trauma patients admitted to ICU in Spain (2012–2015) were young men, and that the main mechanism of injury was falls (37%).[73] A study conducted in Australia by Harris et al, which included 355 patients with major trauma, found that 63% of the cases were due to MVCs and that males were more overrepresented (72%).[74] Similar results were found by Alberdi et al in another Spanish study investigating the epidemiology of severe trauma in all age groups, where the main cause of trauma among patients aged 15–25 years was road traffic related injury, and that older patients (>65 years) had a greater mortality rate than younger people (35% cf. 15%).[75]

Major trauma studies in Australia have found that males aged between 15 and 24 years account for the majority of all trauma admissions, with blunt trauma from MVCs being the main cause of injury.[76,77] However, the New Zealand MTNCN's annual report (2018–2019) showed that there are three age peaks (15–29, 45û60 and 85+), with the 15–29 age group having the greatest burden of injury.[78] Although patterns of trauma are similar in Australia and New Zealand, incidence rates differ.[77] According to the Victorian State Trauma, the incidence of major trauma in 2016–2017 was 55/100,000,[79] which is greater than that reported by the New Zealand MTNCN in 2018–2019 (48/100,000).[71]

In the current review, among major trauma patients the head was the most common body region injured. [32,39,40,48,51,53,56,58,66] A Spanish study conducted by Rastogi et al of 748 patients (all ages) admitted to a major trauma centre in India reported 57% of patients had sustained head injuries.[80] Alberdi et al, in their study of the epidemiology of severe trauma in Spain, found a lower prevalence (33%–47%).[75] The Spanish studies both identified a statistically significant association between ISS and mortality.[73,75] The studies included in this review suggest that length of stay in hospital is influenced by ISS.[43,47,50] However, the relationship between ISS and mortality could not be examined in this review because seven of the 10 included studies defined major trauma as death and did not include information about ISS.[58,59,61–63,65,66]

Trauma admissions in New Zealand have experienced a decrease during the COVID-19 pandemic,[36–38,81] mainly due to the restrictions on the free movement orchestrated by different governments around the world, reinforcing the notion that trauma is a social disease. The studies reviewed reveal a reduction of more than 40% in major trauma admissions during lockdown, with the greatest reductions observed in males, children aged 0–14 years and MVCs.[36,37] The New Zealand MTNCN's annual report (2019–2020) showed the incidence of major trauma was lower in 2019/20 than in 2018/19 (44/100,000 cf. 48/100,000) and reported a 50% reduction in major trauma admissions across the country during the initiation of level 4 (lockdown), mainly due to changes in transport injuries.[82] Similar results were found in a study conducted in South Australia by Harris et al, who reported a 33% reduction in major trauma admissions, especially for those aged 40 years or older and for transport-related trauma (45% reduction in each case).[83]

Strengths and limitations

This review provides a useful summary of studies of major trauma in New Zealand that have been published up until September 2021, providing historical context for those working in the trauma or injury prevention fields. The strength of this review includes a rigorous methodology to identify relevant studies through an exhaustive search of the current data in multiple electronic databases. Two independent reviewers (LM and BK) performed the literature search, selected and evaluated the quality of the articles, which enhanced validity and reliability. Results have been reported following the PRISMA guidelines.[27]

The strengths of studies included in this review that analysed data from the MoH[58–66] include the ability to explore trends over time, and the population-based nature of the data. However, MoH morbidity databases do not include trauma-specific injury severity indices,[58] which explains why information related to ISS was not reported in some articles or had to be calculated in others using the AIS. Comparisons of findings between studies were difficult due to the differences in sample sizes, population groups and major trauma definitions.

The review findings need to be considered in light of some limitations. The review period included studies from 1987 to 2021, a time during which there were a number of AIS revisions,[19,25] resulting in potential differences in how major trauma is defined and having a potential impact on injury research. Since the development of AIS in 1971 by the Association for the Advancement of Automotive Medicine (AAAM), there have been some updates,[15,25,84] the most recent being the AIS 2015.[19,85] The AIS 2005 update brought significant changes in scores for some body regions, in particular for the thorax and head regions.[15,84] The 2008 update provided further refinements to the classification deficits.[20,25] The AIS 2015 update improved brain injury and spinal cord coding.[85] Palmer et al noted that there is a significant decrease in the number of patients classified as major trauma when converting AIS98-coded data to AIS08.[86] From the information provided, 48% of the studies included in this review used the AIS98 or previous versions, and the remaining studies used the AIS05/08 versions. Given the findings of Palmer et al, this may mean the earlier studies in this review may have overestimated the severity of injury reported.

Another limitation is the ability to calculate an overall estimate of the incidence of major trauma in New Zealand; this is challenging due to the lack of a clear definition of major trauma in included studies, and difficulties in comparing trauma registry studies with non-trauma registry studies due to the exclusion of non-physical trauma in the former (eg, poisoning, asphyxiation and drownings). Although ISS has been recognised as the "gold standard" scoring system for trauma, it has substantial limitations.[11,12,24,87] Firstly, ISS scoring is expensive as a significant amount of time and effort is required for AIS collection.[88,89] Moreover, the scored injuries are often not even the three

most severe injuries as the ISS only considers at most only three of a given patient's injuries, one per body region.[11,24] Additionally, it does not take account for contextual information such as comorbidities and issues relating to the event itself that may have contributed to patient outcomes.[89] A study of the accuracy of injury coding in New Zealand by Davie et al found, in a random sample of public hospital discharges, that 14% of the principal injury diagnosis and 26% of the external cause codes had inaccuracies, which were identified on the first, second or third characters.[90] This is likely to have affected the completeness of case ascertainment in the studies reviewed.

Only half of the studies reviewed reported ethnicity. Previous New Zealand research has highlighted that Māori are disproportionally represented in national injury data.[91,92] Additionally, it has been found that ethnicity reported on the national systems can differ to what patient identifies. The study of Scott et al evaluated the quality of ethnicity data (self-reported compared to that recorded by the Waikato Hospital trauma registry) and found the percentage of self-identified ethnicity that mismatched trauma registry ethnicity was 21% for Māori compared to 4% for non-Māori.[93]

There was limited South Island data included in the published studies reviewed. The majority of studies found were conducted or included data from the North Island, especially from Auckland and the Waikato region. Trends over time were unable to be described due to the heterogeneity of the included studies.

There is a scarcity of data relating to ethnicity, and major trauma among children in the international published literature which makes it difficult to compare the findings of this review with those from other countries.

Conclusion

The incidence of major trauma in New Zealand varies by age, sex and ethnicity. Although the New Zealand MTNCN has provided national level data on the incidence and outcomes of major trauma since 2015, the findings of this review highlight the need for further analytical studies that can explore factors that may impact survival from major trauma and continued efforts to prevent injuries in New Zealand. Changes in major trauma admissions during the COVID-19 pandemic as part of public health interventions, reinforce the notion that trauma is a social disease.

Table 1: Epidemiology of major trauma in New Zealand: summary of included studies (all ages).

Study	Participants	Findings	Comments
Patient hospital/ambulance record-based studies			
Streat SJ (1987)[56]	569 patients who died or were admitted to hospitals in the Auckland Hospital Board region as result of trauma between 15 November and 12 December 1982 Major trauma was defined as ISS≥16	9% major trauma Median ISS=5 (range: 1–75) MVCs 64% Head injury 53% 3% died	No ethnicity data reported - Only one month of data included in the study
Civil I (1987)[55]	114 patients who presented to the emergency department (ED) of Auckland Hospital following injury between 1 July to 31 December 1983 Major trauma was defined as ISS≥16	53% with an ISS of 16–24 82% blunt trauma due to falls or MVCs 30% died	No ethnicity data reported
Civil I (1988)[54]	602 patients presented to the ED of Auckland Hospital following injury during 1983 Major trauma was defined as ISS≥16	37% major trauma MVCs 58% and falls 25% 10% died	Only included information from Auckland Hospital Injured patients were taken to the closest hospital, which could mean an under representation of the trauma cases No ethnicity data reported
Safih MS (1999)[52]	2,092 patients with severe trauma admitted to the ICU of Auckland Hospital between January 1987 and December 1996 Major trauma was defined as ISS≥16 or death	*Older group ≥65 years (n=183; 9%)* Median ISS 25 ; ISS≥16 80% MVCs 57% and falls 34% Mortality 28% *Younger group <65 years (n=1909; 91%)* Median ISS 26 ; ISS≥16 89% MVCs 67% and falls 13% Mortality 14%	Information of ethnicity was available from 1989
Mittal A (2001)[50]	75 patients admitted to Auckland Hospital following trauma between December 1999 and January 2000 Major trauma was defined as ISS>15	22% <50 years had major trauma 14% ≥50 years had major trauma Length of stay (LOS) 19 days for patients with no co-morbidities LOS 24.5 days for patients with co-morbidities	Information of ethnicity and sex was not reported

Table 1 (continued): Epidemiology of major trauma in New Zealand: summary of included studies (all ages).

Study	Participants	Findings	Comments
Wakeman C (2003)[57]	93 patients with liver injuries admitted to Christchurch Hospital over a five-year period (1996-2000) NB. "major trauma" not defined. ISS is reported	*Paediatric population 0–17 (n=22; 23.7%)* Median ISS 17.5 (range 4–59) LOS 4 days (range 1–12) Mortality 5% *Adult population ≥18 (n=71; 76.3%)* Median ISS 17.0 (range 5–50) LOS 8 days (range 1–52) Mortality 13% (ISS 32)	Information of ethnicity and sex was not reported
National morbidity/mortality data-based studies			
Collins BA (1993)[5]	238 cases of pedal cycle injuries resulting in death between 1979 and 1988 NB. ISS not reported but injury-related deaths	88% collisions with motor vehicles 60% had head injuries 39% of fatalities aged 5–14 years Mortality rate 0.8/100,000 persons/year	No ethnicity data reported The nature of injury was not specified for a small proportion of the deaths
Langley JD (1994)[59]	1,175 cases of motorcycle crashes resulting in death between 1978 and 1987 NB. ISS not reported but injury-related deaths	96% MVCs Mortality rate 3.5/100,000 persons/year	The body regions injured were not specified
Chalmers DJ (2000)[60]	224 cases of aircraft crashes and related events in civil aviation, resulting in hospitalisations (1988–1993) and death (1988–1992) NB. 'major trauma' not defined. ISS by groups is reported	Hospitalisations (n=120; 54%): ISS≥20 3.3% 38% involved fixed-wing aircraft Fatalities (n=104; 46%): ISS≥20 82% 53% involved fixed-wing aircraft	No ethnicity data reported ISS could not be calculated in 17 cases of death A clear definition of major trauma was not provided

Table 1 (continued): Epidemiology of major trauma in New Zealand: summary of included studies (all ages).

Study	Participants	Findings	Comments
Kool B (2013)[66]	51,912 people (all ages) admitted to hospital between 2000 and 2009 or who died between 1999 and 2008 as result of head injuries NB. ISS not reported but injury-related deaths	Hospitalisations (n=47,565; 92%): Incidence rate 118.1/100,000 Higher incidence rates in males Highest incidence rates for Māori Mortality 2% Fatalities (n=4,347; 8%): Mortality rate 10.8/100,000 Mortality rate in aged ≥65 21/100,000 Mortality rate in aged 15–24 17.3/100,000 Highest mortality rates for Māori	Under-estimation of head injuries due to the inclusion of cases with a principal diagnosis of head injury
Trauma-registry-based studies			
Pang JM (2008)[46]	186 trauma deaths (all ages) occurred between 1 January 2004 and 31 December 2004 in the Auckland region NB. ISS not reported but injury-related deaths	Median ISS=25 (range: 1–75) MVCs 32% Hanging 36%	No ethnicity data reported Inclusion of hanging could affect the median ISS
Creamer GL (2008)[30]	448 patients (all ages) with severe injuries (ISS>15 or death) admitted to hospital during 2004	Injury rate 33.6/100,000 MVCs 50% and falls 19% Hangings 15% (all resulted in death) Mortality rate 14.4/100,000	No ethnicity data reported

Table 1 (continued): Epidemiology of major trauma in New Zealand: summary of included studies (all ages).

Study	Participants	Findings	Comments
Creamer GL (2010)[31]	448 trauma patients (all ages) admitted to one of the four hospitals in Auckland region, with an ISS>15 or who died as result of injury during 2004	Māori (n=95; 21%): MVCs 45% Hanging 25% Assault 18% Injury rate 61.4/100,000 Mortality rate 28.4/100,000 Pacific (n=66; 15%): MVCs 44% and falls 23% Assault 14% Injury rate 38.6/100,000 Mortality rate 16.4/100,000 Other (n=287; 64%): MVCs 52% Hanging 22% Assault 12% Injury rate 28.5/100,000 Mortality rate 11.9/100,000	The data used to calculate the rates were projections
Wood A (2013)[39]	101 trauma patients (all ages) admitted to Waikato Hospital between February 2007 and March 2001 as result of quad bike-related injuries Major trauma was defined as ISS>15 or death	27% major trauma 37% rollovers 26% collisions 29% head injury 1 death (traumatic brain injury)	Single-centre study Information of rural hospitals in the Waikato region was not included, which could cause an underestimation of the quad bike injuries
Tosswill M (2018)[42]	168 trauma patients (all ages) admitted to a Midland hospital with livestock-related injury from 2012 to 2015 Major trauma was defined as ISS>12	5% major trauma Mean ISS=3.6 (highest ISS=22) 76% cattle-related 7% head injuries 40% upper/lower extremity injuries Mean LOS=2.3 days	Injuries treated in the community were not included

Table 1 (continued): Epidemiology of major trauma in New Zealand: summary of included studies (all ages).

Study	Participants	Findings	Comments
Burstow M (2019)[29]	26,882 patients (all ages) admitted to Auckland hospital between 1995 and 2014 following trauma Major trauma was defined as ISS≥16	<65 years (n=22,454; 84%) 18% major trauma Median ISS=4 (IQR*: 4–10) 37% falls 2% died (13% with an ISS≥16) ≥65 years (n=4,428; 16%) 15% major trauma Median ISS=4 (IQR*: 4–9) 72% falls 6% died (28% with an ISS≥16)	No ethnicity data reported
Singh N (2019)[34]	998 patients (all ages) admitted to hospital between 1 June 2012 and 31 July 2016 as a result of cycling-related injuries in the Midland Region Major trauma was defined as ISS≥13	8% major trauma 15% Māori 62% occurred in road 52% upper/lower extremity injuries Injury rate 21.1/100,000 in males aged≥20 years (2013-2014) Injury rate 9.4/100,000 in females aged≥20 years (2015-2016)	Injury patients who died pre-hospital were not included
Christey G (2020)[38]	195 trauma patients (all ages) admitted to a level one trauma centre between March 5–18 2020 and March 26 to April 8 2020 Major trauma was defined as ISS>12	Pre-lockdown (n=124; 64%): Major trauma 18% 68% male 29% Māori 37% falls 33% home injuries During lockdown (n=71; 36%): Major trauma 15% 59% male 31% Māori 34% falls 48% home injuries	Single centre experience

Table 1 (continued): Epidemiology of major trauma in New Zealand: summary of included studies (all ages).

Study	Participants	Findings	Comments
Kandelaki T (2021)[35]	702 patients (all ages) with major trauma admitted to Christchurch Hospital between 1 June 2016 and 31 May 2018 Major trauma was defined as ISS≥13	Māori (n=63; 9%): 75% male 44% MVCs 22% falls 5% mortality Other (n=639; 91%): 69% male 45% MVCs 30% falls 11% mortality	Possible incorrect ethnicity entry data in the Waikato trauma registry
McGuinness MJ (2021)[36]	286 patients (all ages) with major trauma admitted to hospitals in the Northern Region between 16 March to 8 June 2019 and the same period but in 2020 Major trauma was defined as ISS>12 or death	2020 (n=123; 43%): 31% falls ; 30% MVCs 97% blunt trauma Mean ISS 20±8.6 14% mortality 2019 (n=163; 57%): 25% falls ; 36% MVCs 91% blunt trauma Mean ISS 20±8.5 12% mortality	Small sample size No ethnicity data reported

Table 1 (continued): Epidemiology of major trauma in New Zealand: summary of included studies (all ages).

Study	Participants	Findings	Comments
Fan D (2021)[37]	83 patients (all ages) with major trauma admitted to Christchurch Hospital between 22 February 2020 and 30 May 2020 Major trauma was defined as ISS≥13	Pre-lockdown (n=36; 44%): Mean ISS 21±9.1 89% male 31% falls 50% transport-related injuries During lockdown (n=21; 25%): Mean ISS 22±6.1 81% male 48% falls 38% transport-related injuries Post-lockdown (n=26; 31%): Mean ISS 21±9.1 (level 3) Mean ISS 19±7.5 (level 2) 85% male 31% falls 46% transport-related injuries	Single centre experience No ethnicity data reported Small sample size

Abbreviations: *IQR: Interquartile range; ISS: Injury Severity Score; MVCs: Motor vehicle crashes; ED: Emergency department; LOS: Length of hospital stay; ICU: intensive care unit.

Table 2: Epidemiology of major trauma in New Zealand: summary of included studies (adults).

Study	Participants	Findings	Comments
Patient hospital/ambulance record-based studies			
Gardiner JP (2000)[51]	2,305 trauma admissions to the ICU of Auckland Hospital from 1 January 1988 to 31 December 1997 Major trauma was defined as ISS≥16	89% major trauma Median ISS 26 (range: 1-75); ISS≥25 64% MVCs 66% 63% of critical injuries were the head and neck region	Information of ethnicity was available from 1989
Czuba KJ (2019)[47]	112 injured patients≥18 years old with an ISS>12 admitted to one of the two trauma centres in Auckland between 15 June 2015 and 14 December 2016	24% with an ISS of 12–15 36% with an ISS of 16-20 MVCs 30% and falls 28% Median LOS greater in patients with higher ISS: ISS 12-20: 7 days ISS 21-25: 10 days ISS 26-30: 22 days ISS>30: 25 days	Only 54% of the eligible population was included
National morbidity/mortality data-based studies			
O'Hare D (2002)[61]	33 cases of injuries associated with white water and other recreational river rafting resulting in death between 1983 and 1995 NB. ISS not reported but injury-related deaths	Drowning 94% 36% due to the raft capsizing	No ethnicity data reported Small sample
Kool B (2007)[63]	73 people aged 25–59 years who died as a result of an unintentional fall-related injury occurring at home between 1993 and 2002 NB. ISS not reported but injury-related deaths	Falls from buildings or structures 26% Falls involving stairs or steps 19% Fatality rate for males 0.63/100,000 Fatality rate for females 0.20/100,000	No ethnicity data reported The type of fall was not specified for 25% of the fatalities

Table 2 (continued): Epidemiology of major trauma in New Zealand: summary of included studies (adults).

Study	Participants	Findings	Comments
Kool B (2011)[65]	40,986 people aged 20–64 discharged from hospital between 2000 and 2009 or who died between 1998 and 2007 as result of unintentional injuries occurring at home NB. ISS not reported but injury-related deaths	Hospitalisations (n=40,382; 99%): 0.6% major trauma Falls 45% Cutting/piercing 17% Deaths (n=604; 1%): Falls 21% Burns 12% Poisoning 38% (Drug-related 78%)	Overestimation of injury incidence due to the inclusion of cases without a diagnosis code and because the no compensation of the cases admitted and discharged in a reference year
Trauma registry-based studies			
Civil I (1998)[28]	96 patients aged≥16 years admitted to Auckland Hospital following penetrating trauma in 1995 NB. ISS not reported but injury-related deaths	4.2% major trauma 75% of major trauma intentional Median ISS=22 (range: 9–75)	The body regions injured were not specified No ethnicity data reported
Johns E (2004)[43]	167 adult (≥15 years of age) admissions to Auckland Hospital for animal-related injury from December 1994 to April 2001 Major trauma was defined as ISS>15 or death	14% major trauma (including 2 deaths) Median ISS=4 (range: 1-32) 86% associated with horses 49% involved the extremities LOS influenced by the ISS (Mean=4 days; range: 1-62)	No ethnicity data reported
Tan C-P (2004)[44]	105 trauma patients aged≥40 years admitted to Auckland Hospital between 1 January and 3 March 2003 Major trauma was defined as ISS>15	15% major trauma 5% died due to head injury	No mechanism of injury and ethnicity data reported

Table 2 (continued): Epidemiology of major trauma in New Zealand: summary of included studies (adults).

Study	Participants	Findings	Comments
Hsee L (2008)[45]	56 trauma patients aged≥15 years admitted to hospital or who died as a result of gunshot injuries between 1995 and 2006 NB. ISS not reported but injury-related deaths	7% major trauma due to brain trauma (ISS range: 25-75) Median ISS 10 (range: 1–75) 52% unintentional injuries Extremities injuries 38%	No ethnicity data reported
O'Leary K (2017)[40]	2,278 trauma patients aged ≥65 years admitted to hospital in the Midland region between 1 January 2012 and 31 December 2014 Major trauma was defined as ISS>12	10% major trauma 98% unintentional injury Falls 39% Transport related injury 43% Chest injuries 22% Head or neck injuries 22% LOS≥10 days: 31%	Information of ethnicity was obtained directly from the patients
Kool B (2017)[41]	2,169 trauma patients ≥15 years old admitted to a Midland hospital with work-related injuries between 1 January 2012 and 31 December 2015 Major trauma was defined as ISS>15	4% major trauma Median ISS=2 (IQR*: 1–4) Falls 19% Injury caused by contact with machinery: 26% Extremities injuries 48%	Pre-hospital deaths were not included

Abbreviations: *IQR: Interquartile range; ISS: Injury Severity Score; MVCs: Motor vehicle crashes; LOS: Length of hospital stay; ICU: Intensive care unit.

Table 3: Epidemiology of major trauma in New Zealand: summary of included studies (paediatric population).

Study	Participants	Findings	Comments
Patient hospital/ambulance record-based studies			
Roberts I (1991)[53]	64 children under 15 years of age injured as pedestrians and admitted to the Department of Critical Care Medicine (DCCM) of Auckland Hospital between 1986 and 1989 Major trauma was defined as ISS≥16	95% major trauma Median ISS=29 (range: 4–75) 83% of critical and severe injuries were in the head region 14% died (all from brain injuries)	Information of ethnicity (census and hospital data) was based on parent report ethnicity
Pearce R (2015)[48]	27 children under 16 years of age with confirmed quad bike injuries and admitted to Starship Children's Hospital from January 2007 to July 2014 NB. 'major trauma' not defined. ISS by age groups is reported	Mean ISS 14 (range: 1–75) ISS 33.8 (range: 9-75) for PICU admissions 26% head injury (Mean ISS 19.4; range: 5-43) 7% died	Only 59.2% had information about the quad bikes A clear definition of major trauma was not provided Small sample
Bajaj M (2018)[49]	179 children with a pelvic fracture admitted to Starship Hospital between July 1995 and May 2015 NB. 'major trauma' not defined. ISS is reported	Mean ISS 9 (IQR: 4–22) Severe traumatic brain injury 19% Pedestrian struck by a vehicle 46% MVCs 23% Mortality 6% (ISS 36.5; range 17–59)	No ethnicity data reported
National morbidity/mortality data-based studies			
Gulliver P (2005)[62]	355 deaths in children under 5 years occurring in the home between 1989 and 1998 NB. ISS not reported but injury-related deaths	Suffocation 36% Homicide rate 2/100,000 children per year	No ethnicity data reported
Anson K (2009)[64]	218 children under 16 years old hospitalised because of ATV-related injury between 2000-2006 Major trauma was defined as ISS>15 or death	Median ISS 9 (range: 4–9); ISS>15 8% Falls from vehicles 49% 6 admissions to PICU 8% died	Data related to ethnicity was not available for 7 patients Limited information about deaths

Study	Participants	Findings	Comments
Trauma registry-based studies			
Couch L (2010)[32]	82 children aged <15 years admitted to hospital as result of trauma between 1 May 2003 and 30 April 2004 Major trauma was defined as ISS>15	Starship Hospital (n=40; 49%) 63% major trauma MVCs 48% and falls 38% 80% head injury KidzFirst (n=42; 51%) 62% major trauma MVCs 60% and falls 31% 77% head injury 1 death (ISS=38)	Small sample size, which affected statistical power. Not all injury presentations were included Problems in defining moderate trauma
Scott A (2011)[33]	146 children under 15 years old admitted or died in Starship Children Hospital between 1 November 1999 and 31 December 2008 as result of motorcycle trauma Major trauma was defined as ISS>12	Motorbikes (n=123; 84%) 9% major trauma Median ISS=3.1 (range: 1–35) 2 deaths due to head injuries All-terrain vehicles (n=23; 16%) 26% major trauma Median ISS=4 (range: 1-25)	The lethality of motorcycles could be underestimated because coroner's records for deaths outside hospital were not searched

Abbreviations: *IQR: Interquartile range; ISS: Injury Severity Score; MVCs: Motor vehicle crashes; PICU: Paediatric intensive care unit; DCCM: Department of Critical Care Medicine.

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Characteristics of patients hospitalised with traumatic brain injuries

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ABSTRACT

AIM: To investigate the volume, injury characteristics and journey of Te Manawa Taki/Midland (TMT) residents hospitalised with a traumatic brain injury (TBI).

METHODS: A retrospective review of TMT Trauma Registry data between 1 January 2012 and 31 December 2019 was conducted. Eligible patients (n=4,875) were TMT residents hospitalised with an injury to the brain parenchyma.

RESULTS: An average 609 residents were hospitalised with a TBI diagnosis per year, increasing by an average of 7.0% annually. Males, Māori and 0–4- and 15–34-year-olds were proportionately over-represented. Transport incidents and falls were key mechanisms. Mild, moderate and severe TBI, derived by Abbreviated Injury Scale severity scores, were classified in 72.1%, 22.6% and 5.3% of patients, respectively. Concomitant injuries occurred in 78.1% of patients. Brain surgery was required by 3.5%, other surgery by 25.5% and intensive care by 14.9%, and 3.7% died. Mean length of hospitalisation was 5.8±9.3 days. There were 1,118 inter-facility transfers: 41.9% to designated out-of-region acute care and rehabilitation centres, an annual average of 59 TMT-domiciled patients.

CONCLUSION: The increasing volume of diverse TBI hospitalisations represents a major burden on individuals, communities and health services. Effective strategies are needed to prevent injury and ensure treatment and rehabilitation are equitable and patient focused.

Globally, traumatic brain injury (TBI) is the foremost cause of death and disability in both children and young adults.[1,2] New Zealand is no exception, with an incidence rate in 2010–2011 of 790/100,000 observed in Hamilton City and Waikato District.[2] At this time, TBI was more prevalent in males, 0–34-year-olds, Māori and those living in rural areas, with falls, exposure to mechanical forces, transport incidents and interpersonal violence recognised as important causes.[2]

Traumatic brain injuries are significant in number, diverse in nature with a severity range from mild concussion and moderate brain oedema, haematoma and/or haemorrhage, to severe crush or penetrating injury causing extended loss of consciousness.[3,4] TBI also commonly occur with other concomitant injuries requiring additional assessment, treatment and rehabilitation.[3,4] Accordingly, TBI can temporarily or permanently affect cognitive, behavioural, emotional and physical aspects of quality of life, including the ability to live independently, maintain relationships and return to work, education or leisure activities.[6–8] Early, equitable and coordinated management is therefore essential to optimise outcomes.

Although the incidence, at-risk populations and common causes of TBI were identified in New Zealand a decade ago[2], less is known about the patient journey through the TMT hospital setting of patients who are admitted with a diagnosis that includes TBI. The TMT Trauma Registry (TR) contains data to enable evaluation of demographics, injury complexity, utilisation of hospital resources and discharge destinations for individuals admitted to acute care facilities in the region. Such information assists quantification of the burden of hospitalised TBI on affected individuals, their families/whānau and regional health systems. It will also assist identification of issues pertaining to clinical service provision and rehabilitation pathways. Anecdotal evidence pointed to an increasing volume of TBI related injury across the region.

The aim of this study is to investigate not only the volume and demographic features of patients, but also processes of care, injury events, injury types and treatment and resource allocation of TMT residents hospitalised with a TBI.

The TMT region encompasses five district health boards (DHB) and displays demographic char-

acteristics reflective of New Zealand for median age (35 vs 38 years) and gender (48% male) and a higher proportion of Māori (26.5% vs 15.7%).[9] The average regional population during the study period was 909,109, with an average annual population increase of 2.0%. Providing tertiary care to the region Waikato Hospital is a Royal Australasian College of Surgeons verified Level 1 Trauma Centre,[10] with specialist teams and resources to manage all acute major and non-major trauma. TBI rehabilitation options in the region include non-specific inpatient wards and DHB and Accident Compensation Corporation (ACC) contracts in the outpatient, community and home-based settings.

Methods

A retrospective review of the TR was conducted from 1 January 2012 to 31 December 2019. The TR collects comprehensive data on all trauma patients across the region admitted to hospital, within seven days of injury. All patients with TBI were defined and identified by use of the 137 Abbreviated Injury Scale (AIS)[3] codes from body region 1 (cranium and brain) defining injury to and around the brain parenchyma. Exclusions included injuries to cranial and spinal nerves, vascular structures and bone in the absence of brain parenchymal disruption. Consistent with other trauma registries, exclusions included insufficiency or peri-prosthetic fractures, exertional injuries, hanging, near drowning or asphyxiation and injuries that occur as a result of a pre-existing medical condition.

Severity of TBI was determined by AIS score, ranging from 1 (minor, 0% threat to life) through to 6 (maximum, 100% threat to life). In accordance with recommendations[10] and other trauma registry studies,[12–14] TBI was defined as mild, moderate or severe by AIS severity scores of 1–2, 3–4 and ≥5, respectively. Isolated TBI were defined when no other anatomic region had an AIS score. The Injury Severity Scale (ISS)[15] standardises injuries sustained in a single incident with thresholds set at ISS≥13 for major and ISS≤12 for non-major.[16] ISS scores are calculated from the square of the highest AIS scores from a maximum of three body systems. We determined the contribution of TBI to ISS scores as a proportion (%) to provide an indication of the severity of TBI to multi-trauma patients.

Hospital resource allocation characteristics including surgical procedures and admission to intensive care were categorically coded. Surgical procedures that have a direct impact on brain parenchyma were identified by International Classification of Disease (ICD-10-AM)[17] codes (n=34). Length of hospital stay was calculated as mean (SD) and median (IQR). In addition to final discharge destinations from TMT hospitals, all transfers to out-of-region facilities during each patient's journey were also recorded.

Populations were estimated from Stats NZ census data.[9] Ethnicities were categorised as Māori, European and Other according to Stats NZ classifications. Mechanism of injury was classified by the ICD-10-AM[17] and grouped by unintentional falls, transport incidents (traffic and non-traffic related), interpersonal violence, exposure to external forces and other causes. Descriptive analyses were performed in Excel (Microsoft Office Professional Plus 2016) and data are presented as number (%), except when outlined as mean (SD) and median (IQR). Ethical approval was deemed out of scope by the New Zealand Health and Disability Ethics Committee and project approval was provided following locality assessment by Waikato DHB and the Māori Research Review Committee (RD21026).

Results

Across the eight-year study period, 4,875 TMT residents were hospitalised with a diagnosis that included TBI, with an average of 609 per year. Figure 1 highlights the increasing trend (R^2=0.833) with an average annual increase of 7.0% and 248 (152%) more TBI-related hospitalisations in 2019 compared to 2012. A further 490 non-domiciled patients were also hospitalised at a TMT facility for an injury that included a diagnosis of TBI but are excluded from analyses.

TBI-related hospitalisations were dominated by males (66.4%), Europeans (61.3%) and by age groups 15–34 (30.7%) and 35–64 (25.3%). However, as a percentage of the respective sub-populations, Māori had 33.4% more TBI-related hospitalisations than Europeans, and age groups 0–4 (211%) and 15–34 (184%) had more TBI-related hospitalisations than 35–64-year-olds. Transport incidents and falls were the causes for 79.2% of all TBI-related hospitalisations. Falls were particularly important in those aged 0–4 and ≥65. Interpersonal violence was a notable mechanism in males, Māori and 35–64-year-olds. Severity of TBI did not appear to be influenced by the cause of injury, with transport incidents, falls and interpersonal violence similarly represented across all grades of severity in TBI-related hospitalisations (Table 1).

The majority (72.1%) of TBI diagnoses were classified mild by AIS severity score. Of these, 25.0% were isolated TBI, 10.9% had major ISS scores, 6.4% were admitted to intensive care units (ICU) and 22.2% received surgery. Of the sample, 22.6% of TBI diagnoses were classified as moderate and 12.1% had an isolated TBI, 60.2% had major ISS scores, 32.3% were admitted to ICU, 7.2% required brain surgery, 32.3% received other surgical intervention and 6.5% died as a result of their injuries. Of the remaining 260 patients (32.5 per year) classified with severe TBI, 21.2% were isolated TBI, all had major ISS scores, 56.2% were admitted to ICU, 33.5% required brain surgery, 41.9% received other surgical interventions and 35.0% died. The mean and median percent contribution of the TBI diagnosis to the total ISS score was greater than 50% across the whole sample and within each severity group, although wide variation existed. Wide variability in mean and median length of hospital stay was also evident for the total sample and across each severity group. In those who survived, 1.6% of mild, 18.6% of moderate and 43.8% of severe TBI patients travelled to out-of-region specialised services for brain and/or spinal rehabilitation (Table 2). Non-availability of a rehabilitation facility bed was cited as an impediment to timely hospital discharge for 19 patients, with delays ranging from 1–17 days. This is considered an under-estimation as the impediment to discharge variable is not always recorded in the TR.

Inter-facility transfers occurred on 1,118 occasions across the 4,875 patients (Table 3). This number excludes initial admissions to non-TMT facilities where incidents occurred to residents outside of the TMT region and is possibly further under-estimated by the inability of the TR to capture direct transfers from out-of-region acute care facilities to out-of-region rehabilitation facilities. Of the recorded inter-facility transfers, 801 (16.4%) patients were transferred once, 142 (2.9%) twice, eight (0.2%) three times and two ≥4 times to receive necessary care. Transfers commonly occurred between the smaller regional hospitals and Waikato Hospital, the Level 1 Trauma Centre. However, 41.9% (468/1,118) of all inter-facility transfers were to designated out-of-region acute care and rehabilitation centres, equating to an average of 48 adults and 11 children per year. Of the 4,694 patients who survived, home was the most common discharge destination (82.1%) captured by the TR. The remainder were discharged to regional hospitals for rehabilitation (3.6%) or continuing and convalescence care (1.9%), aged care or nursing home not usual residence (2.0%) and out-of-region facilities (8.0%). A further 1.5% left against medical advice.

Figure 1: Count of hospitalisations that included a traumatic brain injury diagnosis by year in Te Manawa Taki residents.

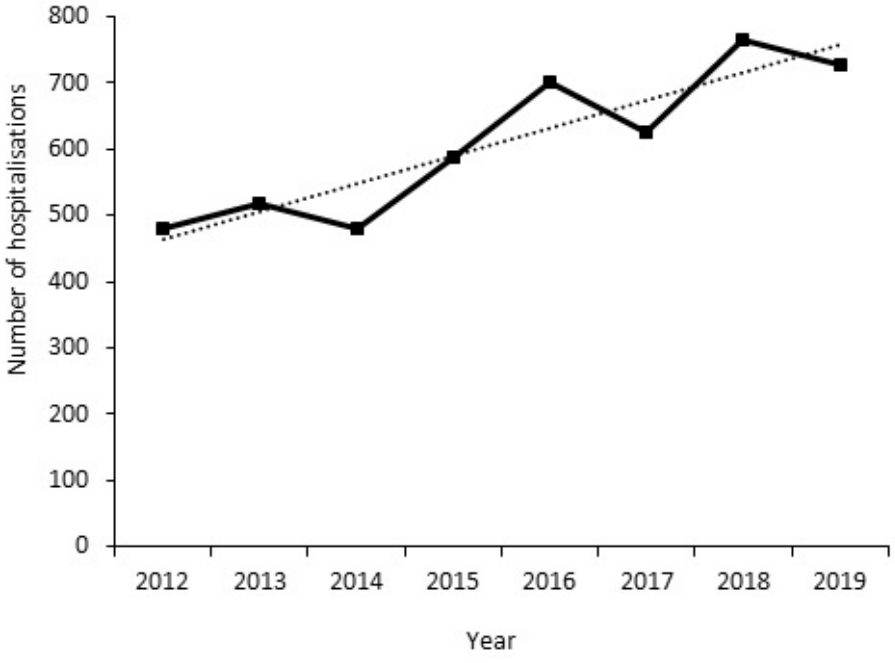

Table 1: Number of hospitalised traumatic brain injuries by mechanism of injury and demographics in Te Manawa Taki residents (2012–2019).

	Average population	Total number (%)	Mechanism of injury				
			Transport incidents	Unintentional falls	Interpersonal violence	Exposure to external forces	Other
Total	909,109	4,875	2,063 (42.3)	1,798 (36.9)	539 (11.1)	402 (8.2)	73 (1.5)
Gender							
Female	464,397	1,636 (33.6)	669 (40.9)	724 (44.3)	109 (6.7)	117 (7.2)	17 (1.0)
Male	444,712	3,239 (66.4)	1,394 (43.0)	1,074 (33.2)	430 (13.3)	285 (8.8)	56 (1.7)
Ethnicity							
Māori	240,074	1,629 (33.4)	661 (40.6)	479 (29.4)	322 (19.8)	137 (8.4)	30 (1.8)
European	587,440	2,990 (61.3)	1,299 (43.4)	1,216 (40.7)	191 (6.4)	244 (8.2)	40 (1.3)
Other/unknown	81,595	256 (5.3)	103 (40.2)	103 (40.2)	26 (10.2)	21 (8.2)	3 (1.2)
Age group (years)							
0–4	63,215	485 (9.9)	59 (12.2)	349 (72.0)	21 (4.3)	48 (9.9)	8 (1.6)
5–14	130,196	784 (16.1)	261 (33.3)	373 (47.6)	22 (2.8)	125 (15.9)	3 (0.4)
15–34	224,780	1,499 (30.7)	890 (59.4)	181 (12.1)	277 (18.5)	119 (7.9)	32 (2.1)
35–64	339,911	1,235 (25.3)	631 (51.1)	296 (24.0)	200 (16.2)	83 (6.7)	25 (2.0)
≥65	151,007	872 (17.9)	222 (25.5)	599 (68.7)	19 (2.2)	27 (3.1)	5 (0.6)
Severity of TBI							
Mild		3,511 (72.1)	1,515 (43.2)	1,254 (35.7)	365 (10.4)	342 (9.7)	35 (1.0)
Moderate		1,104 (22.6)	442 (40.0)	437 (39.6)	150 (13.6)	50 (4.5)	25 (2.3)
Severe		260 (5.3)	106 (40.8)	107 (41.2)	24 (9.2)	10 (3.8)	13 (5.0)

Table 2: Hospitalisation and health service characteristics by severity of traumatic brain injury in Te Manawa Taki residents (2012–2019).

	Total number (%)	Mild		Moderate		Severe	
		Abbreviated Injury Scale severity score					
		1	2	3	4	5	6+
Total	4,875	1,705 (35.0)	1,806 (37.1)	740 (15.2)	364 (7.5)	258 (5.3)	2 (0.04)
Isolated traumatic brain injury	1,067 (21.9)	556 (32.6)	322 (17.8)	104 (14.1)	30 (8.2)	54 (20.9)	1 (50.0)
Major injury (ISS≥13)	1,309 (26.9)	84 (4.9)	300 (16.6)	301 (40.7)	364 (100.0)	258 (100.0)	2 (100.0)
Proportion of TBI to ISS (%)							
• Mean (SD)	66.1 (29.9)	57.0 (34.1)	65.1 (27.1)	76.7 (23.2)	78.5 (20.8)	85.5 (17.7)	-
• Median (IQR)	75.8 (55.6)	50.0 (80.0)	80.0 (35.6)	90.0 (25.7)	88.9 (30.7)	96.2 (25.9)	-
Did not survive	181 (3.7)	2 (0.1)	16 (0.9)	29 (3.9)	43 (11.8)	89 (34.5)	2 (100.0)
Intensive care admission	727 (14.9)	61 (3.6)	163 (9.0)	181 (24.5)	176 (48.4)	146 (56.6)	0 (0.0)
Surgery							
• Any surgery	1,244 (25.5)	299 (17.5)	479 (26.5)	227 (30.7)	130 (35.7)	108 (41.9)	1 (50.0)
• Brain surgery	170 (3.5)	0 (0.0)	3 (0.2)	39 (5.3)	41 (11.3)	87 (33.7)	0 (0.0)
Length of hospital stay (days)							
• Mean (SD)	5.8 (9.3)	3.1 (4.5)	4.9 (7.6)	8.4 (11.5)	12.8 (13.4)	13.0 (15.8)	-
• Median (IQR)	2.0 (5.0)	2.0 (2.0)	2.0 (4.0)	4.0 (7.3)	8.0 (13.0)	8.0 (13.0)	-
Specialised rehabilitation (survived)	320 (6.8)	10 (0.6)	44 (2.5)	93 (13.1)	99 (30.9)	74 (43.8)	0 (0.0)
• Acquired brain injury service	301	8	38	89	96	70	0
• Spinal service	10	2	5	2	1	0	0
• Paediatric service	9	0	1	2	2	4	0

LOC, loss of consciousness.

Table 3: Journey of care pathway of Te Manawa Taki residents hospitalised with a traumatic brain injury (2012–2019).

	Total (%)
Facility admissions per patient	
• 1	3,922 (80.5)
• 2	801 (16.4)
• 3	142 (2.9)
• 4	8 (0.2)
• 5	1 (<0.1)
• 6	1 (<0.1)
• Mean (SD)	1.3 (0.5)
Inter-facility transfers across the study period	1,118 across 4,875 patients
Out-of-region facility transfers (total)	468
• Acute care	70
• Convalescence	3
• Rehabilitation	311
• Paediatric acute care	75
• Paediatric rehabilitation	9
Final discharge destination	
• Home	3,852
• Regional facility	
◊ Acute care	8
◊ Convalescence	82
◊ Rehabilitation	171
• Out-of-region facility	375
• Did not survive	181
• Aged care or nursing home not usual residence	92
• Left against medical advice	71
• Other	43

Discussion

This study provides comprehensive information on domiciled residents in the TMT region who were admitted to hospital with a diagnosis that included TBI. The 7.0% average annual increase in TBI-related hospitalisations, which is higher than the 2.0% average annual population growth, is a major concern for funding, budgeting and resource allocation. The 152% increase in TBI-related hospitalisations between 2012 and 2019 also indicates a rising incidence despite currently established TBI prevention initiatives.[6]

In 2010–2011, a prospective TBI investigation of domiciled Hamilton City and Waikato District residents was conducted.[2] During the 12-month study, 882 patients with TBI were admitted to Waikato Hospital. This figure is higher than our observations of 479–765 TBI-related hospitalisations per year from the TMT region, and definition differences explain this discrepancy. We defined hospitalisation by admission to an inpatient bed and by death that occurred in the emergency department, whereas the earlier study[2] referred to site of case detection by the study team (hospital, family doctor or other), meaning emergency department presentations with or without subsequent admission to an inpatient bed were included. Further, we diagnosed TBI by the AIS which uses radiological and surgical findings to determine anatomical injury to the brain. Conversely, the earlier study[2] functionally defined TBI by the presence of confusion or disorientation and/or loss of consciousness and/or post-traumatic amnesia and/or other neurological abnormalities. Nevertheless, regardless of the requirement for hospital admission, the increasing volume of TBI we observed suggests the burden on regional residents and the health system is increasing.

The higher population-based percentage of hospitalisations for males, Māori and those aged 0–4- and 15–34-years-old aligns with previous New Zealand investigations.[2,18] Transport incidents were the most frequent cause (42.3%), but despite the same ICD-10-AM cause categories, an earlier New Zealand study[2] observed transport incidents were involved in only 19.0% of TBI. This discrepancy is likely due to the increased requirement of hospitalisation following transport incidents due to multi-trauma occurring with or without a serious TBI. Indeed, only 21.9% of all hospitalisations in our study were isolated TBI. Notwithstanding, our data are consistent with the earlier study,[2] with transport incidents the most common cause of TBI in 15–64-year-olds, falls being particularly important in 0–4- and ≥65-year-olds and interpersonal violence evident in males, Māori and 35–64-year-olds. Cause of injury did not appear to influence severity of TBI, with transport incidents, falls and interpersonal violence similarly represented across mild, moderate and severe TBI-related hospitalisations. Escalating TBI-prevention strategies as they relate to gender, age, ethnicity and cause of injury is warranted. The treatment, management and cultural needs of at-risk population groups must be considered in acute-care and rehabilitation service planning and for workforce availability within hospitals, residential services and in the home and community.

Our study also identifies the complexity and diversity of TBI-related hospitalisations. Although it may seem encouraging that the large proportion (72.1%) of TBI were defined as mild, 75% of this group sustained concomitant injuries that contributed to the requirement for inpatient bed admission and utilisation of hospital resources. Non-isolated injuries were also more common in moderate (87.9%) and severe (78.9%) TBI patients. As the severity of TBI increased, so did mortality, ICU admissions, surgical operations, length of hospital stay and discharge to specialised residential rehabilitation services. In contrast, a study from Israel reported a lower proportion (40.4%) of non-isolated TBI, across all severities, in their national sample of hospitalised patients.[5] The disparity is likely explained by differences in the AIS severity cut-off for concomitant injuries to define non-isolated TBI. Notwithstanding, significantly higher rates of mortality, resuscitation, surgery, ICU admission, ICU stay ≥7 days, total hospital stay ≥14 days and residential rehabilitation service requirements were highlighted in non-isolated compared to isolated TBI patients.[5] Isolated TBI were also more frequent in females and ≥65-year-olds and more commonly occurred at home, whereas non-isolated TBI occurred more frequently in traffic incidents, particularly among pedestrians and motorcyclists.[5] Differences between isolated and non-isolated TBI have important implications for assessment and acute management decisions, resource allocation, collaborative multi-disciplinary teamwork, hospital discharge planning and rehabilitation service provision.

Reporting inter-facility transfers provides a unique insight into the journey of care pathway experienced by patients. The majority (80.5%) of patients remained at the same TMT facility until

discharge. It is likely that the 650 (of 1,118) transfers that occurred between the smaller hospitals and Waikato Hospital were due to more severe injuries requiring the resources of the Level 1 Trauma Centre. The 90 patients that had a final discharge destination at a TMT hospital for acute care or convalescence purposes suggests the TR is not currently capturing all patient transfers and discharges. Ongoing development and data collection processes for the TR should ensure patients are completely and accurately tracked through the inpatient acute care and rehabilitation journey. In doing so, assessment of the appropriateness, timeliness, cost and outcome of patient transport between facilities will be possible and serve as a quality control indicator for efficiency in trauma systems,[19] and also highlight inequities in health service provision. Such indicators are important given 41.9% of all inter-facility transfers were to designated out-of-region acute care and rehabilitation centres.

The ACC TBI Strategy and Action Plan (2017–2021) suggests TBI services are fragmented and poorly coordinated with support provided in isolation of each other and in isolation to the personal circumstances of people with a TBI.[6] Indeed, utilisation and access to rehabilitation services may be significant barriers for people with TBI and delays in service delivery affect rehabilitation progress. In the 12 months after injury, only 32%–37% of Hamilton City and Waikato District residents who sustained mild and moderate/severe TBI reported to follow-up with general practitioners.[20] Allied health and specialist medical service provision was also only received by 17% and 14% of the mild TBI cohort, and 41% and 29% of those with moderate-severe TBI, respectively.[20] This is concerning given that at 12 months after injury 48% of adults with mild TBI report persistent symptoms.[21,22] The sustained and ongoing long-term skills shortage of rehabilitation providers throughout New Zealand,[23] discrepancies in the ratio of rehabilitation providers for rural areas and the disproportionately low participation of Māori in the rehabilitation workforce[24] may contribute to the low access and utilisation of rehabilitation services. The costly assessment, treatment and rehabilitation of TBI may also be a barrier to progress for affected individuals and health systems. The 2010 financial burden of TBI to New Zealand, including hospitalisations, outpatient rehabilitation, equipment and home modifications and productivity loss for the person affected, was estimated at US$101 million, with projections increasing 20.9% to US$123 million by 2020.[20]

A limitation of the study was not utilising the Glasgow Coma Scale (GCS) for comparison with other TBI studies that did use this measure for diagnostic purposes. This decision was made as GCS is not assessed for every TBI patient during the initial hospital admission phase and mechanisms not related to TBI can induce changes in GCS, including psychological stress, drugs and alcohol and concomitant injuries.[25] We also reiterate that the nature of this study was not to report incidence but rather the growing volume of TBI-related hospital admissions, which exceeds the rate of population growth, and the impact this has on a regional health system. Acute care hospital costs would also lend further valuable information to this study.

Conclusion

The growing volume and complexity of TBI-related hospitalisations identified in this study have significant implications for affected individuals, their families/whānau and for health system resource planning and allocation. Despite current injury prevention initiatives, males, Māori and 0–4- and 15–34-year-olds are proportionately over-represented in TBI-related hospitalisations. Transport incidents and falls remain key causes of TBI and concomitant injuries. The current requirement for out-of-region transfers for an average 59 TMT residents with TBI each year to acute care and specialised rehabilitation facilities requires service delivery level review and should ideally include qualitative work on patient experiences to optimise care and outcomes.

COMPETING INTERESTS
Nil.

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Endoscopic submucosal dissection: the first reported experience from a New Zealand centre

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ABSTRACT

AIM: Endoscopic submucosal dissection (ESD) is internationally accepted as a minimally invasive procedure to treat early gastrointestinal cancers endoscopically. Uptake of this procedure in the West is limited. No published data are available in New Zealand. We aimed to evaluate outcomes of this procedure at North Shore Hospital, Auckland.

METHODS: Following an overseas fellowship training period, we prospectively collected clinical outcomes, complications and defined quality indicators for patients undergoing ESD referred following a multidisciplinary meeting.

RESULTS: Between January 2020 until July 2021, 29 ESD procedures were performed in 27 patients, including 14 gastric, five oesophageal and 10 colorectal cases. The mean age was 72 (standard deviation (SD) 10.6). The majority of cases (62%) were done under general anaesthesia. The median lesion size resected was 30mm (interquartile range (IQR) 20–58mm). The pre-endoscopic diagnosis was accurate as confirmed on final histology in 93% of cases. Thirty-four percent of lesions were T1 adenocarcinoma and completely resected. The median total duration of the procedure was 90 minutes (IQR 55–180). 86% of lesions were resected en-bloc. R0 resection was achieved in 72% of cases. All cases with R0 resection were curative except one. Muscular defects without perforation were seen and clipped at the time of endoscopy in 34% of cases. Two perforations were identified and sealed at the time of endoscopy. There were no cases of delayed bleeding, perforation or mortality.

CONCLUSION: These data demonstrate clinical success, efficacy and safety of ESD at our centre. A larger study, comparison with other centres and longer clinical follow-up is required to confirm findings and further improve outcomes.

Cancers of the gastrointestinal tract (GIT) account for 26% of cancers diagnosed and 35% of all cancer related deaths worldwide.[1] Both internationally and within New Zealand, oesophageal, gastric and colon cancer incidence are increasing.[2–5] Strategies such as screening programmes have been introduced to aid in detection, with resultant earlier stage diagnosis of cancer.[6–9]

Curative endoscopic therapy is possible for such cancers or precancerous lesions if they are detected at an early stage when the depth of neoplastic invasion is small and therefore the risk of lymph node metastasis is low.[10] Attempts at endoscopic treatment of such lesions have been largely performed in the western world and in New Zealand using endoscopic mucosal resection (EMR). This technique was first described in 1955 in rigid sigmoidoscopy[11] and later adapted for flexible colonoscopy in 1973.[12] This procedure involves injection of a fluid cushion into the submucosal space to separate the lesion from the underlying muscular layer, with final resection using a metal snare. EMR of larger lesions (≥15mm) may require removal in fragmented pieces ("piecemeal"), which limits histological assessment, tumour staging, subsequent stratification of therapeutic approach and potential cure.[13] This method also results in a significantly increased risk of recurrence.[14,15] Inability to determine adequacy of resection according to oncologic standards (en-bloc and R0) may lead to organ resection surgery which may not have been necessary.

To overcome these issues, endoscopic submucosal dissection (ESD) was pioneered in 1998 in Japan initially to treat early gastric cancer.[16] This has now expanded to include the entire GIT and is considered the standard of care for neoplastic lesions in Japan and Korea, as well as being included in Western society guidelines as the gold-standard treatment for superficial lesions.[17,18] When the criteria for anatomopathological curability are met, ESD has the same treatment efficacy as surgical resection.[19–23]

The essence of the technique is similar to EMR. However, the methodology of cutting the lesion differs. ESD generally employs a small (1.5–2mm) electrocautery metal needle to precisely cut free-hand the lesion away from the muscular layer in one section (en-bloc). ESD thus allows higher en-bloc and curative resection compared with EMR in the oesophagus, stomach and colon.[15,24–27] In addition to patient acceptability with organ preservation, decreased length of hospital stay (11 vs 2 days; p<0.0001) and lower morbidity (28% vs 14%; p=0.06), there is a significant lower cost (€8960 vs €1770; p<0.0001) when compared to surgery.[21,28,29] It has comparable costs with EMR for large lesions in the colorectum, with additional benefit of reduction of burden of follow-up endoscopy.[30,31]These benefits come at the expense of significantly increased procedural time and an increased complication rate, including bleeding and perforation (OR 2.20 and OR 4.09), compared to EMR.[15,32,33] Therefore, particularly in the colorectum, case selection is paramount.[34]

Traditionally the majority of ESD literature emanates from Asia, with series and outcomes from high volume centres and experienced practitioners, which may not reflect local experience. However, more recently large publications from Western centres have shown comparable results, particularly in the upper GIT.[35–40] Whilst ESD has been performed in New Zealand by a select few practitioners over the years, no data have been published on cases and outcomes, and Australasian data in general are similarly scarce.[41,42]

Prior to this study, ESD had been performed infrequently at Waitemāta District Health Board (WDHB). This hospital services a population of nearly 630,000 people. To further develop this service, Dr Schauer was awarded a scholarship from the Japanese Society of Gastroenterology for a Fellowship programme at NTT Hospital in Tokyo, Japan. This hospital is one of the highest-volume ESD centres in the world, performing over 900 resections per year, including duodenal and oropharyngeal cases.[43] This fellowship involved systematic teaching on lesion detection and staging with image-enhanced endoscopy to ensure correct indications for ESD, tutoring of resection principles, animal model workshops, case observation and finally supervised procedures with patients.[44]

We present the first report of patient demographics, outcomes and complications of ESD from a single tertiary centre in New Zealand.

Methods

Following specific advice and systematic suggestion for building and maintaining a high-quality service,[45–47] we began to prospectively collect key performance indicators for all patients undergoing ESD between January 2020 and July 2021. Regular review of lesion selection and ESD practice was undertaken by recorded video assessment with Dr Yohei Minato from NTT Hospital, with subsequent feedback and discussion.

Patient selection

The indication in each patient was according to consensus Japanese guidelines.[48–50] All patients with lesions possibly amenable for ESD were discussed in a multidisciplinary meeting (MDM). Referrals were gained from gastroenterology, upper gastrointestinal and colorectal surgery. In addition, cases were referred from Whangārei Hospital via the MDM.

Lesions were accepted for ESD for either primary curative, diagnostic and/or curative intent, or less common staging (assumption of deep malignant invasion but unclear as to extent with other modalities). All procedures were performed at North Shore Hospital by three senior endoscopists, who had also attended international hands on ESD courses. All patients gave informed consent prior to their procedures.

Procedure and pathological review

Procedures were completed under either local sedation with fentanyl or midazolam, anaesthetist-assisted propofol or general anaesthesia. Submucosal injectate was either gelofusion with methylene blue or Orise gel (Boston Scientific). Knives used were either dual-knife J or IT-knife (Olympus). In all cases, we used a high frequency electrosurgical unit (Erbe Elektromedizin, Tübingen, Germany).

Submucosal fibrosis is known to increase the rate of perforation and effect the success rate of en-bloc resection. This was assessed and recorded based on the findings identified at the time of ESD and classified F0 (no fibrosis), F1 (mild fibrosis) and F2 (severe fibrosis).[51,52] Traction was not used in any cases.

All pathological specimens were pinned flat to cork to assist histological assessment and fixed in 10% formalin, with review performed by GIT pathologists including assessment for clearance of both vertical and lateral margins.

Endoscopic outcomes

"En-bloc resection" was defined as removal of a lesion in one piece. A successful histological resection (R0) was one where the lesion was removed with clear vertical and lateral margins. "R1" was defined as a lesion with a positive margin. "Curative resection" was defined as tumour-free vertical or lateral margins in a resected lesion and absence of vascular or lymphatic involvement. It was also defined by invasion <1,000µm, <500µm and <200µm from the muscularis mucosa in colorectal, gastric and oesophageal lesions respectively (ie, meeting the criteria for indication of treatment).[17] Significant bleeding was pre-determined to be defined as that requiring blood transfusion and repeat endoscopy after the ESD procedure. "Deep injury" was defined as visible damage to the muscularis propria layer without perforation. Perforation was defined as complete muscular defect requiring closure, categorised as either immediate or delayed (occurring after the conclusion of the procedure). All patients were followed up to assess the site and check for recurrence.

Results

Between January 2020 and July 2021, 29 ESD procedures were performed in 27 patients (Table 1). The mean age was 72 (standard deviation (SD) 10.6). The majority of cases (62%) were done under general anaesthesia. The median and mean lesion diameter resected was 30mm (interquartile range (IQR) 20–58mm) and 42mm (SD 28mm) respectively. The pre-endoscopic diagnosis was accurate as confirmed on final histology in 93% of cases. Thirty-four percent of lesions were T1 adenocarcinoma and completely resected. The median total duration of the procedure was 90 minutes (IQR 55–180), giving an average dissection speed of 0.08cm^2/minute.

In total, 86% of lesions were resected en-bloc. R0 resection was achieved in 72% of cases. All cases with R0 resection were curative except one, an 82-year-old lady with a 15mm, poorly differentiated gastric cancer, which was invading 450µm into the submucosa. The patient opted against operative management offered and will undergo surveillance.

Muscular defects (deep injury) without perforation were seen and clipped at the time of endoscopy in 34% of cases. Two perforations were identified and sealed at the time of endoscopy. In one patient with an 80mm rectal lesion, perforation was identified at time of endoscopy and treated, but subsequently required readmission on day five post procedure, with fever and a retroperitoneal collection seen on imaging that resolved after five days of intravenous antibiotics (this is the single case of severe adverse event within 30 days). There were no cases of immediate or delayed bleeding or death.

Gastric ESD was most commonly performed, including two synchronous lesions. Five lesions were located in the antrum, three in the cardia, three in the corpus, three on the incisura and one in the pyloric channel. One perforation in a patient was closed at the time of procedure without complication. Two of the cases located in the cardia were felt to be highly suspicious for deep submucosal invasive cancer (SMIC), but the MDM agreed a diagnostic ESD was required to confirm or refute the suspected diagnosis, given the possibility of extensive surgery required. Similarly, a 55mm lesion within Barrett's oesophagus was suspicious for deep SMIC, but the patient and treating team requested diagnostic ESD. Deep SMIC was demonstrated in these Three cases. Seven (70%) of the colorectal cases were performed in the rectum. The other three cases were located in the transverse, descending and sigmoid colon. Two rectal lesions were performed for previous failed EMR including adenocarcinoma arising with a traditional serrated adenoma with significant (F2) fibrosis. The third case with severe fibrosis was a polyp growing over a previous haemorrhoidal banding scar.

In the eight cases with R1 resection (28%), four gastric lesions had deep SMIC and proceeded to gastrectomy. An oesophageal lesion with deep SMIC and positive vertical margin proceeded to Ivor-Lewis oesophagogastrectomy, and another oesophageal lesion with a positive lateral margin was site checked without recurrence. One rectal lesion with a positive lateral margin was site checked without recurrence, and a descending colon lesion with a positive lateral margin was site checked with regrowth of HGD requiring further endoscopic treatment.

Discussion

In this first New Zealand prospective report of ESD, we demonstrate clinical success, efficacy and safety of this procedure.

En-bloc and R0 resection rates of 86% and 72% are slightly better than a similar Australian centre's series (80% and 60% respectively)[41] and are

Table 1: Patient demographics, lesion characteristics and results.

	Gastric	Oesophageal	Colorectum	Overall
no. of cases, n	14	5	10	29
Age, mean (SD)	74 (11.2)	70 (12.7)	72 (7.7)	72 (10.5)
Gender, male, n (%)	8 (57)	4 (80)	7 (70)	19 (66)
Ethnicity, n (%)				
NZ European	9 (64)	4 (80)	7 (70)	20 (69)
Asian	2 (14)	1 (20)	2 (20)	5 (17)
Other	3 (21)	0	1 (10)	4 (14)
ASA (mean)	1.6	1.6	1.4	1.6
Sedation, n (%)				
General anaesthesia	10 (71)	4 (80)	4 (40)	18 (62)
Propofol	2 (14)	1 (20)	1 (10)	4 (14)
Local	2 (14)	0	5 (50)	7 (24)
Paris Classification, n (%)				
IIa	6 (43)	5 (100)	4 (40)	15 (52)
IIa + Is	1 (7)	0	4 (40)	5 (17)
IIa + c	2 (14)	0	1 (10)	3 (10)
Is	2 (14)	0	1 (10)	3 (10)
IIc	3 (21)	0	0	3 (10)
Size				
Diameter, median mm (IQR)	33 (20–80)	40 (20–53)	30 (23–60)	30 (20–58)
Area, median mm/2 (IQR)	80 (30–50)	126 (31–217)	70 (40–283)	70 (30–260)
Final histology, n (%)				
LGD	3 (21)	0	2 (20)	5 (17)
HGD (IMc)	5 (36)	0	6 (60)	11 (38)
Adenocarcinoma (T1)	4 (29)	4 (80)	2 (20)	10 (34)
Adenocarcinoma - invasive	3 (21)	1 (20)	0	4 (14)
Pre-endoscopic diagnosis confirmed, n (%)	12 (86)	5 (100)	8 (80)	27 (93)

Table 1 (continued):

	Gastric	Oesophageal	Colorectum	Overall
Procedure				
Fibrosis, n (%)				
F0	7 (50)	4 (80)	2 (20)	13 (45)
F1	4 (29)	1 (20)	5 (50)	10 (34)
F2	3 (21)	0	3 (30)	6 (21)
Duration, mins, median (IQR)	95 (40–200)	100 (61–190)	90 (60–150)	90 (55–180)
Dissection speed (cm^2/min)	0.08 (0.06–0.29)	0.08 (0.05–0.20)	0.16 (0.05–0.19)	0.08 (0.06–0.22)
En-bloc, yes (%)	11 (79)	5 (100)	9 (90)	25 (86)
R0, yes (%)	10 (71)	3 (60)	8 (80)	21 (72)
Inpatient stay, median days (IQR)	1 (0–2)	1 (1–1.5)	1 (0-2)	1 (1–2)
Bleeding, n %	0	0	0	0
Deep injury, n (%)	5 (36)	3 (60)	2 (20)	10 (34)
Perforation, n (%)	1 (7)	0	1 (10)	2 (6.8)
Delayed perforation, n (%)	0	0	0	0
Severe adverse event within 30 days, n (%)	0	0	1 (10)	1 (3.4)
Mortality	0	0	0	0

SD: Standard deviation; NZ: New Zealand; ASA: American Society of Anesthesiologists; IQR: Interquartile range; LGD: Low grade dysplasia; HGD: High grade dysplasia.

in keeping with larger Western series at 77–92% and 73–100% respectively.[46,53–56] Our overall R0 resection rate is reduced by three diagnostic cases where the vertical margins were positive in lesions which pre-procedure were highly suspicious of deep SMIC.

There were no cases of delayed bleeding, perforation or death, which we attribute to fastidious post-ESD resection bed review, including cautious inspection of possible muscular injury and subsequent clip placement. This likely contributed to an over-estimation of deep injury (34%). Patients are currently admitted post-ESD for observation on a case-by-case basis, depending on lesion location, size, difficulty, age, co-morbidity, geographical residence (ie, travelling from rural area) and sedation type. There is suggestion that perhaps more cases could be done as day-stay procedures,[57,58] which may make ESD even more cost-effective. Six of our cases were discharged same day, and with no cases of delayed complication, more patients may be able to be considered for this in the future.

We have placed great emphasis on case and lesion evaluation, decision-making with regard to proper indication and thorough discussion of each patient as a group and at the MDM. Although some centres avoid biopsy of lesions prior to consideration of endoscopic resection for fear of causing scarring and fibrosis, we have generally encouraged this to assist in our decision-making. This is in conjunction with fastidious mucosal inspection protocols, magnified endoscopic vascular and structural pattern analysis and chromoscopy to most exactly determine predicted final pathology. This is reflected in our 93% pre-endoscopic prediction accuracy, and high curative resection rate. We believe this time taken on lesion assessment and risk stratification is important to avoid possible over or undertreatment, and provide the safest, most resourceful outcome tailored to pathology.[13] Although it is not an internationally benchmarked indicator, we feel review of our final histological outcomes confirms an overall appropriate lesion selection.

The additional time required for ESD is often discussed and debated in the literature as a drawback, with a number of techniques and devices utilised to improve dissection speed. An overall speed of dissection benchmark of 0.15cm^2/min is suggested.[46] Although this was obtained in the colorectum (0.16cm^2/min), likely owing to the larger size of rectal cases and stable endoscopic access, we were slower in stomach and oesophagus (0.08cm^2/min). Although we have initially emphasised safety, efficiency of the procedure is vital, in particular in the upper GIT tract when cases are performed with local sedation only and procedural time is limited by patient tolerance. Ongoing video review of cases with experts to improve technique will further improve efficacy and efficiency.

ESD is the standard of care and a well-established procedure in Asia, but it has been slower to penetrate Western countries. This delay in uptake has been widely criticised, discussed and debated and is likely multifactorial.[45–47,59]It is postulated to be due to its high technical proficiency requirement, the time commitment for both learning and doing procedures and steep learning curve, a lack of mentors, interdisciplinary conflicts, concern regarding complications and a lack of support from institutions and interfacing departments.[47] There is a comparatively low frequency of early gastric cancers compared to Eastern populations, which limits skill acquisition and training opportunities.[47] Finally, its uptake has been further limited by the absence of appropriate reimbursement systems in countries such as USA where this is an important factor.[28] However, demand for this procedure in New Zealand is likely to grow as rates of GIT tumours increase. Oesphageal cancer is increasing in incidence. In New Zealand in 1950, the age standardised registration rate was 2.2/100,000 with 46 cases diagnosed, which increased to 4.3/100,000 with 364 cases diagnosed by 2000.[3] In addition, over 400 new cancers of gastric cancer are diagnosed each year.[4] Both have documented significant ethnic inequality, with Māori having both an increased incidence and mortality.[60–62] These rates are expected to rise with increased immigration from Asian countries where rates are over five-times higher.[2,63] Finally, colorectal cancer (CRC) is both the second most common cancer diagnosed and cause of cancer death in New Zealand, as absolute rates continue to rise in the face of an ageing and increasing population.[5,64] Improved access to endoscopic evaluation, earlier detection of lesions through the National Bowel Cancer Screening Programme and increased awareness of detection of early cancer are likely to further drive ESD volume and growth. Such volume is key to ongoing improvement of outcome measures and rates of complications.[65] Current short-term projections for our service demonstrate referral growth and capacity to complete at least 3–4 cases per month.

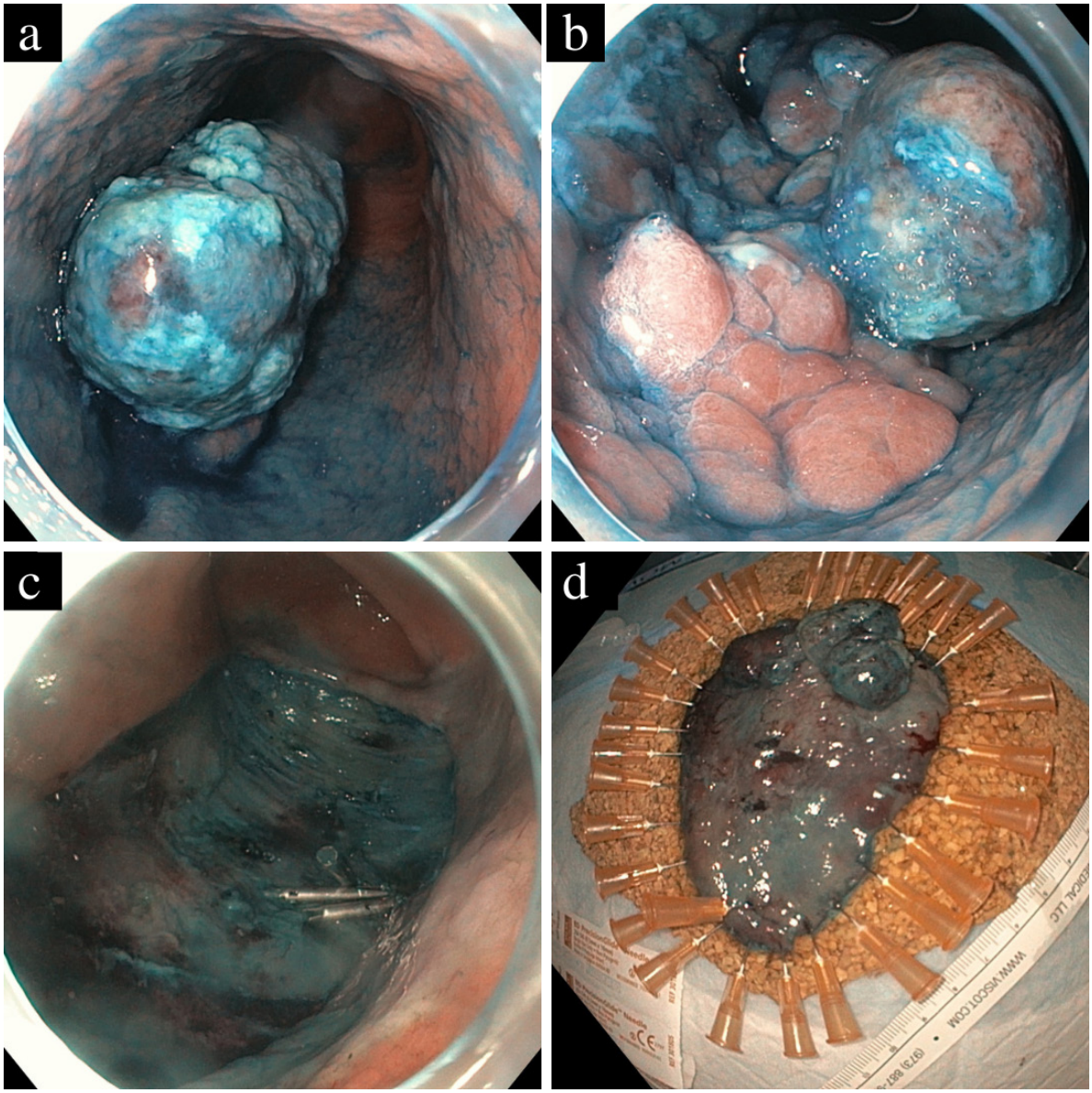
Finally, critical in success of this programme is ongoing support from surgical, gastroenterology, pathology, oncology and anaesthetic colleagues. We have fostered an understanding and supportive environment, where patients are able to be presented with a full picture of pros, cons, risks and alternatives for potential options for management of their lesion. Additional assistance is needed from hospital management teams to accommodate these procedures while competing with other interventional third-space procedures, such as peroral endoscopic myotomy (POEM), endoscopic diverticulotomy, submucosal tunnelling endoscopic resection (STER) and full thickness resection (FTR). An important area of improvement to target must include formalising inter-district-health-board referral pathways, such that patients may have equal access to this procedure, and be seen and treated in a timely manner, irrespective of their geographical location. We hope publication of this work will help to inform clinicians that this procedure is available and accessible. Furthermore, ongoing data collection and audit with respect to ethnicity and inequality must be paramount. It is known that Māori present with more advanced disease, which may explain why none were treated in this series. However, there is a demonstrably higher overall mortality irrespective of stage, with access to specialised cancer services postulated to be contributory, and we must review our service with this in mind.[66,67]

Strengths of this paper include reflection of a real-world experience of cases with varying location, difficulty, fibrosis and size. This series also included a 10cm gastric antral lesion (Figure 1) that was completely resected, en-bloc and R0. Prospective sequential patient data collection and complete data and follow-up limit bias. Study outcomes include all defined quality indicators for ESD.

Limitations of note include lack of collection and reporting of all cases referred for ESD. Many patients, in particular proximal laterally spreading colonic lesions were deferred for piecemeal EMR with its current superior speed, safety and efficacy.[34] Not all lesions were followed to final treatment outcome and histological review, some of which may have been inaccurately assessed and perhaps were better suited for ESD removal. In spite of the favourable ESD outcomes achieved in this study, some lesions may have been adequately treated with EMR techniques based on the retrospective assessment of the final ESD histology. A full financial assessment was not performed and is beyond the scope of this paper, but should be considered in future studies to assess cost effectiveness compared to possible surgery, but also EMR. Lastly, at the time of publication, patients have not been followed for the requisite years to assess for potential long-term recurrence rates, and both cancer-specific and all-cause mortality.

In conclusion, this initial prospective ESD data demonstrates clinical success, efficacy and safety of ESD at our centre. A larger study, comparison with other centres and longer clinical follow-up is required to confirm findings and further improve outcomes.

Figure 1: Endoscopic submucosal dissection (ESD) of gastric lesion.



Panel a: Mid-body gastric lesion (10cm) seen in forward view from fundus. Blue indigo-carmine dye used to assist with delineation of margins. Panel b: distal aspect of lesion seen in retroflexion. Panel c: post-ESD resection bed with three clips in situ to close muscular injury. Panel d: resected specimen pinned onto corkboard for histological analysis (complete resection, R0; all margins clear).

COMPETING INTERESTS
Nil.

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Structural discrimination in the COVID-19 vaccination programme for people with mental health and addiction issues: now is the time to be equally well

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ABSTRACT

People with mental health and substance use issues (tāngata whai ora katoa), regardless of ethnicity, are much more likely to be hospitalised or die from COVID-19 and were identified as a priority population (Priority Group 3) in Aotearoa New Zealand's vaccination roll-out plan. Data released by the Ministry of Health show that, despite tāngata whai ora katoa being a priority group, their vaccination rates are well below those of the general population. These inequities are pronounced for Māori with mental health and addiction issues (tāngata whai ora Māori). This is not acceptable. To support tāngata whai ora physical health and wellbeing, the onus is on all of us in the health system to actively reach out, have conversations, be supportive and provide accessible vaccination for people with mental health and addiction issues. Urgent action is needed. Now is the time to ensure tāngata whai ora katoa can be equally well.

For far too long the physical health inequities experienced by people with mental health and addiction issues (tāngata whai ora katoa) have been invisible. Forms of structural discrimination, particularly vaccination policies and eligibility criteria, exacerbate these inequities by excluding or delaying access to life saving vaccinations against infectious diseases. The COVID-19 pandemic has brought these issues to a head. Now is the time for urgent, concerted efforts to bring change at policy and practice levels, to achieve equitable access to vaccination for tāngata whai ora, particularly tāngata whai ora Māori.

The evidence is clear. Tāngata whai ora katoa are at significant risk of poorer health outcomes from COVID-19.[1] People with severe mental illnesses (defined as meeting diagnostic criteria for schizophrenia, depression and bipolar disorder) are twice as likely to require hospitalisation if infected with COVID-19, and are almost three-times as likely to die as a result of COVID-19 infection, compared to those with other underlying health conditions.[2] There is also a significantly elevated risk for people with problematic substance disorders. Furthermore, the wellbeing of New Zealanders with mental health and addiction issues has been disproportionately affected by stay-at-home orders, with this group being significantly more at risk of lockdown-related psychological distress, anxiety and suicidal ideation.[3]

This evidence was recognised in the Ministry of Health's vaccination roll-out plan when, on 28 May 2021, people with a diagnosis of severe mental illness, or those in contact with specialist mental health and addiction services, were included in Priority Group 3 for earlier vaccination.[4]

However, it has recently been suggested that New Zealanders with experience of mental health and addiction issues and health providers may not have realised that they were a priority group for vaccination.[5] Furthermore, structural discrimination embedded within the health system makes accessing physical healthcare, including vaccinations, more challenging.[4] A large UK cohort study with 58 million participants found that people with a diagnosis of severe mental illness were much less likely to present for COVID-19

vaccination than others.[6] Access to other preventative vaccination programmes, like the influenza vaccine, has historically been comparatively low among people with serious mental illness, despite the underlying health risks in this group.[7]

In January 2021, the mental health and addiction COVID-19 vaccine expert advisory group recommended, in order to support implementation and vaccination uptake, that the Ministry of Health design and develop a specific information and communication programme for tāngata whai ora katoa alongside people with lived experience and cultural leaders.[8] Targeted support and information for tāngata whai ora kotoa only became available towards the end of 2021.

Given experiences in other countries and a lack of any specific communication programme, we suspected that the uptake of vaccinations amongst tāngata whai ora katoa in Aotearoa New Zealand may have been lagging.

This was confirmed by a review of vaccination rate data (as of 29 September 2021) obtained from the Ministry of Health. The COVID-19 two-dose (ie, full) vaccination rate across all people accessing district health board (DHB) specialist mental health and addiction (ie, substance use disorder) services was approximately 30% compared to 48% of the eligible population of Aotearoa (Table 1). As a more telling comparison, the fully vaccinated rates of the over 65 population, also Priority Group 3, on the same date was 85%.[9]

There is considerable variation between DHBs in vaccination coverage for those using mental health and addiction services, from 37% to 73% on 29 September 2021 (Table 2), despite the Group 3 rollout commencing in June and July. Although the vaccination rates for tāngata whai ora katoa are somewhat higher in those over the age of 65 years (ranging from 33% to 100% depending on DHB), these figures are concerning considering the compounding risk factors of age and health conditions.

There is also considerable variation within tāngata whai ora in contact with mental health and addiction services across Aotearoa, as outlined in Table 1, with coverage being lower among those accessing addiction services. As of 29 September 2021, 30% of mental health and 23% of addiction service tāngata whai ora were fully vaccinated, and 61% of mental health and 50% of addiction service tāngata whai ora had received one dose.

For tāngata whai ora Māori, the data on vaccinations are even more concerning, with only 47% having received first doses (compared with 79% of the general population), and even fewer (38%) Māori in contact with addiction services. This brings into stark relief the deeply entrenched health inequities in Aotearoa New Zealand. Māori have higher rates of chronic health conditions and socioeconomic disadvantage. These risks then overlap with the additional health burden borne by those with mental health and addiction issues, resulting in a double jeopardy situation termed "intersectionality."[10]

The vaccination figures for tāngata whai ora katoa are worryingly low, especially as they are one of the populations most at risk of premature mortality.[11] At the time of writing, the delta variant had already infected people with mental health and addiction issues in transitional housing in South Auckland. The risks from infection in unvaccinated people are high, and vulnerable groups will continue to be disproportionately affected. This cannot be allowed to happen. It is

Table1: Vaccination rates of tāngata whai ora katoa (all people in contact with secondary mental health and addiction services) compared to the total eligible population in Aotearoa New Zealand. 29 September 2021.

	First dose			Second dose		
	MH tāngata whai ora	**Addiction tāngata whai ora**	**Total eligible population**	**MH tāngata whai ora**	**Addiction tāngata whai ora**	**Total eligible population**
Māori	47%	38%	57%	21%	14%	31%
Pacific	61%	48%	73%	30%	20%	44%
Other	67%	56%	84%	34%	26%	52%
Total	**61%**	**50%**	**79%**	**30%**	**23%**	**48%**

MH=mental health. Ministry of Health, 2021 COVID vaccination data - at 29 September 2021.

Table 2: First dose vaccination rates of tāngata whai ora katoa (all people in contact with secondary mental health and addiction services) by DHB region. 29 September 2021.

Current DHB of domicile	Addiction	Mental health
	tāngata whai ora %	tāngata whai ora %
Auckland	62%	72%
Bay of Plenty	58%	53%
Canterbury	56%	54%
Capital and Coast	60%	70%
Counties Manukau	54%	67%
Hawkes Bay	44%	59%
Hutt Valley	73%	66%
Lakes	64%	58%
MidCentral	56%	59%
Nelson Marlborough	55%	61%
Northland	59%	58%
South Canterbury	57%	62%
Southern	71%	67%
Tairāwhiti	58%	68%
Taranaki	37%	55%
Waikato	61%	64%
Wairarapa	72%	55%
Waitemata	63%	69%
West Coast	67%	50%
Whanganui	56%	56%

Ministry of Health, 2021 COVID vaccination data - at 29 September 2021.

imperative that all health and community services become proactively engaged in improving vaccination coverage for this group.

Mental health and addiction services and health practitioners have an important role in being part of the solution to improve vaccination coverage.[1] Taking time for a discussion about tangata whai ora thoughts and feelings about vaccination and the reasons for vaccination is likely more effective than a simple offer of a vaccine,[12] and helping to remove some of the barriers to vaccination, particularly around transport and costs, are also important. Vaccination training and support is also available for mental health and addiction services staff to carry out vaccinations.

Primary care practices and pharmacists need to proactively contact patients who experience mental health and addiction issues about vaccines, and again offer conversations, listen to and acknowledge any concerns and provide information and practical support to access vaccination clinics. All practitioners need to reach across the divide between mental and physical healthcare. Joining up the silos of mental health, addiction and physical healthcare is overdue.

Working with whole whānau / family / aiga and population groups (eg, people who inject drugs) to support vaccination, rather than focusing on individuals, may likewise be a more effective and welcomed approach. Transportation to vaccination centres, going to centres at quieter times and innovative and proactive solutions, like the well-publicised Shot Bro vaccination buses, are also needed. Outreach is a familiar practice in health services and has an important role in supporting vaccination in a public health crisis.

Some DHBs are already offering at-home or low-sensory vaccination solutions for people with physical and mental health conditions, but this is inconsistent across the country.[13] Anecdotal evidence suggests tāngata whai ora intentions to be vaccinated are the same as the general population. The onus is on health services and practitioners to be proactive and ensure tāngata whai ora katoa have all the information they require to have their questions answered and to provide accessible services actively.[14]

The Equally Well collaborative, an evidence-informed and action-focused network of champions across the country, are collecting and sharing examples of good practice. It is this collaborative approach that is crucial at times like this, as it takes multiple people across the health and health-related system to address health inequities.

For far too long the physical health inequities experienced by tāngata whai ora katoa have been invisible. It is crucial that all health practitioners, particularly mental health and addiction practitioners, primary care teams and pharmacists, adopt new approaches to engaging and supporting people with mental health and addiction issues around vaccination. Now is certainly the most important time to act to be equally well.

About Equally Well

- To find out more or to get involved in the Aotearoa Equally Well collaborative, visit https://www.tepou.co.nz/initiatives/equally-well-physical-health.
- To join the discussion, share information and good practice on vaccination and supporting people with mental health and addiction issues, join Whāriki: https://www.tepou.co.nz/initiatives/te-wh%C4%81riki-o-te-ara-oranga.
- To access the latest data on tāngata whai ora katoa vaccination rates, visit https://www.tutohi.nz.

Addendum

Data on vaccination rates, 14 February 2022

Since this article was first submitted in September 2021, updated data on the vaccination rates of tāngata whai ora have been made available through the data platform, Tūtohi, developed by Wild Bamboo using data provided by the Ministry of Health.

Vaccination rates in this group continue to lag well behind the general population. At 14 February 2022, first and second does rates were as follows:

Population group	First dose	Second dose
tāngata whai ora katoa receiving alcohol and drug treatment	83.4%	77.6%
tāngata whai ora Māori receiving alcohol and drug treatment	79.7%	71.9%
tāngata whai ora katoa receiving mental health treatment:	86.5%	80.4%
tāngata whai ora Māori receiving mental health treatment	81.4%	73.8%
eligible general population	96.3%	94.7%

Source. Tūtohi (www.tutohi.nz. 14 February 2022).

COMPETING INTERESTS
The authors are part of Aotearoa Equally Well, an evidence-informed collaborative taking action across the health and health-related systems to achieve physical health equity for people who experience mental health and addiction issues.

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An evaluation of mandatory bicycle helmet legislation

Rahul Makam

Bicycles are an important form of exercise, transportation, and recreation in New Zealand.[1,2] However, bicycle injuries are a leading contributor to unintentional injury. From 2016 to 2019, cyclist injuries accounted for an average of 9.4 deaths per year and 7.2% of all serious injuries.[3] In an effort to reduce cyclist head injury, New Zealand cycle helmet legislation became effective in 1994, requiring all cyclists to use standard approved helmets for all on-road cycling. Subsequently, helmet use increased to above 90% for all ages.[4] However, this legislation has generated significant controversy. Detractors criticise it as an ineffective intervention, citing unintended consequences including reduced cyclist participation, increased risk of crash, and therefore net population harm. Population health interventions like mandatory legislation must demonstrate evidence of net individual and population benefit in order to be justified. By consideration of criteria assessing benefits and harms, a recommendation can be made regarding the use of mandatory helmet legislation in New Zealand for the mitigation of unintentional child and adult injury.

Are bicycle helmets effective in reducing head injury risk in event of crash?

Literature investigating the efficacy of bicycle helmet use to prevent injury in the event of a crash consists primarily of case-control studies, with randomised controlled trial precluded given ethical considerations. Three relevant systematic reviews with meta-analysis have been performed.[5,6,7] All find helmet use to be associated with a significant odds reduction of head, brain, facial, and fatal injury. However, Attewell et al[6] additionally found evidence of a nonsignificant odds increase of neck injury associated with helmet use. Elvik[8,9] updated Attewell et al, to adjust for publication bias, and ultimately found concordant results regarding neck injuries. But the most recent review of these three relevant systematic reviews, by Olivier et al[7] in 2017, identified limitations of Elvik's re-analysis. Their meta-analysis of 40 studies yielded an odds reduction of 51% for head, 69% for serious head, 33% for facial, and 65% for fatal head injuries. The odds ratio for neck injury was near null effect (OR=0.96) and no strong evidence of publication or time trend bias was identified.

Biomechanical evidence[10–12] supports the conclusions of these meta-analyses, with McNally et al[10] by computer simulation finding no evidence of any association between helmet use and neck injury. Although Curnow[13,14] has posited that helmet use might exacerbate diffuse axonal injury, McIntosh et al[15] have published biomechanical evidence reporting no association of helmet use with angular acceleration, contradicting this hypothesis.

Is mandatory helmet legislation effective in increasing helmet use?

Given that evidence supports the efficacy of helmets in the event of crash to reduce head injury risk, evidence that mandatory helmet legislation increases helmet use will provide indirect support of population benefit.

Karkhaneh et al[16] undertook a pertinent systematic review, finding twelve observational before-and-after and non-equivalent control group studies, with one specific to NZ. All reported increased helmet use; baseline rates of 4%–59% increased to 37%–91% following legislation and the pooled odds ratio for helmet use was 4.60. The authors note the plausible confounding effects of the variable promotional activities used to support legislation. However, they refer to evidence that benefit of legislation is conferred even in the absence of rigorous enforcement,[17–20] and that fear of enforcement contributes relatively little to reasons for helmet use,[21] to ultimately conclude legislation effective in increasing helmet use.

Is mandatory helmet legislation effective in reducing head injury risk?

Evidence that mandatory helmet legislation reduces head injury risk will provide direct support of population benefit. Macpherson et al[22] performed a relevant systematic review in 2008 collecting four non-randomised controlled before-and-after studies, all examining legislation applying only to children. Three demonstrated significant benefit of legislation for children in Canada and California. Authors expressed concern regarding paucity of evidence, failure of included studies to measure helmet use, and potential inadequacy of controls. However, they conclude mandatory legislation effective in reducing mortality and head injury risk.

Excluded from review on basis of design were the only two extant publications addressing legislation efficacy in New Zealand. Povey et al[23] reported a 20% reduction in cyclist head injuries in motor vehicle crashes for all children and 24% and 34% reductions in non-motor vehicle crashes for primary and secondary school children respectively, using limb injury rates to control for background confounders of injury risk. Robinson[24] contended that results were an artefact of baseline trends. However, Wang et al[25] in later re-analysis confirmed the validity of the original results. The second publication centred in New Zealand by Scuffham et al[26] found when controlling using non-head injury rates that legislation averted 139 head injuries over a three-year period.

Additional pertinent literature has since been published internationally. Importantly, Walter et al[27] found when controlling using limb injury rate that legislation in New South Wales contributed a 29% reduction in cyclist head injury. Injury rates showed continued divergence with time, evidencing maintenance of benefit.[28] Olivier et al[29] demonstrate a 46% reduction in cycling fatalities post-legislation, and an absence of evidence suggesting confounding by the introduction of other road safety measures. Further international evidence supports legislation efficacy among children in Australia,[30] Canada[31,32] and the USA.[33–36] Conflicting evidence comes from publications indicating mixed results for children in Sweden[37] and an absence of benefit for children and adults in Canada.[38]

Clarke[39] used retrospective injury data to conclude that legislation in New Zealand has increased cyclist injury risk by 20% from the period 1988–1991 to 2003–2007. Olivier et al[40] contend that Clarke ignores data from the period most directly following introduction of legislation and fails to separate head injuries, for which helmets are a targeted intervention, from other injury types. Additionally, Clarke's methodology fails to address background confounders and baseline trends and therefore does not evidence a causal association between cyclist injury and the introduction of helmet legislation. The subsequent re-analysis by Olivier et al of injury data from the same period supports a decline in cyclist injury following legislation.[40]

Does mandatory helmet legislation reduce cycling participation?

Literature investigating the association between cycling participation and rates of collision have largely concluded an inverse or non-linear relationship, including most recently Jacobsen,[41] whose results seemed to evidence a "safety in numbers" effect. Bhatia et al[42] identify as limitations confounding and inability to establish the temporal direction of effect; however, the inference remains plausible. Consequently, if helmet legislation reduces cycling participation, the corollary may be an increased risk of crash. Further, reduced participation implies reduced physical activity, itself a population hazard. Both effects engender population harm.

Publications investigating the effect of legislation on cycling participation draw mixed conclusions. Robinson[43] used New South Wales and Victorian data to conclude legislation in Australia to have reduced cyclist participation; however, Olivier et al[40] note the omission of relevant data which, when included, support the contrary position. Rissel et al[44] reported that a repeal of helmet legislation would produce an increase in cyclist participation in Sydney; however, Olivier et al[45] criticised their statistical analysis, performing a re-analysis with opposing findings.

Canadian literature evidences no significantly reduced ridership following legislation among

children.[46,47] Australian literature concurs for cyclists of all ages.[48,49] American evidence is contradictory, reporting separately a significantly reduced ridership among children,[50] and limited evidence of reduced ridership among high school students.[51]

Does helmet use increase the risk of a crash?

Adams et al[52] argue that risk compensation might temper helmet efficacy, whereby helmet use yields riskier cyclist behaviour and therefore increased risk of a crash, yielding population harm.

A recent systematic review by Esmaeilikia et al[53] identified 23 pertinent studies, with 18 opposing the hypothesis of risk compensation, and only two providing supportive data. One supportive study by Walker[54] reported significantly reduced motorist overtaking distance associated with helmet use, but Olivier et al[55] performed a multivariate re-analysis, categorising overtaking distance according to the typically recommended safe distance of 1m, finding no association of helmet use with unsafe passing.

Review authors considered most included studies inadequate, as they did not directly measure cyclist risk compensation, and instead analysed indirect proxies, such as perceived risk, or general risk-taking in non-cycling contexts. No randomised trials were identified, though a single random crossover design study was performed which did not support risk compensation.[56] Overall, the current systematic review has found little to no support that bicycle helmet use is associated with engaging in risky behaviour, though there certainly exists a paucity of high-quality evidence.

Does mandatory helmet legislation provide total population health benefit?

A single publication has attempted to model the total population health impact that mandatory helmet legislation might have in a jurisdiction in which it is enacted.[57] Here, De Jong concludes a large negative health impact of legislation in jurisdictions where cycling is already "safe" as defined by model parameters, and a small positive impact in jurisdictions where cycling is considered "unsafe." However, De Jong's model assumes that helmet legislation necessarily yields reduced cyclist participation and increased riskiness of behaviour. As demonstrated, these assumptions remain unsupported by the available evidence. When excluding this assumption, Olivier et al[40] find De Jong's model to yield the opposite verdict.

Conclusion

Strong evidence supports that helmet use reduces head injury risk in the event of a crash, and that mandatory helmet legislation increases helmet use and reduces head injury risk for child and adult populations to whom legislation applies. These conclusions provide evidence of the population health benefit of legislation. Conversely, no evidence exists to support that helmet legislation reduces cycling participation, and no strong evidence supports that helmet use increases the risk of a crash, providing no evidence of population health harm. Accordingly, the balance of evidence supports that mandatory helmet legislation is an efficacious population health intervention, and should remain in effect in New Zealand for the mitigation of child and adult unintentional injury.

COMPETING INTERESTS
Nil.

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Patient choice may improve adherence to follow-up in cervical screening: a randomised-control trial

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ABSTRACT

AIMS: We investigated whether patient choice of follow-up type improves health-related quality of life (HrQOL) and follow-up attendance in women who have undergone large loop excision of the transformation zone (LLETZ) for cervical intraepithelial neoplasia grade 2 to 3 (CIN 2–3).

METHODS: A three-armed randomised controlled trial including women with newly diagnosed CIN 2–3 post-LLETZ treatment was performed. Consenting women were randomised (1:1:1) to either: (a) colposcopy review at the hospital, (b) follow-up with high-risk human papilloma virus (HrHPV) and smear test in the community or (c) a choice of the aforementioned follow-up options, six months post-treatment. HrQOL was measured and participants were surveyed at baseline and six months regarding preferences for follow-up.

RESULTS: Sixty-eight participants were randomised to follow-up (a), 67 to follow-up (b) and 65 to follow-up (c) (n=200). At six months post-treatment, 47% of patients indicated a preference for (a), 24% for (b) and 26% for (c). We found no significant difference in HrQOL between the study arms. Attendance was greater among patients who chose their follow-up (95.5% vs 91.1%, p=0.06).

CONCLUSION: Choice of follow-up was associated with greater attendance. However, larger studies examining these potential effects are warranted.

Both patient-centred care and evidence-based medicine are central to the practice of modern healthcare. The former is focused on individualising a patient's care; the latter requires standardisation of care. Creating an alliance between these concepts is a major challenge for clinicians and researchers alike. For New Zealand gynaecological clinicians, adapting evidence-based information to foster a woman's sense of being respected and able to participate in their own health decisions is critical in the evolution of cervical screening guidelines. Women who have received treatment for cervical intraepithelial neoplasia (CIN) grades 2 to 3 are a high-risk population for developing cervical cancer, particularly if they do not attend follow-up screening. Until recently, all women were recalled back to the hospital colposcopy clinic for their initial post-treatment assessment, which enabled standardisation of care. However, since 2020 the National Screening Guidelines of New Zealand have allowed either colposcopic or community follow-up in the post-treatment setting.[1] This new approach promotes patient-centred care, and is consistent with many international healthcare policies where, for the initial follow-up after treatment, HPV screening and cytology alone are allowed, and may also take place in either the community or hospital settings.[2,3]

Successful cervical screening programmes rely heavily on long-term patient participation, and studies from other fields show that participation is dependent on factors such as patient choice.[4,5] Allowing patients a choice of follow-up is a patient-centred approach that has potential advantages.[5] Despite research in other medical fields showing a positive relationship between patient choice and health outcomes, this "preference effect" is largely overlooked in the literature informing CIN screening guidelines.[1–3] To date, there are no studies investigating health-related quality of life (HrQOL) and patient preferences in the post-treatment setting, and there are no specific data informing the updated New Zealand screening guidelines.[1] Considering that the new guidelines now offer patient choice, this information may be particularly useful to practitioners offering follow-up to women who are at greater

risk of developing cancer (ie, CIN 2–3 post-treatment) or becoming lost to follow-up.[6] Other potential advantages are improved HrQOL, decreased patient anxiety and greater adherence to the screening programme.[4,5,7]

Colposcopy follow-up requires women to visit the hospital and see a specialised doctor or nurse for a minor procedure. Often the practitioner will be seeing the woman for the first time. The advantages of colposcopy include the possibility of a diagnostic test, with a potentially shorter time to treatment. With regards to patient perspective, some studies have shown a long-lasting negative effect on HrQOL in women following colposcopy, whereas others suggest a high satisfaction rate, due to specialist reassurance.[8,9] The disadvantages of colposcopy in this setting include inter-observer variability, poor cost-effectiveness, and less flexibility for appointment times.

Smear and HrHPV testing can be done in the community by a GP or nurse specialist. To the practitioner, these tests have the advantage of being objective, and they require less specialised training to administer. Triaging colposcopy visits with this preceding step, allows colposcopy with a specialist to be reserved for women who need it most. For many women, community smear and HrHPV testing offers more flexibility of appointments, which may confer a quality-of-life advantage. Disadvantages of this approach include a delay in diagnostic testing (by way of colposcopy-directed biopsy), and some women reporting a preference towards attending a specialist hospital clinic.[10,11]

The primary aim of this study was to determine whether a significant quality of life difference exists among women receiving treatment for CIN 2–3 who are followed up in either a hospital-based colposcopy clinic, in the community, or given a choice. The secondary aims of this study were to estimate costs for the different follow-up options.

Methods

This three-arm, parallel-group, randomised controlled trial was conducted at Christchurch Women's Hospital between 2013 and 2015 (Trial registration: ACTRN12617000931370). Currently, there is no core outcome set (COS) that addresses the topic of measuring and comparing quality of life for women receiving treatment for CIN 2–3 with different follow-up options. Approval for this study was obtained through the New Zealand HDEC (Ref: URA/11/10/056). Potential participants were sent information about the study by mail, prior to their appointment for large loop excision of the transformation zone (LLETZ) treatment. Women aged between 18 and 70 with a new diagnosis of CIN 2–3 appropriate for LLETZ treatment and capable of giving informed consent were eligible. The exclusion criteria included those with a history of immunosuppression, cancer or associated vulvar intraepithelial neoplasia (VIN), vaginal intraepithelial neoplasia (VAIN) and anal intraepithelial neoplasia (AIN), as, in New Zealand, these women would be recommended to continue regular colposcopic follow-up.

At their attendance for LLETZ treatment, consenting women were allocated to one of the three study groups by computer-generated block randomisation. Randomisation was prepared by a statistician external to the study team. A folder was arranged with patient packs identified by study number. The randomisation was concealed in the patient packs prior to enrolment. Due to the nature of the intervention, blinding of participants following enrolment was not possible. Following LLETZ, if the patient was found to have cancer or positive endocervical boundary, the gynaecologist could override the randomised follow-up: the women was allocated to the colposcopy review (group a) and the results analysed in an intention-to-treat analysis. All clinical data were collected in the clinic by treating clinicians and later transferred to an electronic database by a study team member.

All groups were followed until six-months post-treatment. The control group (group a) underwent the routine follow-up in a hospital-based colposcopy clinic. The community follow-up group (group b) had HPV and cytological testing at their GP or family planning clinic. The patient choice group (group c) was given the choice of either colposcopy or community-based follow-up.

Participants were twice asked to complete identical questionnaires, initially at enrolment and again at their six-month follow-up. The Medical Outcomes Study Short Form version 2 (SF12v2) survey was used to measure HrQOL. This uses two scores to evaluate HrQOL: mental (MCS) and physical (PCS) component scores. A higher score indicates a better health status. Participants also received questions about baseline characteristics, cost associated with visit, preferences for place of follow-up, as well as barriers and facilitators associated with each follow-up option. Follow-up attendance was measured through review of medical records. The primary outcome of the

study was self-reported HrQOL measured using the SF12v2 survey at six months. Secondary outcomes included attendance to follow-up, patient preferences, and costs.

Statistical analysis

A target of 200 participants was set (at least 64 per group) allowing for loss to follow-up, which would achieve greater than 80% power to detect a difference of at least d=0.5 with α_2=0.05. In a previous study the effect sizes (measured as standard deviations between the means) of 0.5 were found.[12] This study looked at HrQOL differences in screening comparing colposcopy and HPV/smear.[12] Since colposcopy is more invasive, we expected that the differences in this study would be greater. Therefore, we planned the study to detect a difference of d=0.5 between arms.

For each follow-up group, the primary outcome was analysed using a one-way ANOVA test to assess for differences in mean SF12v2 scores between baseline and follow-up at six months. We obtained all SF12v2 questionnaires at baseline, and 64.0% (n=128) at six months. Using colposcopy as the control, a pairwise analysis of mean HrQOL scores from both the community and choice groups (groups b and c) was made using a t-test with a significance level of p<0.05 (Table 2). Adherence to follow-up was measured using the risk ratio, risk difference and associated 95% confidence intervals of non-attendance between different follow-up methods. Preferences of follow-up were summarised using proportions and analysed using a one-sample test for binomial proportions. Cost analysis of the groups was performed, including the costs of missed appointments, recalls, re-referrals and subsequent appointments by different means and analysed descriptively. No imputations were performed for the management of missing data—these participants were excluded from the HrQOL analysis. Patient preferences were assessed by both the analysis of the choice group responses and through the questionnaire. We used Stata version 14 (StataCorp, College Station, TX, USA) for the analyses. We estimated the costs of a colposcopy at Christchurch Women's Hospital to be $140 per patient, and the average cost of a smear in the community as $50 in Christchurch. The total costs per group were calculated as shown in the below tables and an average cost estimated. Costs of missed appointments, recall, re-referral and subsequent appointment by different means were included in the calculation.

Results

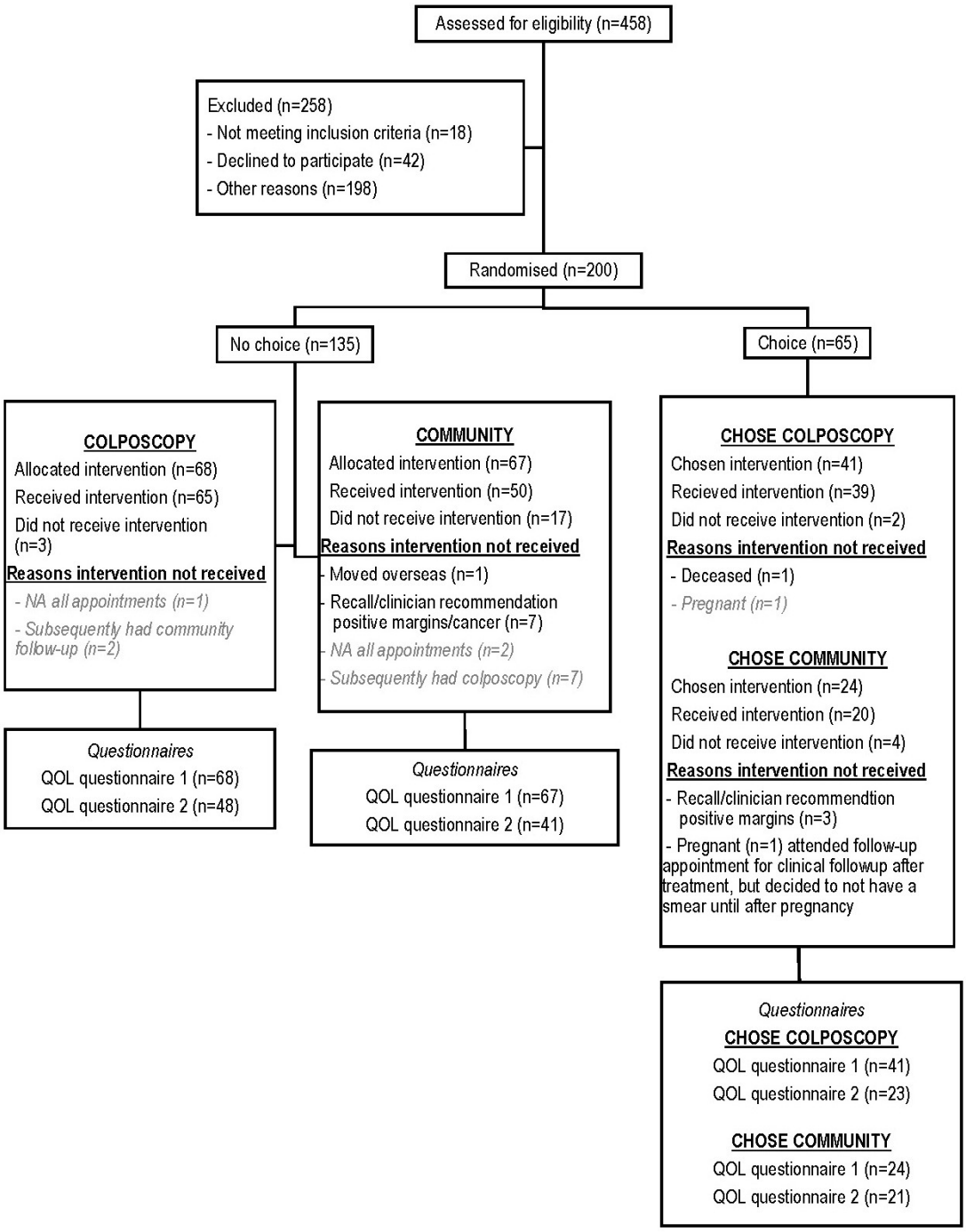
A total of 458 women at Christchurch Women's Hospital were assessed for eligibility, of which 200 patients were enrolled in the study between 2013 and 2105. Patient characteristics for age, gravidity, parity, contraception method or smoking are shown in Table 1. The most common contraception used was the combined oral contraceptive pill (COCP) although a quarter of women used no contraception. Of the data available, a high proportion of women had not received the HPV vaccine, which may be justified by the age distribution of study participants—Gardasil only became part of the New Zealand immunisation schedule in 2009.[13]

A one-way ANOVA analysis showed no significant differences in HrQOL between the colposcopy and community groups at six months (MCS 0.50 [-3.42–2.96], PCS 0.22 [-3.42–2.96]). Similarly, there were no significant differences between the colposcopy group and the patient choice group at six months (MCS 0.92 [-3.03–4.88], PCS =-0.79 [-3.41–1.82]). Analysis of the change between baseline and six months between these groups showed no significant difference (Supplementary Material 1).

Attendance to clinical follow-up was a secondary analysis (Table 3). The greatest non-attendance (of 17 patients) was observed in the community group (Figure 1), despite nine of these patients reporting community follow-up as feasible. In the colposcopy group, three patients did not receive their allocated intervention despite self-reported feasibility of follow-up allocation. Among the women not attending follow-up ("NA"), the total number was, therefore, twelve patients. In the choice group, only one patient did not attend follow-up. Our analysis showed a trend for higher rate of non-attendance among women who were assigned a follow-up option (8.9%) compared with women who chose their follow-up option (1.5%, risk difference=7%, 95% CI 2%–13%, p=.06).

Assessing patient preferences for method of follow-up found 63.1% of the choice group (41/65, Figure 1) electing to have follow-up at the colposcopy clinic compared to 36.4% (24/65) who elected follow-up in the community. A one-sample test for binomial proportions suggests there may be a true difference favouring colposcopy (63.1% [95% CI 50.2–74.7]). Patient preference was also assessed in the questionnaire and showed differences over time. Those preferring the choice group increased by 5% and the community group by 4%. However,

Figure 1: CONSORT flow diagram—participant allocation.



Consort diagram, flow of patients. NA: did not attend, QOL: quality of life. Grey italics: patients included in the NA analysis.

Table 1: Baseline characteristics of participants by randomised follow-up group.

	Randomisation			
	Group A	**Group B**	**Group C**	
	Colposcopy (n=68)	Community (n=67)	Community (n=24)	Colposcopy (n=41)
Age years median(IQR)	28 (25,33)	32(27,39)	32 (27,37)	28 (26,35)
Gravidity median(IQR)	1 (0,3)	1 (0,3)	1 (0,3)	0 (0,2)
Parity median(IQR)	1 (0,1)	1 (0,2)	1 (0,1)	0 (0,1)
Contraception n(%)				
Barrier	7 (10.3)	4 (6.0)	3 (12.5)	4 (9.8)
IUCD	11 (16.2)	7 (10.4)	2 (8.3)	1 (2.4)
Jadelle	1 (1.5)	1 (1.5)	0 (0)	2 (4.8)
Mirena	0 (0)	0 (0)	0 (0)	2 (4.8)
POP	2 (2.9)	2 (3.0)	1 (4.2)	2 (54.8)
Depe provera	8 (11.8)	3 (4.5)	2 (8.3)	6 (14.6)
COCP	15 (22.1)	15 (22.4)	8 (33.3)	10 (24.4)
Tubal ligation	1 (1.5)	2 (3.0)	0 (0)	0 (0)
Vasectomy	1 (1.5)	2 (3.0)	1 (4.2)	0 (0)
Nil	16 (23.5)	16 (23.9)	5 (20.8)	10 (24.4)
Unknown	6 (8.8)	13 (19.4)	2 (8.3)	5 (12.5)
Smoking status n(%)				
Smoker	20 (29.4)	20 (29.9)	10 (41.7)	11 (26.8)
Non-smoker	32 (47.0)	31 (46.3)	10 (41.7)	24 (58.5)
Smoking status unknown	16 (23.5)	16 (23.9)	4 (16.7)	6 (14.6)
Vaccination to HPV n(%)				
yes	5 (7.4)	2 (3.0)	0 (0)	10 (24.4)
no	29 (42.6)	25 (37.3)	10 (41.7)	21 (51.2)
unknown	34 (50.0)	40 (59.7)	14 (58.3)	18 (43.9)

n: number of women, IQR: interquartile range, IUCD: inter-uterine contraceptive device, POP: progestogen-only pill, COCP: combined oral contraceptive pill, HPV: human papillomavirus

Table 2: Comparison of health-related quality of life scores[§] in follow-up groups: colposcopy versus community/ choice.

		Randomisation				
		Group A	**Group B**		**Group C**	
		Colposcopy	**Community**	*Diff (colp-comm)*	**Choice**	*Diff (colp-choice)*
		n = 42	**n = 41**		**n = 44**	
		mean (SD)	**mean (SD)**	*diff(95% CI) p**	**mean (SD)**	*diff(95% CI) p**
SF12 domains	**MCS**	49.25 (9,2)	48.75 (9.63)	*0.50 (-3.42-2.96), 0.92*	48.2 (9.35)	*0.92 (-3.03-4.88), 0.70*
	PCS	54.15 (5.22)	54.37 (8.75)	*-0.22 (-3.42-2.96) 0.83*	54.94 (6.96)	*-0.79 (-3.41-1.82), 0.52*

§ The Medical Outcomes Study Short Form version 2 (SF12v2) survey was used to measure health-related quality of life. This form consists of two domains: MCS mental component score, PCS physical component score, Diff (colp-comm), difference in SF12 scores between colposcopy and community follow-up, Diff (colp-choice) = difference in SF12 scores between colposcopy and community follow-up,* p value indicates t-test versus colposcopy.

Table 3: Observed frequencies of attendance to follow-up: choice versus no choice.

		Randomisation				
		Group A	**Group B**		**Group C**	
		Colposcopy	**Community**	*Diff (colp-comm)*	**Choice**	*Diff (colp-choice)*
		n = 42	**n = 41**		**n = 44**	
		mean (SD)	**mean (SD)**	*diff(95% CI) p**	**mean (SD)**	*diff(95% CI) p**
SF12 domains	**MCS**	49.25 (9,2)	48.75 (9.63)	*0.50 (-3.42-2.96), 0.92*	48.2 (9.35)	*0.92 (-3.03-4.88), 0.70*
	PCS	54.15 (5.22)	54.37 (8.75)	*-0.22 (-3.42-2.96) 0.83*	54.94 (6.96)	*-0.79 (-3.41-1.82), 0.52*

(HrHPV) and smear test in the community; or group C; a choice of the aforementioned follow-up options.

those preferring the colposcopy group decreased by 7% (Supplementary Material 2).

The average cost of the follow-up options per person was $147 for colposcopy, $88 for community and $114 for choice. This would result in savings of $59 per person if all patients were initially referred to the community and a saving of $33 if women were given the choice of follow-up.

Discussion

Health-related quality of life

We found no objective HrQOL difference associated with follow-up type in patients after LLETZ treatment for CIN 2–3. This supports the newly introduced guidelines, which recommend that clinicians offer both hospital and community options to women for post-treatment follow-up.

Attendance

Attendance at follow-up in cervical screening programmes is of paramount importance. It is well-established that women with a history of high-grade (CIN 2+) disease are at high risk of developing cervical cancer. Among women who have developed cancer following a previous abnormality, 50% have been lost to follow-up.[9] Factors that impact on cervical screening uptake include timing of appointments, economic factors, education/knowledge, fear/embarrassment and the gender of the smear taker. However, to date, the cervical screening literature has not identified patient choice as a factor contributing to attendance.[15,16] Studies in other medical fields demonstrate a "preference effect," whereby choice itself may have an outcome advantage.[20] Other studies also observe a high correlation between women's choice of management type and their attendance at follow-up.[21] In our study, women that were given the option of either hospital or community follow-up type (group c) had better attendance at cervical screening services (risk difference=7%, 95% CI 2%–13%, p=.06) than those given no choice of follow-up type (groups a and b). Therefore, offering a choice of follow-up type may improve women's adherence and attendance.

Cost-effectiveness

Community follow-up was the most cost-effective but least adhered-to option. When compared to routine colposcopy, the group given a choice of follow-up (group c) had a cost benefit of $33 per patient and was associated with the highest rates of adherence.

Limitations

We acknowledge that this was a secondary analysis with the limitation of small numbers informing a potential association. Nonetheless, this highlights the importance of patient choice in medical decision-making, which is often overlooked in research and guideline development.

We acknowledge that study designs that allow participants to choose their treatment are susceptible to confounding factors. For example, a more anxious group of women at baseline may be more inclined to choose colposcopy. In order to minimise this in the analysis of the primary outcome, the choice group was analysed separately and not according to the follow-up chosen.

The potential for information bias requires consideration. For the collection of data, we considered several options. We identified four specific cervical screening questionnaires in our literature search: the Process Outcome Specific Measure (POSM) from the Trial of Management of Borderline and Other Low-Grade Abnormal Smears (TOMBOLA) group,[17] Psychological Effects of Abnormal Pap Smears Questionnaire (PEAPS-Q),[18] Cervical Dysplasia Distress Questionnaire (CDDQ)[16] and the HPV Impact Profile (HIP).[19] However, none of these have been widely used or validated. Therefore, we chose to use a generic HrQOL tool, the SF12v2, for which there is a large body of supporting evidence. As a generic assessment tool, the SF12v2 allows comparison of health status between groups, including those suffering from different diseases. Such a tool also allows analysis of a wide range of populations, ascertaining any deviations from a "healthy norm."[5] As such, a broader range of comparison is possible. However, use of the SF12v2 in the context of this study may be criticised for its potential imprecision in assessing disease-specific effects.[7] Furthermore, since a small number of women completed the questionnaire at home with return by post, the day and location of survey completion has the potential to bias survey outcomes.

Strengths

One of the strengths of the current study lies in its randomised design and intention to treat analysis which supports the internal validity of the trial. All participants completed their clinical care, and we had no missing clinical data for baseline and follow-up. We obtained all HrQOL questionnaires at baseline, and 64.0% (n=128) at six months.

Further research

This study highlights that patient choice, where equivalent management options exist, may warrant further research due to associations with improved adherence and cost benefits. Larger studies are warranted to examine the potential effects of patient choice on follow-up type in cervical screening, and to test these findings in a wider clinical setting. A larger study involving different centres throughout New Zealand would also better represent the wider New Zealand population because choice options and the costs associated with follow-up type are likely to vary between regions. Patient choice of colposcopy or community follow-up type depends on numerous factors, such as perceived standard of care, geographical factors, financial considerations and patient experience. For example, women living in rural areas may feel more comfortable with their own general practitioner and access to colposcopy services should also not be assumed to be homogenous throughout New Zealand.

Additionally, although the importance of adherence to follow-up is well-documented in women who have had previous high-grade disease, a study with a longer follow-up period would provide more certainty of potential long-term effects.

Finally, future management and research decisions should consider costs to the patient. In New Zealand, screening services are free for patients in the hospital but not in the community. Although costs to patients were subsidised in this study, the increased personal costs associated with screening was an important issue raised by some patients and may be a major deterrent to follow-up for some women.

Conclusion

In New Zealand, guidelines for cervical screening have recently been amended to allow either colposcopic or community follow-up in the post-treatment setting, thus presenting the clinician and patient with a choice. Although it is known that patient choice can influence participation—and thus health outcome—this has not yet been explored with regards to cervical screening. We investigated whether patient choice of follow-up screening type improves HrQOL and attendance for women who have undergone LLETZ for CIN 2–3. Using a randomised control trial study design, we found no significant difference in HrQOL between three study groups of hospital follow-up, community follow-up or patience choice of follow-up type. However, attendance was greater in patients allocated to a group where they could choose their follow-up type. Larger and longer-term studies examining these potential effects are warranted.

COMPETING INTERESTS
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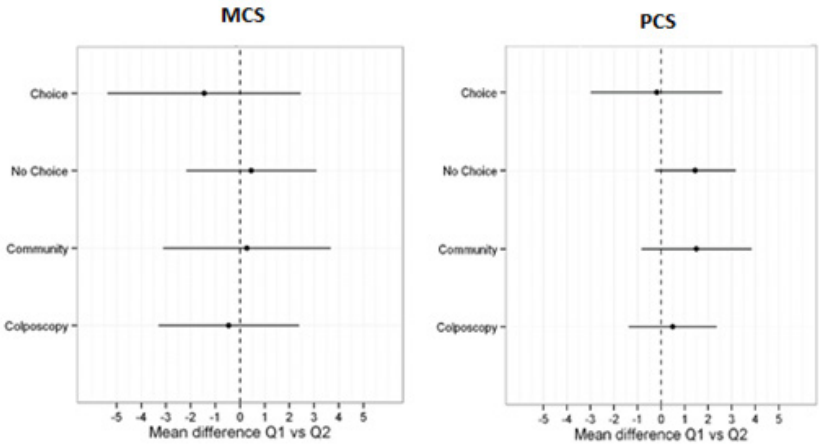
Supplementary material

Supplementary Material 1: Comparison of health-related quality of life between groups baseline and six month (MCS and PCS scores).



Supplementary Material 2: Patient follow-up preferences.

Follow-up preferences	Baseline	Six months	Difference
	n(%)	n(%)	%
Colposcopy	108 (54)	60 (47)	-7
Community	20 (20)	31 (24)	4
Choice	42 (21)	33 (26)	5
Multiple selections	10 (5)	6 (3)	-2

Patient preference, assessed by questionnaire and presented by group, showed differences over time.

Cardiac magnetic resonance imaging can identify a diagnosis in suspected myocardial infarction with non-obstructive coronary arteries: illustrative case presentations

Danting Wei, Mansi Turaga, Peter Barr, Ruvin Gabriel, Jen-Li Looi

Myocardial infarction (MI) with non-obstructive coronary arteries (MINOCA) is an increasingly recognised condition and accounts for 5% to 9% of all MI cases.[1,2] Recent study has shown that MINOCA has a higher rate of all-cause mortality than age and sex-matched population without cardiovascular disease (CVD) and the predominant contributor to mortality is non-CVD death.[3] This suggests the predisposing factors for MINOCA remain a potent risk factor for non-CVD death. Thus, recent American and European expert consensus documents have defined MINOCA as a "working diagnosis" that should prompt further investigations to ascertain the aetiology of the condition.[1,2]

Cardiac magnetic resonance (CMR) is not only accurate in the assessment of cardiac anatomy and function but is also superior in myocardial tissue characterization. Late gadolinium enhancement (LGE) and T2-weighted imaging allow assessment of myocardial scar, focal fibrosis, and myocardial oedema, respectively, thereby enhancing the capacity to delineate causes of suspected MINOCA. Advanced CMR imaging myocardial tissue characterisation methods such as T1 and T2 mapping techniques further improve the diagnosis of myocarditis and Takotsubo syndrome.

Novel T1 mapping techniques allow quantitative CMR assessment of myocardial fibrosis, with the two most common measures being native T1 and extracellular volume (ECV) fraction. Native T1 differentiates normal from infarcted myocardium, is abnormal in hypertrophic cardiomyopathy, and is useful in the diagnosis of Anderson–Fabry disease and amyloidosis.[4] In acute MI, native T1 mapping can differentiate microvascular obstruction (MVO) in infarcted myocardium; it is characterised by T1 values higher compared to those of remote myocardium but lower compared to those of infarcted myocardium.[5,6] Native myocardial T1 relaxation time was significantly higher in patients with acute myocarditis which is attributed to cellular oedema, increased extracellular space and water, inflammation, and myocyte necrosis, all of which commonly occur in the acute stage of myocarditis.[7]

ECV is a surrogate measure of the extracellular space and is equivalent to the myocardial volume of distribution of the gadolinium-based contrast medium. It is reproducible and correlates well with fibrosis on histology. ECV is abnormal in patients with cardiac failure and aortic stenosis, and is associated with functional impairment in these groups.[8]

T2 mapping has emerged as a valuable tool in the CMR assessment of myocardial oedema in ischaemic and non-ischaemic cardiomyopathies.[9,10] A high T2 value reliably identifies acute myocardial oedema in acute MI without the limitations associated with T2-weighted imaging.[9] whereas in chronic MI, T2 value is normal as myocardial oedema resolves within six months after an acute insult. T2 value is also significantly elevated in patients with acute myocarditis indicating myocardial inflammation.[10]

We describe three cases in which CMR ensures the correct diagnosis for optimal management and treatment of patients with MINOCA.

Case 1

A 57-year-old woman with hypertension, hyperlipidaemia, and family history of premature coronary artery disease presented with chest pain, elevated high-sensitive troponin (hs-TnT), and dynamic ST-segment changes in the anterior leads on electrocardiogram (ECG). Coronary angiography showed trivial coronary artery disease

and transthoracic echocardiogram demonstrated hypokinesis of anteroseptal and inferoseptal, apical inferior and lateral walls. The diagnosis of Takotsubo syndrome was initially made based on these findings. Subsequent echocardiograms continued to show persistent hypokinesis of the septum. CMR (Figure 1A–1C) demonstrated myocardial fibrosis involving the septal wall, a pattern in keeping with previous left anterior descending (LAD) territory infarction. Further review of her angiography revealed paucity of the septal branches arising from the LAD (Figure 1D, Supplementary Video 1), raising the possibility of an occluded vessel.

Case 2

A 57-year-old woman presented with fever, chest pain, elevated hs-TnT, and C-reactive protein (CRP). Coronary angiography demonstrated near normal coronaries. CMR was performed as part of the workup of suspected myocarditis. T2-weighted short-tau inversion recovery (T2-STIR) imaging and T2 mapping (Figure 2A and 2B) showed an oedematous area in the inferolateral wall. Native T1 mapping (Figure 2C) and LGE imaging (Figure 2D and 2E) revealed transmural myocardial fibrosis with MVO in the inferolateral wall, a pattern in keeping with circumflex artery territory infarction. Further review of her angiography (Figure 2F, Supplementary Video 2) demonstrated occlusion of the distal circumflex artery due to spontaneous coronary artery dissection (SCAD).

Case 3

A 75-year-old woman with hypertension, hyperlipidaemia, and previous transient ischaemic attack presented with chest pain and elevated hs-TnT. She was competing in an art competition a few hours prior to admission. Transthoracic echocardiogram demonstrated hypokinesis of the anteroseptal and anterior walls. Coronary angiography showed moderate disease in mid LAD (Figure 3A). Fractional flow reserve (FFR) was performed to the LAD as the vessel is large and does wrap around the apex and it suggested non-obstructive disease (FFR 0.87). The appearance of the left ventriculogram raises the possibility of Takotsubo syndrome (Figure 3B). CMR was subsequently performed to clarify the diagnosis. Native T1 mapping (myocardium T1 value 1201 msec, normal range 1225–1275 msec) and LGE imaging showed no evidence of myocardial fibrosis (Figure 3C and 3D). The regionality previously noted on transthoracic echocardiogram had resolved and this is in keeping with the diagnosis of Takotsubo syndrome.

Supplementary material

- **Supplementary Video 1:** Angiography showing paucity of the septal branches arising from the LAD, raising the possibility of an occluded vessel.
- **Supplementary Video 2:** Angiography showing occlusion of the distal circumflex artery due to spontaneous coronary artery dissection.

Figure 1: A. Pre-contrast T1 mapping showed an abnormally increased T1 signal (black arrows) involving the anteroseptal wall, suggestive of myocardial fibrosis. B & C. On LGE imaging, there was near transmural enhancement (red arrows) involving the anteroseptal wall, a finding in keeping with myocardial infarction. D. Coronary angiography revealed paucity of sepal branches arising from the LAD (yellow circle) raising the possibility of an occluded vessel.

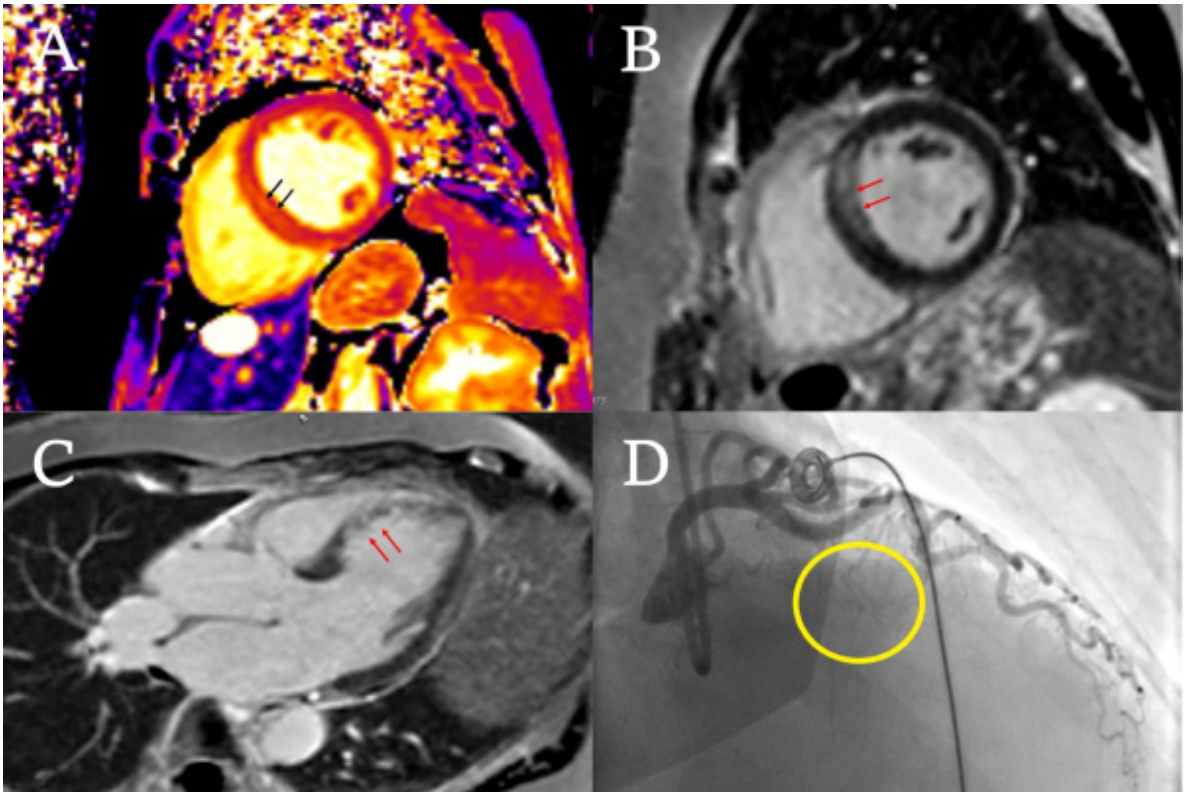


Figure 2: A. There was a hyperintense signal (yellow arrows) in the inferolateral wall, suggestive of myocardial oedema on T2-STIR imaging. B. Compared to the anterolateral wall (mean T2 value 35 msec, normal range <50 msec), T2 value was significantly higher in the inferolateral wall (mean T2 value 60 msec) indicating acute myocardial oedema. C. Pre-contrast T1 mapping showed an abnormally increased T1 signal involving the inferolateral wall. There was a dark region (red arrows) within the bright myocardium in keeping with microvascular obstruction (MVO). D & E. On LGE imaging, there was transmural myocardial enhancement in the inferolateral wall. MVO is observed as hypo-enhanced region within hyper-enhanced infarcted myocardium (yellow arrows). F. Coronary angiography revealed occlusion of a large circumflex artery (yellow arrow) secondary to spontaneous coronary artery dissection.

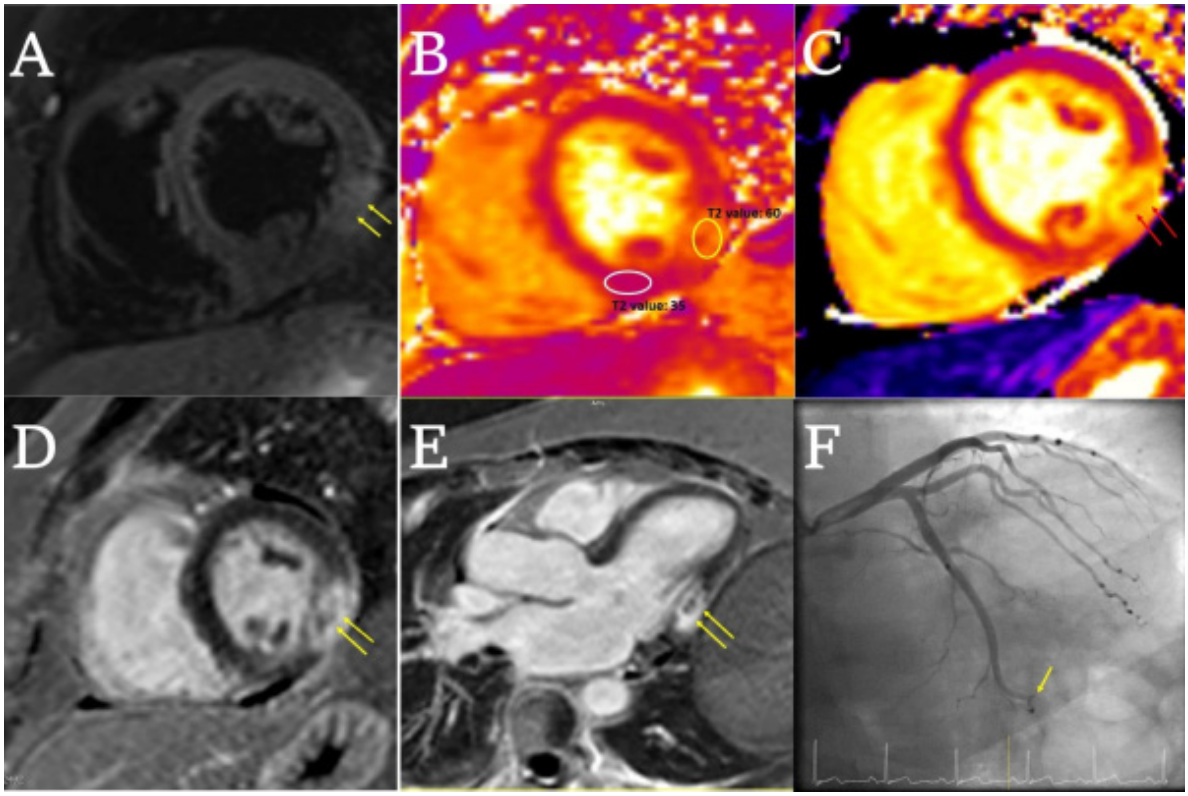
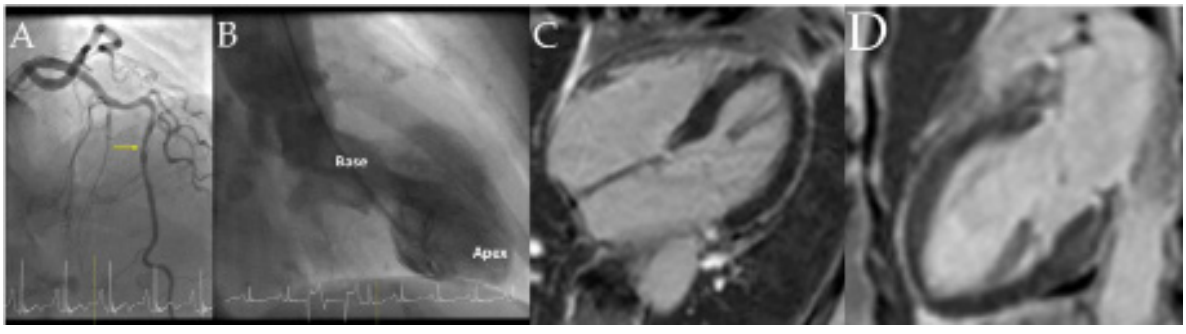


Figure 3: A. Coronary angiography revealed moderate disease in mid LAD (yellow arrows). B. Left ventriculogram demonstrated apical akinesis and basal hypercontractility raised the possibility of Takotsubo syndrome. C & D. There was no myocardial fibrosis on LGE imaging. This is in keeping with the diagnosis of Takotsubo syndrome.



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Nil.

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The persistence of neutralising antibodies up to 11 months after SARS-CoV-2 infection in the southern region of New Zealand

Reuben McGregor, Alyson Craigie, Susan Jack, Arlo Upton, Nicole J Moreland, James E Ussher

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which causes coronavirus disease 2019 (COVID-19), was first detected in New Zealand in February 2020. Following this initial introduction, and a community outbreak of 1,154 confirmed cases, New Zealand successfully eliminated the virus in the community.[1] With the exception of several isolated border incursions and short lockdowns in Auckland, the country remained largely COVID-free until the outbreak of the delta SARS-CoV-2 variant, which began in August 2021.

The emergence of novel viral variants of concern (VoC), such as delta (B.1.617.2) and most recently omicron (B.1.1.529), combined with reports of the gradual waning of antibodies over extended timeframes,[2] highlights a need for ongoing studies tracking immune responses following natural infections and vaccination, particularly since the initial waves of infections, and the currently licenced vaccines, are based on the original SARS-CoV-2 strain rather than VoC that have dominated global infections subsequently. Here we present a follow-up serological assessment of PCR-confirmed cases nearly oneyear post-infection, including levels of neutralising antibodies to alpha, beta, delta and omicron VoC.

During the first wave of infection in New Zealand, a cohort of PCR-confirmed COVID-19 cases was recruited in the Southern District Health Board (SDHB) region.[3] We have previously reported on antibody dynamics in this cohort, alongside participants from other cohorts, up to eight-months post-infection.[4] Antibody (IgG) responses to the viral spike protein and neutralising antibodies were relatively stable over this eight-month period compared with antibodies to the nucleocapsid protein. This persistence of spike-specific antibodies compared with the rapid decay of nucleocapsid antibodies has since been widely demonstrated, with the latter now being utilised as a marker of recent infection.[5]

The original SDHB cohort comprised n=78 PCR confirmed cases infected between 11 March and 5 April 2020, with up to three serum samples collected post-symptom onset (Figure 1 (clear circles) and Table 1). Of these, 30 participants donated further samples at later time points, represented as red circles in Figure 1. As there were no successive community outbreaks in SDHB during the study timeframe, nor had any participants received a COVID-19 vaccine, the immune responses observed likely represent a single exposure event tracked over the time course. Median days post symptom onset for this additional timepoint was 302 days (Table 1). Samples were assayed for antibodies to both nucleocapsid (Abbott Architect SARS-CoV-2 IgG assay, Figure 2a) and spike proteins (Abbott Alinity SARS-CoV-2 IgG II Quant assay, Figure 2b). We have previously reported 99.7% specificity for the nucleocapsid assay using 300 prepandemic anti-natal samples.[3] The same procedure was followed for the recently released Spike Alinty IgG assay for this study, for a calculated specificity of 100% (0/100 of anti-natal samples with sera available were above the 50 AU/mL cut-off).

Neutralising antibodies were measured using a surrogate viral neutralisation test (sVNT), based on the receptor binding domain of the spike protein (cPass™ SARS-CoV-2 Neutralization Antibody Detection Kit, GenScript). This domain contains >90% of neutralising antibody epitopes—that is, regions that block the entry of the virus into host cells via the hACE-2 receptor.[6] Specificity was previously determined to be 100% using the 300 anti-natal samples and an additional 113 pre-pandemic samples.[7]

Recent analyses suggest that the level of neutralising antibodies is an important component

Figure 1: Cohort summary. Individual participants are ordered by days post onset of symptoms, with temporal samples from the same individuals connected by grey lines. Samples were obtained at one to four timepoints over the study period. Samples included in this study are indicated by red circles with ealier timepoints indicated by unfilled circles.

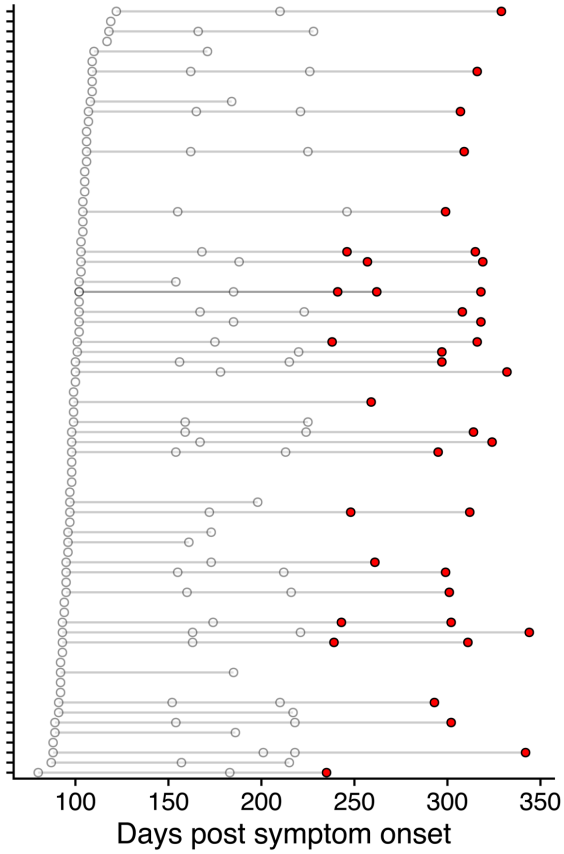


Table 1: Cohort demographics. All participants in this study had mild to moderate symptoms and none were admitied to hospital.

	Total	**This study**
Participants, *n* (samples, *n*)	78 (172)	30 (37)
Sex, *n* (M/F)	31/47	9/21
Age (year)		
Median	51.5	52
Range	17-81	27-81
Days post symptom onset (days)		
Median	158	302
Range	80–344	235–344

of a correlate of protection.[8] There is now intense effort on understanding how sequence changes within the receptor binding domain in VoC might impact on neutralising antibody activity, and protection from re-infection.[6] In this study neutralising antibodies were assessed to alpha (B.1.1.7), beta (B.1.351), delta (B.1.617.2) and omicron (B.1.1.529) VoC using an adapted sVNT assay that incorporates receptor binding domains corresponding to the sequence for each of these variants.[9]

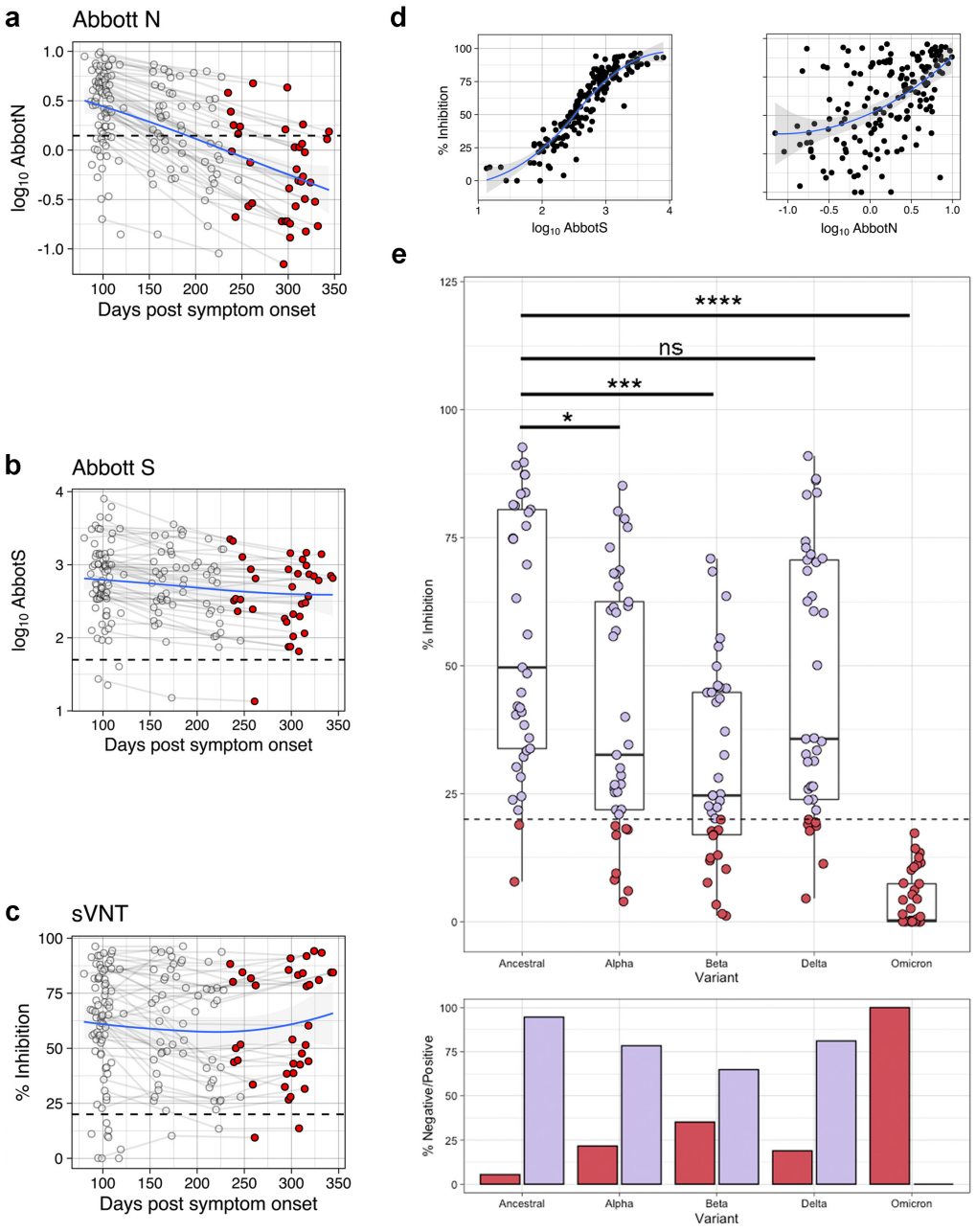
With the inclusion of later time-points, the relative stability of spike antibodies (Figure 2b), compared with nucleocapsid antibodies (Figure 2a), has been confirmed. Indeed, nucleocapsid antibodies continue to decline rapidly between 8 and 11 months, with 27/37 (72.97%) below the cut-off at this later time-point. This contrasts with spike antibodies where 36/37 (97.30%) remained positive at the later timepoint. Similarly, neutralising antibodies to the original SARS-CoV-2 virus showed no decline at this later timepoint (Figure 2c), with 35/37 (94.59%) remaining positive. This trend was also reflected in the strong correlation between spike and neutralising antibodies, which was not observed with nucleocapsid antibodies (Figure 2d).

To assess the neutralisation capacity of sera against VoC generated by a single natural exposure approximately 300 days prior, the sVNT with alpha, beta, delta and omicron was performed following standard protocols.[4,9] There was a dramatic and highly significant reduction in neutralisation capacity to the omicron variant compared with the ancestral strain (median inhibition 0.23% versus 49.7%, $p<0.0001$). There was also a notable reduction to the beta variant (median inhibition 24.7% versus 49.7%, $p<0.0001$), and a significant, but less marked, reduction to the alpha variant (32.6%, $p<0.05$). In contrast, there was a non-significant reduction to the delta variant (35.7%, $p=0.117$) (Figure 2e). This trend was mirrored in the proportion of samples below the assay cut-off (<20% inhibition), with omicron showing the highest proportion of negative samples (37/37, 100%) compared with beta (13/37, 35.1%), alpha (8/37, 21.6%) and delta (7/37, 18.9%) (Figure 2e).

These data are in keeping with observations internationally where the beta and omicron variants are thought to evade humoral immunity compared to the alpha and delta variants.[2,10,11] For beta, this is partly driven by the E484K mutation in the beta receptor binding domain that interferes with antibodies generated in response to ancestral strain sequences.[12] The omicron variant, first identified in November 2021, harbours a staggering 15 mutations in the receptor binding domain including at the 484 position.[10] Recent data have shown omicron crossneutralisation from a previous, non-omicron infection is extremely limited by six-months post-infection,[11] consistent with the lack of omicron cross-neutralisation observed in our study up to 11-months post-infection. This, combined with the increased transmissibility associated with omicron, highlights the need for vaccination of previously infected individuals as omicron surges globally. Although two doses of the Comirnaty (Pfizer/BioNTech) vaccine, which is based on the original spike protein sequence and currently being administered in New Zealand, produces antibodies that effectively neutralise the delta variant, a third booster dose is needed to restore high levels of neutralisation against omicron.[10]

In conclusion, this study provides novel insight from a unique setting in the Southern region of New Zealand where the probability of SARS-CoV-2 re-exposure has been extremely unlikely. Although a single exposure generated a neutralising antibody response that persists for at least 11 months for the original and delta variant, this was not the case for omicron. Given the risks of serious disease associated with SARS-CoV-2 infection, and the ongoing omicron surge, vaccination remains strongly recommended.

Figure 2: Antibody responses following SARS-CoV-2 infection over time. Antibody responses targeting Nucleocapsid (N) protein (a), spike (S) protein (b) as well as neutralising antibodies (c) over time. New samples are indicated by red circles with previously reported samples inidcated by unfilled circles (n=172). (d) Correlation between S protein antibodies and N protein antibodies versus neutralising antibodies. LOESS regression line shown in blue and standard error of regression is shaded in grey (n=172), with the residual standard error being 0.208 and 0.422 for S protein and N protein antibodies, respectively. When Spearman linear regression is applied the r^2 are 0.87 ($p<0.001$) for S protein and 0.28 ($p<0.001$) for N protein antibodies versus neutralising antibodies. (e) Neutralising antibody responses to variants of concern including only the most recent samples (represented by red circles in a-c) (top). Kruskal-Wallis test showed a significant difference ($p<0.001$) with follow up Wilcoxon test Holm adjusted p-values indicated by stars, *$p<0.05$, ***$p<0.001$, ****$p<0.0001$ (n=37). Percentage of samples above (purple) and below (pink) the assay cut-off (bottom). Dashed horizontal lines represent respective test cut-offs throughout.



COMPETING INTERESTS
Nil.

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Establishing research tikanga to manaaki research participants in a pandemic

Joanna Hikaka, Anneka Anderson, Nora Parore, Robert Haua, Mariana Hudson, Brendon McIntosh, Kevin Pewhairangi, Rachel Brown

The need for, and importance of, kaupapa Māori methods in science and health research is now clearly articulated in best practice guidance[1,2] and is increasingly recognised as important by research funding bodies.[3] In this article we discuss the formation of a research partnership between two Māori-led and -governed health organisations and the planned, intentional application of agreed kaupapa Māori research principles and practices[4,5] before the research had even commenced. This has supported our ability to quickly make decisions and pivot in approaches while continuing to show manaaki (care, respect) to research participants during the COVID-19 pandemic.

In October 2020, Ngā Kaitiaki o Te Puna Rongoā o Aotearoa – The Māori Pharmacists' Association (MPA) and The National Hauora Coalition (NHC) formed a partnership to develop a research proposal and grant application to explore how pharmacists can better support equitable access to medicines for Māori. The major focus of the research was to explore this question through the experiences and perceptions of whānau Māori. Fifteen wānanga, involving a brief presentation from facilitators, in-depth discussions between participants and facilitators and completion of a survey with Māori, were to be undertaken in six regions of Aotearoa. Two facilitators would support each wānanga and it was proposed that six to eight participants would attend each wānanga. Our grant application was successful, and in May 2021 we started the research titled *Te Puna Rongoā: Achieving medicines access equity for Māori – Pharmacists' role* funded by the Health Research Council and PHARMAC (HRC: 20/1466).

In developing the grant application and subsequent study protocol we discussed the application of kaupapa Māori practices within our work. Although there were seven core kaupapa Māori research practices articulated and applied in our work,[5] we have presented three of these here: kanohi kitea, manaaki ki te tangata and kia tupato.

Kanohi kitea speaks to being present, engaging face-to-face with people and communities providing a sense of familiarity. Our research team members, who are all Māori and majority frontline health workers, were known locally and had responded to, and supported, their communities, which spanned six regions in Aotearoa, during multiple lockdowns. Our researchers are also involved in their Māori communities. For example, with kura (school), kōhanga reo (total immersion Māori early childhood centres) and marae committees and within Māori health networks. The concept of being known in the community was extended and applied at an organisational level. MPA and NHC are organisations where Māori health equity is central to all levels of work including vision, strategy and decisions. Both organisations are known and trusted within various Māori communities. Extending the practice of kanohi kitea to these particular organisations was intentional and strategic, and offering alternatives may have altered community perceptions if, for example, the researcher organisations were larger, non-Māori-led and non-Māori-governed organisations.

In our research approach, we chose to privilege in-person recruitment, consent and participation methods. However, we had made provisions for online participation in the case of escalated COVID-related restrictions. The potential for online engagement was enhanced by researchers being known faces in their communities, with past in-person engagement with potential participants.

Manaaki ki te tangata speaks to being caring to those involved in research, honouring reciprocity in the research relationship, and being responsive to the varying needs of those who may be potential participants in the research. Our initial ethics application was made in May

2021 when Aotearoa had reported few community cases of COVID-19 for months. However, we understood that further community outbreaks of COVID-19 could happen at any point. Our study protocol included specific strategies for managing COVID-19 implications and restrictions within our research project, including the potential to utilise online recruitment, consent and data collection methods. Online methods have been used in other kaupapa Maori research[6] and gave us further confidence that tikanga Māori could be upheld. There are inequities in access to digital technology in Aotearoa with Māori having reduced access compared to non-Māori,[7] which could be a barrier to participation for some whānau. However, there are also potential opportunities such as increased participation for those who may find it difficult to attend in-person events. Having established kaupapa Māori practices in our research partnership allowed our research team to quickly pivot from planned, in-person wānanga (discussions/focus groups) to online options when prolonged high Alert Level restrictions were in place during August to December 2021. To further manaaki participants, the option to participate in-person and at a later date was also given. Although these options for participation were driven by COVID-19, our team believes options should be provided in all research, independent of COVID-related restrictions, to manaaki participants to contribute in a way that suits them.

The practice of **kia tupato** means that a cautious approach is taken in research. We decided as a research team that we would operate at a higher level of caution than what was mandated by government, to support protection of Māori communities given inequities in pandemic-related outcomes for Māori being demonstrated historically and predicted (and since realised) within the current pandemic.[8] This cautious approach has been articulated by others, including Pihama and Lipsham, who discuss it in relation to responses by iwi and Māori organisations,[9] and Kvalsvig et al, who frame the discussion in the context of inequities in health which disproportionately impact Māori.[10] We made decisions that inter-regional travel would not occur between areas at different Alert Levels.[11] For example, to uphold the principle of kanohi kitea (and to support less experienced researchers), the principal investigator may have travelled to support local researchers and communities with regional dissemination of study findings. On 4 October 2021, the government announced a roadmap into the future for living in Aotearoa that relied heavily on vaccination. The following day, the research team made the decision by consensus that we would only have in-person data collection as an option for those who were double-vaccinated. An ethics amendment was sought, and granted, to allow us to ask this question. Online participation options were still in place for those who were unvaccinated, chose not to disclose their status or preferred to participate online. We also decided that in-person wānanga would only occur if the local researcher felt it was appropriate. Having researchers located within research communities allowed us to understand local comfort levels, policies and practices regarding in-person gatherings and respond accordingly. The practice of kia tupato was also important to protect local communities, as a number of our researchers continue to work as health professionals in face-to-face services.

The practices discussed here extend past the research, and as a team we have an understanding that the responsibility of our members to serve their community in the COVID-19 response will always come above the need to undertake research. Establishing a kaupapa Māori principles-based research partnership between our two organisations, and the application of kaupapa Māori research practices, allowed for an agile response within the setting of a pandemic and supported our commitment to uphold mana whānau and mana Māori.

COMPETING INTERESTS
Nil.

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Is PHARMAC's decision-making fair? Findings from an evaluation of decision-making in the New Zealand health system

Emma Tumilty, Fiona Doolan-Noble, Robin Gauld, Peter Littlejohns, Tim Stokes

The recent publication of the interim report of the PHARMAC Review Panel[1] raises important questions of the role and processes of PHARMAC in securing equitable access to pharmaceuticals for all New Zealanders. The panel's report has generated unfavourable media coverage,[2] with commentators highlighting the report's observations that PHARMAC has a "fortress mentality that permits little transparency and openness."[1] We consider it therefore both important and timely to report the key findings of a research project we carried out in 2017 assessing the fairness of decision-making in the New Zealand health system,[3] with a specific focus on PHARMAC and the district health boards (DHBs).

Our research assessed fairness of decision-making using the Decision-Making Audit Tool (DMAT) developed by Katharina Kieslich and Peter Littlejohns in the United Kingdom (UK).[4] Ethics approval was obtained from the University of Otago Human Ethics Committee (F16/008). We experienced difficulties in conducting this research with DHBs, due to a lack of publicly available documentation, the transparency on their websites and our inability to recruit appropriate staff for interviews (as reported in other studies).[5] In contrast, PHARMAC were supportive of the research. We were, therefore, able to review their publicly available documentation against the DMAT and conduct interviews with a number of their staff, as well as feeding back our findings to their Consumer Advisory Panel. We were also able to get input from them about the usefulness of DMAT and some of the issues around procedural justice and engagement with PHARMAC's decision activities.

The DMAT draws on two frameworks for fair and legitimate priority setting in healthcare: accountability for reasonableness framework[6,7] and the social values framework.[8] The accountability for reasonableness framework is premised on the idea that it is easier to agree on fair process than on the fair principles for decision-making in priority setting and resource allocation activities.[6,7] Daniels and Sabin[6,7] describe four criteria that need to be met for procedural justice. They are:

- Transparent—open to public scrutiny
- Justifiable—supported by reasons considered relevant/appropriate
- Revisable—include a process to make changes or have the decision questioned
- Accountable—ensure that the above criteria are met

The social values framework developed by Clark and Weale[8] came from their work in health technology assessment and stipulated that there is a need to address content not just process. That is, that resource allocation and priority-setting decisions should be judged both on the way decisions are made and communicated and what accountability is shown for these decisions and related processes. In addition, the information that feeds into these decisions in terms of the clinical (evidence), the economic (cost) and values (public engagement) needs to be transparent and accessible. The DMAT, since publication of its first iteration,[4] has been refined through a variety of stakeholder engagement activities to eight domains with a total of 28 items to cover areas of process and content. The eight domains cover: Institutional Setting, Transparency, Accountability, Participation, Clinical Effectiveness, Cost-Effectiveness, Quality of Care, and Fairness (Table 1).

In 2017, we used PHARMAC's and the DHBs' websites to assess their performance against the DMAT items (as had previously been done in the UK with commissioning groups). This involved two team members (GR and ET) agreeing on working categorisations, reviewing documentation and webpages and cross-checking each other's assessments.

Although we concluded that the DMAT would need further adaption for use in the New Zealand environment, we did find that it provided useful information. Seven of the eight domains of the DMAT applied to PHARMAC (Quality of Care was not relevant). Of the seven domains that did apply, PHARMAC received full points in five domains (Table 2). The two domains where it did not receive full scores were Accountability (13 of 15 points available) and Participation (21 of 25 points available). Overall, PHARMAC scored 119 points of possible 125 (excluding the one domain). This is a score of 95.2%. Where PHARMAC scored lower was tied to the lack of clarity of how stakeholder voices (across the spectrum) inform PHARMAC judgements using their Factors for Consideration.

Of note, as a comparator, DHBs scored significantly poorer with an average of 77.45 points of a possible 140 (range: 47–109). For most categories, a lack of information about decision-making and engagement activities was the confounding factor in understanding what it is that the DHBs may or may not be doing in terms of decision-making.

Our key findings from this research, carried out in 2017, are that PHARMAC has a clear decision-making process underpinned by values that are largely transparent. Important strengths are clear processes to communicate the basis of decisions on clinical and cost-effectiveness grounds determined by appropriate evidence. We consider PHARMAC stands alone in this regard when compared to other entities in the New Zealand health system.

The one area we considered there was room for improvement was around accountability (how open the organisation is about how it makes final decisions) and participation (consultation process and transparency around how the views of stakeholders influence final decisions). In these matters, our findings offer some support for the preliminary observations of the PHARMAC Review Panel[1] that there is scope to improve transparency around the weighing of Factors for Consideration and the engagement of public/patients in decision-making as well as issues of equity and Te Tiriti o Waitangi. It is important to note, however, that since we conducted this work PHARMAC has undertaken a review of its strategic direction[9] with a stated objective of improving stakeholder participation in decision-making.

Our conclusion is that PHARMAC's decision-making framework is both fair and legitimate, noting that there is scope to further improve transparency around decision-making and stakeholder participation. More generally, we hope that the restructuring of the New Zealand health system,[10] with its abolition of DHBs, will lead to the proposed new health entities placing more focus on engagement, accountability and transparency when making decisions to achieve an equitable and sustainable healthcare system.[11]

Table 1: DMAT Domains and items.

Domain	Item	Item description
Institutional Setting	1	Information about the organisation's legal responsibilities and duties in commissioning (buying) healthcare services for their population is publicly available and easy to find.
	2	The organisation demonstrates how it fulfils its legal responsibilities and duties in commissioning (buying) healthcare services for their population.
	3	The organisation is clear about its relationships and collaborations with other organisations in making decisions about local health services.
Transparency	4	Information about the organisation's structure, its decision-making criteria, important dates, and any other information that is of interest to you, is publicly available and easy to find.
	5	Information about the organisation's structure, its decision-making criteria and important dates and events is understandable.
	6	The organisation offers reasons for its decisions.
	7	The reasons that the organisation offers for its decisions are legitimate.
Accountability	8	The organisation clearly states to whom it is accountable.
	9	The organisation demonstrates that it fulfils its duty to be accountable.
	10	The organisation is open about how it makes decisions when faced with competing demands from different groups, individuals or organisations.
Participation	11	The organisation consults all groups whom it is required to consult by law.
	12	Information on the ways in which patients, members of the public, health professionals and other stakeholders can get involved is publicly available and explained.
	13	The organisation uses a wide range of techniques in consulting and engaging with stakeholders and the public.
	14	The organisation is transparent about how the views of patients, the public, health professionals and other stakeholders influence the ultimate decisions.
	15	The organisation's strategy for consulting patients, members of the public, health professionals and other stakeholders ensures that a wide range of views are heard.

Table 1 (continued): DMAT Domains and items.

Domain	Item	Item description
Clinical Effectiveness	16	The organisation has a system in place to identify relevant national guidance or standards.
	17	The organisation a system in place to manage uncertainties about, or unavailability of, evidence on clinical effectiveness.
	18	The organisation has a system in place to identify clinically ineffective services or treatments.
	19	The organisation has a system in place to decommission clinically ineffective services or treatments.
Cost-effectiveness	20	The organisation has a system in place to collect and evaluate evidence in order to ensure that what is commissioned is cost effective.
	21	The organisation has a system in place to manage uncertainties about, or unavailability of, evidence on cost effectiveness.
	22	The organisation explains how it considers the financial implication of each decision (including the financial impact on other services, for example).
Quality of Care	23	Information on quality of care, such as strategies and definitions, is publicly available and easy to find.
	24	Information on the quality performance of the services that the organisation commissions is publicly available and easy to find.
	25	The organisation can demonstrate that it has systems in place to identify and follow national quality care initiatives
Fairness	26	The organisation demonstrates that it has policies in place to identify equality and diversity concerns that may arise from its decisions and strategies.
	27	The organisation can demonstrate that it commissions services on the basis of clinical need and not on the basis of other characteristics such as age, gender, ethnicity or sexual orientation.
	28	When services are prioritised for special patient or population groups (children or older people, for example), the organisation explains the reasons for this.

Table 2: PHARMAC scores in DMAT framework.

DMAT value	Item		PHARMAC
Institutional Setting	1	Information about the organisation's legal responsibilities and duties in commissioning (buying) healthcare services for their population is publicly available and easy to find.	5
	2	The organisation demonstrates how it fulfils its legal responsibilities and duties in commissioning (buying) healthcare services for their population.	5
	3	The organisation is clear about its relationships and collaborations with other organisations in making decisions about local health services.	5
	Domain points possible: 15		**15**
Transparency	**4**	Information about the organisation's structure, its decision-making criteria, important dates, and any other information that is of interest to you, is publicly available and easy to find.	5
	5	Information about the organisation's structure, its decision making criteria and important dates and events is understandable.	5
	6	The organisation offers reasons for its decisions.	5
	7	The reasons that the organisation offers for its decisions are legitimate.	5
	Domain points possible: 20		**20**
Accountability	**8**	The organisation has clearly states to whom it is accountable.	5
	9	The organisation demonstrates that it fulfils its duty to be accountable.	5
	10	The organisation is open about how it makes decisions when faced with competing demands from different groups, individuals or organisations.	3
	Domain points possible: 15		**13**

Table 2 (continued): PHARMAC scores in DMAT framework.

DMAT value	Item		PHARMAC
Participation	**11**	The organisation consults all groups whom it is required to consult by law.	5
	12	Information on the ways in which patients, members of the public, health professionals and other stakeholders can get involved is publicly available and explained.	5
	13	The organisation uses a wide range of techniques in consulting and engaging with stakeholders and the public.	5
	14	The organisation is transparent about how the views of patients, the public, health professionals and other stakeholders influence the ultimate decisions.	3
	15	The organisation's strategy for consulting patients, members of the public, health professionals and other stakeholders ensures that a wide range of views are heard.	3
	Domain points possible: 25		**21**
Clinical Effectiveness	**16**	The organisation has a system in place to identify relevant national guidance or standards.	5
	17	The organisation a system in place to manage uncertainties about, or unavailability of, evidence on clinical effectiveness.	5
	18	The organisation has a system in place to identify clinically ineffective services or treatments.	5
	19	The organisation has a system in place to decommission clinically ineffective services or treatments.	5
	Domain points possible: 20		**20**
Cost-effectiveness	**20**	The organisation has a system in place to collect and evaluate evidence in order to ensure that what is commissioned is cost effective.	5
	21	The organisation has a system in place to manage uncertainties about, or unavailability of, evidence on cost effectiveness.	5
	22	The organisation explains how it considers the financial implication of each decision (including the financial impact on other services, for example).	5
	Domain points possible: 15		**15**

Table 2 (continued): PHARMAC scores in DMAT framework.

DMAT value	Item		PHARMAC
Quality of Care	**23**	Information on quality of care, such as strategies and definitions, is publicly available and easy to find.	N/a
	24	Information on the quality performance of the services that the organisation commissions is publicly available and easy to find.	N/a
	25	The organisation can demonstrate that it has systems in place to identify and follow national quality care initiatives	N/a
	Domain points possible: 15		**N/a**
Fairness	**26**	The organisation demonstrates that it has policies in place to identify equality and diversity concerns that may arise from its decisions and strategies.	5
	27	The organisation can demonstrate that it commissions services on the basis of clinical need and not on the basis of other characteristics such as age, gender, ethnicity or sexual orientation.	5
	28	When services are prioritised for special patient or population groups (children or older people, for example), the organisation explains the reasons for this.	5
	Domain points possible: 15		**15**
Total points possible: 125 points			**119**

COMPETING INTERESTS
TS is a general practitioner member of PHARMAC's PTAC (Pharmacology and Therapeutics Advisory Committee), which provides independent expert clinical advice to PHARMAC. PL is supported by the National Institute for Health Research (NIHR) Applied Research Collaboration South London (NIHR ARC South London) at King's College Hospital NHS Foundation Trust. The views expressed are those of the author and not necessarily those of the NIHR or the Department of Health and Social Care. No other competing interests to declare.

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www.nzma.org.nz/journal-articles/is-pharmacs-decision-making-fair-findings-from-an-evaluation-of-decision-making-in-the-new-zealand-health-system

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This pākehā life: an unsettled memoir

Kaaren Mathias

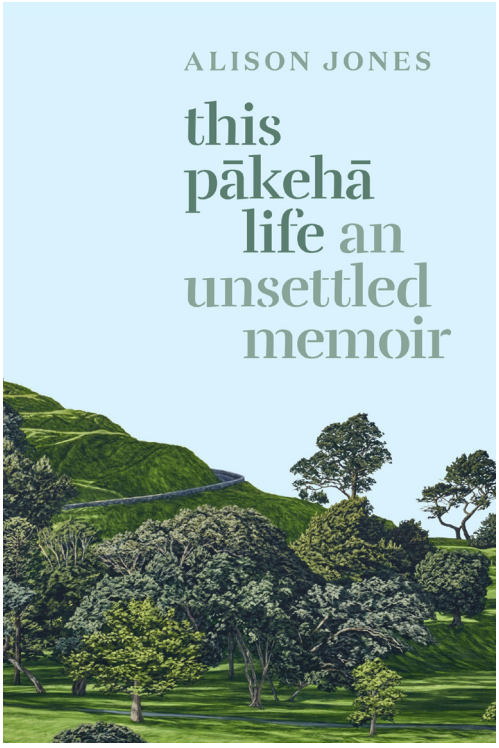
This pākehā life: an unsettled memoir is a candid memoir by Alison Jones, who currently is a Professor in the Faculty of Education and Social Work at the University of Auckland in the school of Māori and Indigenous Education, Te Puna Wānanga. She reflects on her identity as a pākehā (she uses lower case for pākehā throughout the book), privilege, belonging and not belonging, and race relations in New Zealand.

This book opens with a description of the place of her birth, in the shadow of One Tree Hill Maungakiekie. Jones reflects on how this volcano in Auckland Tāmaki Makaurau is emblematic of two stories: one with a Māori lens, where Maungakiekie was a large and active Māori pa with strategic location and views of the isthmus which commemorates Chief Tāmaki; the another with a pākehā lens and a focus on the grave of John Logan Campbell. Perhaps every place in Aotearoa has "another name, another history, another identity." Throughout the book, Jones invites pākehā to engage with our identity and our relationship with Māori as an ongoing journey rather than a one-off fix-it: "to engage with the inevitable pākehā state of permanent lively discomfort, eschewing a single resolution of our relationship with Māori."

This pākehā life was shortlisted for the General Non-Fiction Award at the 2021 Ockham New Zealand Book Awards and selected by *New Zealand Listener* as one of the best books of 2020. The title references Michael King's acclaimed *Being Pākehā*, although this book is more personal and less confident. Jones tells of her own halting professional and personal engagement with te ao Māori across decades: from taking her son to kōhanga reo, to learning te reo Māori in the 1980s, joining activist groups and working professionally as an academic at the University of Auckland in education for Māori. As well as discussing ancestral connection, Jones engages with intersectional identities, with a focus on feminism and gender relations in New Zealand. I appreciated the perspectives of Jones as an active participant in the national feminist movement while also affirming mana wāhine and leadership by Māori women.

This is an important book for readers of the *New Zealand Medical Journal*. It promotes critical reflection on our own intersectional identity. Noticing our own privilege and participation as white settlers can be (rightfully) uncomfortable, and this is an example of how one person has engaged with this mahi. Jones says, "it is in the space between us where everything happens," and further:

> *"Relationships seemed always to be at the heart of all my engagements with Māori and Māori things, and at the heart of Māori understandings of the world. I thought about how Māori profoundly understood and understand the world as a series of never-ending, never-resolved relationships- between people, objects, time, space and on and on... The complex, fluid, shifting site occupied by the hyphen in Māori-Pākehā engagements."*



This pākehā life: an unsettled memoir, by Alison Jones. Published by Bridget Williams Books, Wellington, NZ, 2020 (ISBN 9781988587288). 240 pages. NZ$36.00 (Kindle US$12.00). Image courtesy of Bridget Williams Books.

This pākehā life is also a thoughtful and well-told story of race relations in Aotearoa New Zealand that traces the author's experiences and those of her own ancestors (nineteenth-century colonists). Many pākehā senior medical specialists, myself included, learned far too little about race relations in Aotearoa in formal education. Reading books such as this is critical to being informed and to acknowledging more of the casual and wilful racism that is part of the history and current experience for people in Aotearoa New Zealand.

Jones helped me recognise that my identity as a pākehā is tightly tied up with Te Tiriti, which provides lawful authority for me to belong to this land by right.[1] I resonated with Jones' accounts of feelings of awkwardness and not belonging as she tried to engage with te ao Māori. She moved with more doubt than certainty while recognising the need to find her place and responsibilities among te tangata Tiriti.

White settlers will find Jones pointing to ways they can "do pākehā." In this land where there is indisputable evidence that health services and health policy continue to be racist,[2–5] perhaps junior and, even more so, senior pākehā doctors can consider how to start to decolonise our own professional practice. Jones provides some signposts on the path she has walked in her efforts to decolonise her practice as an educator: through building professional and personal relationships with Māori, inviting others to share in her privilege, learning and using te reo and advocating for equity in education for Māori through her academic writing. *This pākehā life* would work well as a as a springboard for discussion in a peer review or other professional group. Reassuringly, this book doesn't provide definite answers but promotes the value of exploring pākehā identity as a complex, important journey: "In the end, the most important things are ineffable, unexplainable, difficult and sometimes even contradictory."

COMPETING INTERESTS
Nil.

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School Hygiene in New Zealand

1921

URL: www.nzma.org.nz/journal-articles/school-hygiene-in-new-zealand

During the year, 1921, a total of 1,365 schools were visited, and the result of the examination (partial or complete) of 78,980 children recorded. Of those who were examined in the routine way an average of 79 per cent. was returned as having physical or mental defect of some kind. In interpreting this percentage it should be understood that under the heading of "dental decay" are recorded only those cases with carious permanent teeth, or more than three carious temporary teeth—*i.e.*, an average of 54.6 per cent. for all districts. The number of children with perfect sets of teeth is probably not more than 2 or 3 per cent.

During the past year effort was concentrated particularly upon the routine examination of the entrant and primer classes, to which the following figures largely refer. Some of the percentages of defect are therefore not so high as those obtained in previous years, when Standard II. was examined for statistical purposes.

Impaired nutrition was found present in 7.25 per cent. I should emphasize that these figures represent only such cases as are not referable to any other heading. For instance, deformity of the chest and dental caries are well-recognised indications of faulty nutrition. Others, again, are included under less definite headings, such as "anæmia" and "suspected tuberculosis."

Deformity of trunk and chest was found present in 23.8 per cent. This figure includes not only cases of such definite deformity as pigeon-breast, spinal curvation, and so on, but also cases of faulty posture associated with round shoulders and flat chest. These habitual faults of posture, unless corrected, develop in time into fixed deformities. It is for this type especially that the "corrective class" with its special physical exercises is devised.

Defective vision was detected in 4 per cent. of the examined. This figure is probably below that of the actual defect existing, as the test was applied by some officers only where defect was suspected. The result of previous examination of children in Standard II. gives 10 per cent. suffering from defective vision.

Obstructed breathing occurs to some extent in 19.0 per cent. of children, in the following proportions: Adenoids, 2.8 per cent.; enlarged tonsils, 13.4 per cent.; adenoids and enlarged tonsils, 2.8 per cent. Many of these cases show obstructed breathing to slight degree, and, by well-regulated breathing-exercises and physical drill, improve without operation. (Extract from Report, 1921, of the Director, Division of School Hygiene.)

Errata

URL: www.nzma.org.nz/journal-articles/nzmjerrata

Choosing Wisely: the lack of validity of ultrasound scans in the investigation of shoulder instability

Callum Oorschot, Khalid Mohammed, Michael Austen, Emma O'Loughlin

First published in: *2021 Nov 26; 134(1549)*

On Friday 4 February 2022, two corrections were applied to this manuscript:

- The manuscript's type was changed from viewpoint to article.
- The manuscript's page numbers were changed from 92–100 to 81–89.

Review of taste and taste disturbance in COVID-19 patients

Guangzhao Guan, Alison Mary Rich, Ajith Polonowita, Li Mei

First published in: *2021 Nov 26; 134(1549)*

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