
COVID-19 outbreak management in a hospital ward: lessons learned to prevent, prepare for and respond to infectious disease outbreaks in healthcare settings

Estimating the risk of outbreaks of COVID-19 associated with shore leave by merchant ship crews: simulation studies for New Zealand

Pacific peoples and alcohol: a review of the literature

Estimating the effect of selective border relaxation on COVID-19 in New Zealand

The clinical workforce caring for emerging adults with diabetes in New Zealand is under resourced
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Estimating the effect of selective border relaxation on COVID-19 in New Zealand
Benjamin J Smith, Arthur J Morris, Ben Johnston, Stephen Child, Simon Thornleye
A data scientist, with a group of senior doctors, have modelled the effect of tailoring border testing and quarantine policy that would enable some international travel from countries where COVID-19 is rare. New Zealand now maintains low levels of COVID-19 in the community, with two-week quarantine, and now predeparture tests, being required for travellers from many regions. Data scientist and lead author, Dr Ben Smith, says: “We have explored how the risk to New Zealanders could be estimated based on how common COVID-19 is in the traveller’s country of origin and the safeguards in place across the traveller journey... By tailoring border, testing and quarantine requirements to a traveller’s country, New Zealand could increase international travel from countries with very low levels of COVID-19 while keeping community exposure to the virus to very low levels.”

Estimating the risk of outbreaks of COVID-19 associated with shore leave by merchant ship crews: simulation studies for New Zealand
Nick Wilson, Tony Blakely, Michael G Baker, Martin Eichner
We conducted a modelling study that aimed to estimate the risk of COVID-19 outbreaks in a COVID-19-free destination country (New Zealand) associated with shore leave by merchant ship crews who were infected prior to their departure or on their ship. We found that the introduction of SARS-CoV-2 through shore leave from international shipping crews is likely, even after long voyages. But the risk can be substantially mitigated by control measures such as PCR testing and mask use.

Referral for investigation: a redundant SNOMED-CT chief presenting complaint
Peter G Jones, Mark Gardener
We audited the use of the non-specific chief presenting complaint ‘Referral for investigation’ for emergency department (ED) attendances and found that this was used around 5% of the time. In 94% of cases a more specific and useful chief presenting complaint was available. ‘Referral for investigation’ was used more often for the most urgent cases, meaning data quality was worse for the sickest or most severely injured patients. To improve data quality, we recommend that ‘Referral for investigation’ be removed from the ministry of health SNOMED-CT ED reference set.

Stereotactic ablative radiotherapy for early stage lung cancer and lung metastases in a New Zealand population
Rebecca Geary, Frank Lin, Ziad Thotathil, Nur Azri Bin Haji Mohd Yasin, Deborah Whalley, Charles DeGroot
Stereotactic radiotherapy is the delivery of higher doses of precisely targeted radiotherapy in fewer treatments than conventional radiotherapy. This study demonstrates that the outcomes of stereotactic radiotherapy in Waikato, when used to treat both lung cancer and cancer that has spread to the lungs, are similar to the outcomes reported from other centres around the world. However, Māori patients with lung cancer have worse outcomes with stereotactic lung radiotherapy than non-Māori patients, despite similar tumour characteristics.
New Zealand’s vocational Rural Hospital Medicine Training Programme: the first ten years
Katharina Blattner, Rory Michael Miller, Rachael Lawrence-Lodge, Garry Nixon, Patrick McHugh, Joel Pirini

This study reports the first-decade outcomes of the Rural Hospital Medicine Training Programme (RHMTP), which was established in 2008 in response to serious rural hospital medical workforce shortages. The study found that, of currently practicing RHMTP graduates, 92% (24/26) are working in rural New Zealand, mostly (22/24) in rural hospitals with the majority of graduates also completing vocational general practice training. This study provides the first real evidence on actual postgraduate practice location (as compared to ‘intent to practice’) for rural career choice for New Zealand medical practitioners and adds to international evidence that dedicated rural postgraduate training is strongly associated with entering rural practice. Although trainees value the RHMTP’s flexibility and breadth of clinical exposure, findings also highlight programme-related factors that are impacting progress through the RHMTP for some trainees. Attention to existing barriers will ensure the RHMTP reaches its potential to benefit all of New Zealand’s rural communities.

Anticoagulant-related intracranial haemorrhage:
time to anticoagulant reversal improving but still slower
than thrombolysis for ischaemic stroke
Holly J Mee, Hugh Carl Hanger, Tim Wilkinson, Teddy Wu, James Michael Beharry

The time taken to reverse anticoagulation (blood thinners) when a patient presents with intracranial haemorrhage (bleeding within the brain) is improving over time at Christchurch Hospital. However, these times are much slower than equivalent thrombolysis (medication given to break down clots acutely) for ischaemic (restricted blood flow) stroke. This study recommends equal priority of treatment for patients presenting with intracranial haemorrhage to those presenting with ischaemic stroke.

The clinical workforce caring for emerging adults with diabetes in New Zealand is under resourced
Ryan Paul, Vickie Corbett

Diabetes is one of the most common disorders in emerging adults (15–25 years of age) and affects approximately 2,300 New Zealanders in this age group. Emerging adulthood is typically the hardest age group in which to achieve good glycaemic control (control of glucose levels), due to the high prevalence of psychosocial stressors and increased insulin resistance of puberty. Consequently, international guidelines recommend emerging adults with diabetes receive care from a dedicated multidisciplinary team consisting of an endocrinologist (specialist diabetes physician), diabetes nurse specialist, dietitian, psychologist and social worker or youth worker. Our survey of all 20 district health boards (DHBs) show that the clinical workforce caring for emerging adults with diabetes in New Zealand is significantly under resourced, with only twelve DHBs having a dedicated multidisciplinary team, only eight DHBs having dedicated dietitian staff, three DHBs having dedicated psychology staff and four DHBs having a dedicated social worker or youth worker/health navigator. Median staffing-to-patient ratios were at least three-fold less than international recommendations, more than ten-fold and thirty-fold less for dietitians and psychologists, respectively, and approximately half that of staff caring for children with diabetes in New Zealand. Despite the increasing prevalence of type 2 diabetes in emerging adults, no DHB had an intervention programme for type 2 diabetes in this age group.
Pacific peoples and alcohol: a review of the literature
Vili Hapaki Nosa, Gemma Malungahu, Janine Paynter, David Newcombe, Dudley Gentles
This is a scoping literature review of recent research exploring alcohol use by Pacific peoples in New Zealand. We conducted a scoping review of published and grey literature written and published between 2009 and 2019. Research was included if the study population, or a clearly identified subgroup of the study population, included one or more Pacific ethnicities and addressed alcohol use. Alcohol consumption by Pacific men has declined significantly, to 60% from 70%, in 2006/07. However, of those who consume alcohol, 46% meet the threshold for hazardous consumption. Alcohol consumption by Pacific youth has also declined.

COVID-19 outbreak management in a hospital ward: lessons learned to prevent, prepare and respond to infectious disease outbreaks in healthcare settings
Catherine Habel, Jerome Ng, Phil Shoemack, Kate Grimwade, Fiona Miller, Jen Boryer, Hayley Bennett, Stephanie Chisholm
A number of COVID-19 outbreak clusters occurred across New Zealand. One such occurrence was in a mental health hospital ward of a medium sized district health board (DHB). This manuscript reflects on the effective management of this COVID-19 outbreak and considers what could have been done better. Lessons learned are shared to support other health providers to improve their outbreak management.

Cobalt toxicity: a preventable and treatable cause for possibly life-threatening cardiomyopathy
Gabriella Giacon, Ken Boon
Cobalt is a metal ion that is commonly used in certain metal-on-metal joint replacements. Commonly, these joints can return patients' mobility and independence. However, as this case report shows, serum cobalt levels can rise and cause a toxic effect on the heart. With rising serum levels can come greater damage, resulting in potentially irreversible cardiac damage and ultimately death.
Ashley Bloomfield

Just over a year ago on 29 January 2020, following the recommendations of the Emergency Committee, the World Health Organization Director-General declared that the COVID-19 outbreak constituted a Public Health Emergency of International Concern (PHEIC) under the International Health Regulations.

A few short days later, on 2 February 2020, New Zealand closed its border to non-New Zealanders travelling from or transiting through China. This was a somewhat contentious decision at the time, but there was much more to come; by the third week of March 2020, the border was effectively closed to all travellers other than New Zealand citizens and residents, and the whole of New Zealand was in Alert Level 4, or ‘lockdown’. The key drivers of these decisions were the desire to protect people from the virus, prevent the health system being overwhelmed, ensure New Zealand was not a route for the virus to be introduced into the Pacific and—hopefully—endure a short ‘painful’ hit to the economy and then recover economically as quickly as possible.

The initial intent of these measures was to ‘bend’ the rapidly growing epidemic curve of COVID-19 infections, so that infection numbers remained at a level that the healthcare system could cope with. However, it soon became apparent that a swift and timely lockdown, coupled with the requirement for 14-days managed isolation for all returnees from early April, had not just bent the curve but had ‘crushed’ it completely. This became known as elimination strategy—that is, keeping the virus out of New Zealand and ‘stamping out’ any community transmission—and it has remained the Government's strategy since.

Countries and jurisdictions pursued a range of responses, including an elimination strategy (eg, China, Vietnam, South Korea, Australia and many Pacific Island nations), while others broadly aimed to suppress or manage the virus to mitigate its impacts on healthcare systems (eg, UK, Sweden and many other European countries and the US). Not everyone agreed with the pursuit of an elimination strategy, with notable opposition from the so-called ‘COVID Plan B Group’ and, at times, some private sector and business leaders.

Much has been written about the comparative effectiveness of different countries’ COVID-19 responses, and most assessments consider New Zealand’s response to have been among the best globally. Features of the response that were key to its success to date: strong ongoing scientific input; rapid decision making, including at the political level; clear and consistent national communication through regular (often daily) media briefings, supported by a strong public communications campaign; the rapid scaling up of testing and contact tracing supported by rapid ICT developments; an excellent response from an already stretched health sector; and effective border management including the establishment and ongoing operation of over 30 managed isolation and quarantine facilities.

The complexity of the response is easy to underestimate, as is the relentless and intense challenge of maintaining it. In today's New Zealand Medical Journal, Wilson et al model one aspect of one border setting (the impact of shore leave for merchant
that has required considered policy work over recent months. Such policy work, undertaken of course with a range of other government departments (Transport, Customs and Foreign Affairs and Trade), agencies (Maritime New Zealand) and stakeholders (port authorities and maritime unions), informs a decision by Government (via Cabinet) and finally results in the development and publication of an Order under the COVID-19 Public Health Response Act 2020. Such Orders are required to be regularly reviewed to ensure that they are still necessary for maintaining a proportionate public health response to COVID-19.

Similar modelling work has been a key input into policy decisions over the last year, and the strong working relationship between government agencies and researchers (in universities, Crown Research Institutes and other organisations) has been critical to New Zealand’s overall successful response to date.

Key to developing and maintaining a successful elimination strategy has been a willingness to constantly revise and improve in response to new scientific evidence or empirical experience in other countries, or in response to emergent problems, identified gaps and formal reviews—of which there have been many! Today’s paper by Habel et al identifies areas of focus to improve the response to an in-hospital COVID-19 cluster, with many of the findings and recommendations relevant for other hospitals. An ongoing commitment to reviewing and refining all aspects of our response will be essential during 2021, as we continue the focus on keeping the virus out of New Zealand and ‘stamping it out’ quickly if it does find its way through the border.

New Zealand also needs to be looking to the future. The next major challenge is the rollout of COVID-19 vaccinations across the country, and work on this has been underway for some months now—at pace. Initially vaccination will protect most of those who receive one or other vaccine (New Zealand has four different vaccines on order), and later in the year we would hope to achieve sufficient coverage for population (‘herd’) immunity. To have safe and effective vaccines less than a year after the pandemic was declared is truly remarkable; the challenge now is to ensure as many New Zealanders as possible receive these vaccines.

Until that time, the country needs to maintain its elimination strategy, although there is keen interest in taking a more nuanced risk-based approach to relaxing controls at the border. Today’s article by Smith et al models the potential impact of selectively relaxing border controls on COVID-19 infection numbers. Policy work on implementing such an approach commenced late last year. However, the emergence of new variants, first identified in the UK and South Africa and that look to be more transmissible than earlier variants of the virus, has led to additional—rather than fewer—controls (pre-departure testing and testing on day 0/1 for most arrivals). New Zealand has not been alone in implementing additional controls, and some jurisdictions that had, until now, not restricted travel across borders and/or had resisted mandatory managed isolation, have moved to implement such measures; the UK is the most obvious example.

The two big tasks for New Zealand in 2021 are to keep the virus responsible for COVID-19 out of the country and vaccinate as many people as possible. The health system has a major role to play in both these tasks. It will take all our collective focus and commitment to ensure we deliver for New Zealanders—but 2020 has also shown that most New Zealanders will support our efforts if they clearly understand why it is so important. Ongoing clear and consistent communication needs to continue, particularly to build and maintain public trust and confidence in COVID-19 vaccination. And we must all continue to relentlessly review, revise and improve our response if we are to adapt successfully to the constantly changing virus and global picture.
Competing interests:
Ashley Bloomfield is an employee of the Ministry of Health.

Acknowledgements:
Ministry of Health colleagues, who worked tirelessly to protect New Zealanders from COVID-19 in 2020.

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Estimating the effect of selective border relaxation on COVID-19 in New Zealand

Benjamin J Smith, Arthur J Morris, Ben Johnston, Stephen Child, Simon Thornley

ABSTRACT

AIMS: We developed a model, updated daily, to estimate undetected COVID-19 infections exiting quarantine following selectively opening New Zealand’s borders to travellers from low-risk countries.

METHODS: The prevalence of infectious COVID-19 cases by country was multiplied by expected monthly passenger volumes to predict the rate of arrivals. The rate of undetected infections entering the border following screening and quarantine was estimated. Level 1, Level 2 and Level 3 countries were defined as those with an active COVID-19 prevalence of up to 1/10^5, 10/10^5 and 100/10^5, respectively.

RESULTS: With 65,272 travellers per month, the number of undetected COVID-19 infections exiting quarantine is 1 every 45, 15 and 31 months for Level 1, Level 2 and Level 3 countries, respectively. The overall rate of undetected active COVID-19 infections exiting quarantine is expected to increase from the current 0.40 to 0.50 per month, or an increase of one extra infection every 10 months.

CONCLUSIONS: Loosening border restrictions results in a small increase in the rate of undetected COVID-19 infections exiting quarantine, which increases from the current baseline by one infection every 10 months. This information may be useful in guiding decision-making on selectively opening of borders in the COVID-19 era.

At the time of writing, the New Zealand government allows only citizens, residents and a small number of other exceptions to travel to New Zealand, and all these travellers must undergo a 14-day managed isolation and quarantine (MIQ) on arrival. This policy has had a significant impact on New Zealand, particularly the tourism industry, which, before the COVID-19 era, accounted for 5.8% of the nation’s gross domestic product (GDP). Further, labour shortages are likely to restrict productivity in a wide range of industries, including agriculture and horticulture, along with creating humanitarian issues from the effective lockout of many partners of recent migrants.

New Zealand has had relatively few cases of COVID-19, with a total of 1,683 confirmed test-positive cases and 25 deaths at the time of writing. At present, 67% of all cases have been either imported or import-related. In an analysis of cases from February to May 2020, 6.3% required hospital treatment, and older age most strongly associated with either hospital treatment or death (crude odds ratio 26 comparing cases aged older than 80 years to those aged 20–34 years).

Many countries are now enforcing border restrictions in proportion to the estimated risk of COVID-19 in the source country of the traveller. New Zealand, at present, is relatively restrictive compared to European and other English speaking countries, because New Zealand’s border policy does not vary by the prevalence of infection at the country of departure, which is arguably the strongest determinant of border risk.

The risk of people exiting MIQ while infectious is largely related to the recent prevalence of infectious cases in the traveller’s country of origin. Around the world, the prevalence of COVID-19 varies widely. Several locations (eg, Taiwan, Thailand) report no active, locally acquired cases. Some (eg, China, South Korea) report fewer
than 10 cases per 10^5 population. Others have high prevalence. For instance, the US, which now has over 900 active infections per 10^5 population. Testing and compliance with MIQ conditions can then further mitigate baseline risk.

At present, New Zealand relies on a 14-day MIQ system for all travellers, irrespective of the prevalence in their country of origin, to reduce the risk of imported infection. Because the risk of a traveller crossing the border with COVID-19 is related to the prevalence of infection in their country of origin, estimating risk by country could aid the planning of a risk-based border control system. Our aim was to estimate the rate COVID-19 would enter New Zealand following risk mitigation based on the traveller's country of origin.

Method

The risk of imported infection posed by international travellers can be estimated from the rate of infections in source countries, the volume of travellers coming from those countries and the success of border measures at reducing travellers' exit into the community while infectious.

Comprehensive details for all assumptions and formulae are provided in the appendices. Appendix 1 lists the supplementary online materials. All data presented here are based on prevalence data accessed on 22 August 2020. Daily updated data is displayed in a public, online dashboard, which will be maintained during the current pandemic: https://bnanalysis.shinyapps.io/border_covid_assessment/ (see Appendix 2 and Appendix 3). Appendix 4 provides details on the methods used to calculate country prevalence and transmission and mitigating steps during the traveller journeys. Inputs for the sensitivity analysis are provided in Appendix 5.

Prevalence

To estimate each country's up-to-date prevalence of infectious COVID-19 cases as accurately as possible, new cases, deaths and recovery data by country were obtained from John Hopkins' register (Appendix 4.1). Since asymptomatic COVID-19 infection is common, official case tallies may not accurately represent the true count of infections. To adjust for this, fatality counts were assumed to be more accurately recorded. Fatality counts were divided by an infection-fatality ratio (IFR), 0.6%, which better describes a population-level IFR than a simple case-fatality ratio, and the resulting infection count estimate was compared to official case counts to estimate a country's detection rate. The detection rate then adjusts prevalence based on active case counts (Appendix 4.1.3). This upwardly adjusted prevalence is then assumed to apply to travellers from that country. In practice, IFRs differ according to a population's age structure and other factors, so we have examined implications of differing IFRs within a sensitivity analysis (see Results, Sensitivity analysis).

COVID-19 deaths may not be reliably assessed in source countries. To check the reliability of fatality counts, we used each country's life expectancy as a proxy, because it is a marker of a health system's capacity to detect cases (Appendix 4.1.4). Countries were then grouped into five risk tiers based on prevalence: COVID-19 free; Level 1 (>0 and <1 active COVID-19 cases/10^5 population); Level 2 (1 to <10/10^5); Level 3 (10 to <100/10^5); and Level 4 (≥100/10^5). These tiers had varying requirements for polymerase chain reaction (PCR) tests and duration of MIQ, with longer periods of MIQ for travellers from higher prevalence countries, since spacing out PCR tests improves the overall sensitivity of the two tests combined. Prevalence was multiplied by historic volumes of passenger arrivals to obtain a predicted rate per month of COVID-19 infections crossing New Zealand's border.

We considered source countries with more than 2,000 travellers to New Zealand in August 2019. We avoided a longer-run average in order to reflect the most recent travel patterns. In reality, any pre-COVID-19 travel data could only roughly approximate current expected travel patterns, but 2019 travel data provides a starting point for estimating travel under one demand scenario. The web app described here is designed to allow policymakers to estimate infection rates under any level of travel demand.

Journey risk

To account for an increase in risk based on observed rates of viral transmission on flights, a small multiplier of 0.43% was applied to the prevalence (Appendix 4.2.6).
This multiplier will be sensitive to prevalence in source countries but not differing airline practices or flight lengths, and a sensitivity analysis (see Results, Sensitivity analysis) tests a higher level of spread (multiplier of 5%). The risk posed by an imported case may then be mitigated by screening and infection control on either side of the border, to either prevent travel or require MIQ after entering New Zealand for those who test positive (Figure 1). We calculated the risk mitigated using a pre-departure PCR test, MIQ of varying lengths on arrival and a second PCR test one day before the end of MIQ. PCR-positive cases detected in New Zealand were assumed to have their risk of infection mitigated almost completely by requiring 14 days in quarantine, following a previous modelling approach. Clinical studies were used to estimate the probabilities of symptoms, infectiousness and the PCR positivity of cases as a function of how many days before arrival each traveller was infected with COVID-19 (Figure 2 and Appendix 4.2.4). These were then combined across the traveller journey to estimate the aggregated sensitivity of border screening, considering both the risk of an infected traveller exiting MIQ undetected and the secondary risk (Appendix 4.2.7) of spreading the infection to another traveller in MIQ (Figure 3).

Designing traveller journeys

We designed three ‘traveller journeys’ based on the prevalence of infection in each country and risk reductions from screening and MIQ (Table 1). The three traveller journeys (below; Figure 3) apply to Levels 1, 2 and 3 and, in addition to separate treatments for COVID-free and very high-risk countries, are intended to limit undetected imported infections. For the purposes of our model, these were applied to all travellers, including New Zealand citizens, based on the country from which they were travelling.

Thailand, Taiwan, Western Samoa and the Cook Islands had no detected cases of infectious COVID-19 at the time of writing. Unrestricted travel from these countries and any others at the same Level could be allowed at minimal risk to New Zealanders. With regular surveillance, no imported infections are expected. Level 1, 2 and 3 traveller journeys include a pre-departure PCR test, so that positive cases are prevented from boarding, to reduce the number of infections entering MIQ and thus to reduce spread. These journeys differ only in the length of MIQ applied, and consequently, the time from arrival to the final PCR test. Level 4 country calculations were carried out initially without pre-departure PCR (because only New Zealand citizens and exceptions are permitted at Level 4), but we provided some supplemental calculations describing an enhanced intervention with a pre-departure PCR included.

For Level 1, a 1-day MIQ and pre-flight PCR reduces risk by 70% (Table 1). For Level 2, a 5-day MIQ stay and pre-flight PCR reduces exposure to cases by 91% (Table 1). Observed data under current policy indicates that a 14-day MIQ effectively mitigates infection for between 98% and 99.9% of travellers. For Level 3, the 14-day MIQ is combined with the PCR pre-flight check, and our estimates indicate that 14-day MIQ screening reduces undetected infections by 99%.

A previous estimate of 5-day MIQ effectiveness with only one PCR test at day three was 75%, in comparison to our estimate of 91%. In contrast, our estimate (1) simulates some arriving cases becoming non-infectious in quarantine, (2) assumes a pre-departure PCR test and (3) expects a pre-release test at day four rather than day three. When simulating a more comparable 5-day MIQ with only one test at day three and no recoveries, our model estimates an effectiveness of 79%, down from 91%, which is only slightly higher than the previous estimate of 75%.

To simulate cases, the model assumes a volume of passengers from each country relative to both lockdown levels and pre-lockdown volumes. The baseline volume of passengers expected is the current number of travellers given heavily restricted borders. Relaxation of restrictions would lead to greater demand. For Level 1 and Level 2, 20% of the difference in volume between the baseline and August 2019 volumes was added. For Level 3, 5% of the difference was added; a 14-day quarantine is expected to deter most short-term visitors leaving only long-term travellers. These assumed volumes are only exploratory, and can be modified in the app.
From the prevalence and rate of expected travellers, along with the risk-based interventions applied, we estimated the rate of undetected infections from each source location.

**Calibration**

We compared model-predicted monthly rates of COVID-19 infection with observed rates at New Zealand's border reported by the Ministry of Health. We used a constant multiplier to improve agreement between these measures. The multiplier was estimated by minimising the sum of squared residuals between observed and predicted monthly counts.

Analyses were conducted in R 4.0.2 and the web app developed in Shiny.

**Results**

**Prevalence**

For most countries, COVID-19 fatality rates indicated that active cases were likely to be under-reported. To compensate, we adjusted prevalence for countries across Levels 1–3 by a detection ratio (median: 1.7; IQR: [1.0, 3.3]; see Appendix 4.1.3). The estimated COVID-19 prevalence by country on 22 August 2020 is displayed in Table 2.

Our estimated risk reduction for MIQs of varying lengths is similar to that reported previously.\(^\text{10}\)

**Aggregate journey risk per imported case**

Relative traveller journey risk is illustrated in Figure 4 and further detailed in Appendix 6. The overall sensitivity of border screening measures for different spacings of PCR tests, with or without daily health checks, are outlined in Table 1 and are consistent with other published estimates.\(^\text{10}\)

In the status quo MIQ, we assumed 11,271 people per month will enter, which was the number of travellers to New Zealand in August 2019 (Figure 1).\(^\text{17}\) At this volume of travel, we estimated 22 infectious cases per month would arrive at the border in August, of which 0.41 (one infection every 2.4 months) would exit MIQ while infectious.

With the introduction of our Level 1–3 measures, the rate of undetected COVID-19 infections exiting MIQ for Level 1–3 travellers based on modelled traveller journeys is shown in Table 2. Basing our models on an assumed fraction of August 2019 travel (Appendix 4.2.2), we estimated that 60,806 travellers a month would come from COVID-free and prevalence Levels 1–3 countries, in addition to 4,467 from other countries—up from 11,271 from all countries in August 2020.

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**Figure 1:** Top line: Simplified COVID-19 border volumes per month released into New Zealand community given status quo policy. Bottom line: An example considering status quo risk as of 22 August 2020 as described in the results section. See Appendix 4.2 for more details.

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<td>Infections in transit New traveller infections in MIQ MIQ breaches Staff exposure at airport and MIQ</td>
<td>Total number of passengers expected assumed to be 20% of 2019 volumes</td>
<td>Pre-flight PCR test Pre-release MIQ PCR test MIQ recoveries MIQ health checks</td>
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**Estimated status quo risk as of 22 August 2020**

Number of cases estimated to exit quarantine in July

Weighted average based on June passenger arrival data scaled to July volumes with prevalence data as of 22 August 2020.

An estimated 0.43 cases generated per 100 pre-existing cases within the journey.

Most risk arises from this component because the 14 day quarantine is less effective at filtering more recent cases.

0.1% risk failure rate for original imported cases.

1.78% risk failure for cases arising due to spread after arrival.
Figure 2: Test sensitivity, proportion of cases with symptoms and proportion of cases that are infectious by number of days since infection.\textsuperscript{11,12,16} See Appendix 4.2.4 for full details on curve design.

Figure 3: Risk considered at each stage of the traveller journeys. Journeys for Levels 1, 2 and 3 included four stages: pre-departure PCR, flight, managed isolation and quarantine and release. Traveller journey for COVID-free countries contains no risk mitigation measures. Traveller journey for Level 4 countries remains the same as status quo (ie, no pre-departure PCR and 14-day quarantine). See Appendix 4.2.7 for detailed information.
Given these expected travellers across all Levels, we estimate that 24 infections per month will enter the traveller journey; around half of those will be screened out in the pre-departure PCR test, and following MIQ, 0.50 (one infection every two months) will exit MIQ undetected. This represents an increase of 0.10 infections per month for the intervention, or one additional infection exiting MIQ every 10 months. This is equivalent to an additional 0.16 per 10\(^{5}\) (0.10 cases per month in 65,272 travellers) during the period measured, relative to current traveller risk of 3.6 per 10\(^{5}\) (0.40 cases per month in 11,271 travellers). The rate of infection arising from the source countries of each level is shown in Table 2.

If these changes were combined with a pre-departure PCR for all travellers, including New Zealand citizens and other travellers from high prevalence countries, the predicted risk would fall below the estimated status quo, to 0.35 infections/month, which means 0.05 fewer infections per month than the status quo.

**Change in rate of undetected infections**

This reduction is achieved by allowing travellers from COVID-free countries to enter New Zealand without screening (0 infections), travellers from Level 1 countries to enter with a 1-night MIQ (0.022 infections a month, 45 months per case), travellers from Level 2 countries to enter with a 5-night MIQ (0.069 infections, 15 months) and travellers from Level 3 countries to enter with a 14-night MIQ (0.032 infections, 31 months).

The analysis was extended by modelling the application of the Level 3 traveller journey to all people, including New Zealand citizen returnees, so that they would require a negative PCR test 2–3 days pre-flight to enable travel. Although we expect 24 cases entering the traveller journey when this policy is applied, some cases are screened out before their flight; these are not present in quarantine to pose a risk to others, and, consequently, we estimate only 0.35 infections per month (one every 2.9 months) will

<table>
<thead>
<tr>
<th>Days from Test 1 to Test 2</th>
<th>Overall traveller journey aggregate sensitivity to detect COVID-19 cases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>without health checks</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>10</td>
<td>8</td>
</tr>
</tbody>
</table>

‘Spread risk’ includes the risk of COVID-19 spreading to other passengers during the flight and MIQ. Steyn, Binny, Hendy et al assumed a daily health check with 33% sensitivity per day for symptomatic cases. To simplify the model, we assumed just a single health check, on the same days as the PCR test, but assumed sensitivity of two consecutive health checks at an aggregate of 55%. Appendix 1 contains a link to the risk calculation spreadsheet used to calculate these values. Further details are in Appendix 4. MIQ, managed isolation and quarantine. PCR, polymerase chain reaction.
Table 2: Aggregate risk for selected countries by risk categories at 22 August 2020. Additional countries displayed at https://bnanalysis.shin-yapps.io/border_covid_assessment/ and in the appendix.

<table>
<thead>
<tr>
<th>Countries</th>
<th>Level</th>
<th>Infection prevalence per 100k</th>
<th>Infections per 100k without border protocols</th>
<th>MIQ Nights</th>
<th>MIQ Effectiveness</th>
<th>Infections per 100k after border protocol</th>
<th>Monthly volume of travellers</th>
<th>% of 2019 levels</th>
<th>Count</th>
<th>Undetected infections per month (months to an infection)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cook Islands, Samoa, Taiwan, Thailand. Australia: ACT, NT</td>
<td>COVID-free</td>
<td>0</td>
<td>0.000</td>
<td>-</td>
<td>-</td>
<td>0.000</td>
<td>20%</td>
<td>8,218</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>China, Malaysia. Australia: TAS, QL, SA, WA</td>
<td>1</td>
<td>0–1</td>
<td>0.043</td>
<td>1</td>
<td>69.8%</td>
<td>0.013</td>
<td>20%</td>
<td>29,030</td>
<td>0.022 (45)</td>
<td></td>
</tr>
<tr>
<td>South Korea, Vietnam. Australia: NSW</td>
<td>2</td>
<td>1–10</td>
<td>6.529</td>
<td>5</td>
<td>91.3%</td>
<td>0.567</td>
<td>20%</td>
<td>17,647</td>
<td>0.0689 (15)</td>
<td></td>
</tr>
<tr>
<td>Hong Kong, Canada, Germany, Japan, Singapore, United Kingdom, Indonesia, Ireland</td>
<td>3</td>
<td>10–100</td>
<td>33.098</td>
<td>14</td>
<td>98.9%</td>
<td>0.368</td>
<td>5%</td>
<td>5,911</td>
<td>0.0319 (31)</td>
<td></td>
</tr>
<tr>
<td>All others</td>
<td>Various</td>
<td>1386</td>
<td>14</td>
<td>98.2%</td>
<td>24.785</td>
<td>100%</td>
<td>1074</td>
<td>0.0423 (24)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sums of traveller numbers here do not include continued arrivals under the status quo system from countries excluded from our COVID-free and Level 1–3. Within each row, infections/100k are aggregated according to each country’s population, not their New Zealand travel rates. The last row, All others, are all countries in the dataset outside of our 22-country shortlist. MIQ effectiveness described in more detail in Table 1. Undetected COVID cases/month across Level 1–3 sums to 0.123, made up of 0.012 risk from Level 1–3 countries in the status quo, plus 0.111 additional risk in the intervention. Infections per 100k for each level weigh each country by its population, so these figures cannot be used directly to find the undetected infections/month in the last column, which is weighted relative to the volume of travellers from each country to New Zealand. For instance, the infections per 100k values for Level 1 mainly reflect China, since China’s population makes up the vast bulk of the population within Level 1 locations. However, undetected infections per month give much more weight to Australian states listed because of the larger volume of travel from Australia relative to China.
Figure 4A: Baseline traveller risk of imported COVID-19 before applying interventions. The width of each bar represents the number of travellers from each country in August 2019, and the height represents counts of infectious cases expected per 1,000 travellers. The area of each bar is proportional to the number of cases that would be expected under 2019 conditions if travel were opened without restriction.

Figures 4B: Expected cases exiting quarantine into the community across countries in three scenarios: the status quo, the risk-based travel interventions and the intervention combined with a PCR test for all returnees.
exit MIQ undetected, which is 0.05 (13%) lower than the status quo rate of 0.40 per month.

Model validation and adjustment

We compared our predicted rates of border-detected COVID-19 infections with observed infections to assess the validity of our model (Table 3). Only values from ‘trusted’ locations were compared, because predictions about other locations may not be reliable. We measured the monthly predicted infections imported from trusted locations based on prevalence rates estimated for the 15th of each month. We then collated data from daily Ministry of Health press releases to tally the observed number of cases imported from trusted locations.

Then, we compared the observed and predicted numbers of cases. We estimated a constant prediction multiplier that minimised the sum of squared differences for all four months: 0.78. Because this would lower the total number of predicted cases, we conservatively opted not to include this in our final predictions presented here.

Sensitivity analysis

Sensitivity to variations in predicted undetected infections exiting MIQ were tested by changing parameter point estimates (Table 4). Using our chosen point estimates, the rate of infections exiting MIQ increased by 0.10 each month (one additional infection every ten months). In comparison, the highest additional risk obtained through changing any one point estimate came when assuming 20% lower PCR sensitivity and two days’ additional incubation period (see Appendix 5, Figure 5.1); under this scenario, the intervention increased undetected infection rates by 0.22 infections per month (one every five months). Raising traveller volumes to very high levels increased undetected infections rates by 0.21 per month (one every five months). The next most sensitive parameter was prevalence of COVID-19 in travellers. If this were doubled, the rate of additional undetected infections per month increased by 0.16 per month (one more every six months). If MIQ breach risk was increased to one out of every 34 COVID-positive travellers, infection rates increased by only 0.12 per month (one every eight months). Flight transmission risk also made little difference—if this was 5% rather than the 0.43% used in this paper, infections would only increase by 0.13 per month (one every eight months). Constraining the traveller volume to 10% and 5% respectively for Level 2 and Level 3 while Level 1’s traveller volume remained at 20% decreased undetected infections to 0.07 per month (one expected every thirteen months).

Discussion

We estimated the rate of undetected COVID-19 infections exiting MIQ, basing our estimate on country prevalence and intervention measures and selective relaxation of current border policies. With the introduction of the proposed measures, the overall rate of undetected active COVID-19 infections exiting MIQ is expected to increase from 0.40 to 0.50 per month, an increase of one every 2.5 months to 2 months, or from 4.8 to 6.0 cases per year.

Table 3: Observed vs predicted cases arriving in New Zealand from trusted locations.

<table>
<thead>
<tr>
<th>Month</th>
<th>Total number of travellers</th>
<th>Trusted location: Predicted cases</th>
<th>Trusted location: Observed cases</th>
<th>Predicted–Observed</th>
<th>Adjusted prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>July</td>
<td>9,037</td>
<td>24</td>
<td>13</td>
<td>11</td>
<td>19</td>
</tr>
<tr>
<td>August</td>
<td>11,271</td>
<td>29</td>
<td>8</td>
<td>21</td>
<td>22</td>
</tr>
<tr>
<td>September</td>
<td>11,482</td>
<td>16</td>
<td>19</td>
<td>-3</td>
<td>13</td>
</tr>
<tr>
<td>October</td>
<td>12,096</td>
<td>57</td>
<td>52</td>
<td>5</td>
<td>44</td>
</tr>
<tr>
<td>Total</td>
<td>43,886</td>
<td>126</td>
<td>92</td>
<td>34</td>
<td>98</td>
</tr>
</tbody>
</table>

‘Trusted locations’ are those where health systems are considered robust due to a life expectancy of 70 or greater. Predictions for each month were drawn from a simulation based on prevalence values drawn from the 15th day of each month.
Table 4: Sensitivity analysis, showing the influence of various parameters on the monthly rate of undetected COVID-19 cases exiting managed isolation and quarantine.

<table>
<thead>
<tr>
<th>Parameter to test</th>
<th>Default value</th>
<th>Test value</th>
<th>Status quo cases in community per month</th>
<th>Intervention cases in community per month</th>
<th>Intervention as absolute increase per month</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Standard)*</td>
<td></td>
<td></td>
<td>0.40</td>
<td>0.50</td>
<td>0.10</td>
</tr>
<tr>
<td>IFR; traveller prevalence</td>
<td>0.6%; 100%</td>
<td>0.2%; 65%; 1%; 100%</td>
<td>0.66</td>
<td>0.77</td>
<td>0.11</td>
</tr>
<tr>
<td>Traveller prevalence</td>
<td>100%</td>
<td>200%</td>
<td>0.80</td>
<td>0.96</td>
<td>0.16</td>
</tr>
<tr>
<td>Traveller volume (Level 0; Level 1; Level 2; Level 3)</td>
<td>20%; 20%; 20%; 5%</td>
<td>50%; 50%; 25%; 20%</td>
<td>0.40</td>
<td>0.61</td>
<td>0.21</td>
</tr>
<tr>
<td>Quarantine breach risk</td>
<td>1/150</td>
<td>12/9000</td>
<td>0.29</td>
<td>0.40</td>
<td>0.11</td>
</tr>
<tr>
<td>Quarantine breach risk</td>
<td>1/34</td>
<td>0.89</td>
<td>1.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quarantine contacts</td>
<td>35</td>
<td>10</td>
<td>0.17</td>
<td>0.27</td>
<td>0.10</td>
</tr>
<tr>
<td>Quarantine contacts</td>
<td>70</td>
<td>0.63</td>
<td>0.74</td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td>Quarantine health checks efficacy</td>
<td>55%</td>
<td>5%</td>
<td>0.40</td>
<td>0.52</td>
<td>0.12</td>
</tr>
<tr>
<td>Symptomaticity</td>
<td>60%</td>
<td>90%</td>
<td>0.40</td>
<td>0.49</td>
<td>0.09</td>
</tr>
<tr>
<td>Flight transmission</td>
<td>0.43%</td>
<td>0.9%</td>
<td>0.39</td>
<td>0.49</td>
<td>0.10</td>
</tr>
<tr>
<td>Flight transmission</td>
<td>5%</td>
<td>0.54</td>
<td>0.67</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>PCR test sensitivity</td>
<td>20% lower and delayed by 2 days</td>
<td>0.40</td>
<td>0.62</td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td>Infectious period is two days longer (see Appendix 5, Figure 5.1)</td>
<td>0.40</td>
<td>0.51</td>
<td>0.11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*In the standard model, infection fatality rate (IFR)=0.6%, traveller prevalence=100%, traveller volume=20% for Level 0–2 and 5% for Level 3, quarantine breach risk=1/150, quarantine contacts=35, quarantine health check sensitivity=55%, taken on the same day as the PCR test, asymptomaticity=40% and infectious period is as modelled in the main paper, based on van Kampen et al (2020). For quarantine breach risk, 1/34 is the number of COVID-positive MIQ detainees reported breaching their conditions in July out of all COVID-positive July detainees; 12/9,000 is the total amount of the same, irrespective of COVID-positive status, and 1/150 is the log-average of the two fractions. Traveller volume was tested with varying rates from the COVID-free level to Level 3; Level 4 is assumed to stay constant as this proposal does not affect Level 4 travel.
Our plan allows an additional 53,372 travellers from low-risk countries, as of August 2020, a risk similar to that from 16,757 travellers under the existing system from the UK or just 707 additional travellers from the US. If all returnees, including New Zealand citizens, who return from Level 4 countries complete a PCR test before departure, we estimate only 0.35 infections per month (one every 2.9 months) would exit MIQ undetected, which is 0.05 lower than the status quo of 0.40 per month.

Limitations of our study
We have tried to balance simplicity with complex reality by focusing attention on factors that are most important and that most reduce uncertainty in our outcome measure—that is, the risk of release of undetected infection after selective border relaxation. Our sensitivity analysis demonstrates that sensible variations in many values, such as MIQ transmission risk, health check efficacy and typical infectious period, make little difference to the risk posed by selective border relaxation. Some of our model parameters, such as the sensitivity of repeated PCR tests, have inherent assumptions. We have assessed the validity of our model by comparing its predictions to historical data, but access to more detailed incoming infection rate data, ongoing monitoring of model assumptions and real-time alignment of predictions with the observed rates would be essential, should the model be used in practice.

Prevalence calculation strengths and limitations
We accounted for infection underreporting but assumed fatalities are accurate and that infection-fatality ratios are constant between countries. Considering comparisons of excess deaths with COVID-19 fatality reports for US states and countries around the world, fatality count is likely to be an accurate measure of deaths due to COVID-19. The adjusted infection count is based on an assumedly constant infection-fatality ratio that may vary between populations, particularly between those with different age structures. In our method we also assumed that the average time from test result to death is 21 days. We assumed specific travel numbers, and, as our sensitivity analysis demonstrates, different traveller numbers will proportionately alter the risk of undetected infection crossing the border into New Zealand.

Data reliability will need to be closely considered for some countries. Some may suppress reporting of outbreaks. Should this policy be enacted, we encourage New Zealand authorities to verify data directly from overseas health authorities.

Our analysis does not distinguish between brief (eg, a 90-minute MIQ breach) and prolonged community exposures (eg, an undetected infectious case exiting MIQ); it simply attempts to estimate the count of cases exposed to the community. The risk arising from undetected infections exiting MIQ have been estimated by other authors.

Traveller journey intervention strengths and limitations
As well as PCR screening, we considered other interventions, such as temperature and symptom screening. Studies show that temperature screening is not an efficient method of detecting infections during travel. Moreover, because 10–70% of infections are asymptomatic, it is unlikely to detect many cases. Nevertheless, we accept these checks could be helpful during MIQ and have included them within our risk calculations (Table 1).

We believe our MIQ breach risk estimate is conservative because the psychological pressure of a shorter confinement is likely to be lower, and thus cooperation is likely to be higher for periods shorter than 14 days. We have not calculated the probability of a community outbreak given the rate of exposure to infections. Accurately estimating this risk is critically dependent on understanding levels of immunity in New Zealand, for which there is now very little information. Other work could be extended using the same methods to estimate risk of community transmission. As New Zealand’s existing contact tracing facilities become more developed, the risk that a single case extends to community outbreak will likely reduce.

Novelty and operational context
While there is one pre-print publication assessing the risk of opening New Zealand’s border to Australia, no other reports assess a wider border-reopening risk; this report
examines travel from our highest source countries. The online dashboard displays up-to-date risk for over 100 countries.

Other countries have applied a variety of border policies. Travellers to Iceland, for example, must fill in a pre-registration form and are encouraged to download a COVID-19 tracing app to use during their stay. Iceland requires two PCR tests and five days of quarantine after entering the country.\textsuperscript{25,26}

Taiwan maintains successful elimination of COVID-19. The island nation allows travel for purposes other than tourism and social visits and requires a COVID-19 test taken three days or fewer before entry to the country, in addition to a 14-day MIQ.\textsuperscript{27}

Thailand, another nation with elimination status, essentially prohibits all entry by foreign nationals, with rare exceptions.\textsuperscript{28}

Managing risk: outstanding operational concerns

This paper may be the first to estimate COVID-19 prevalence in all countries and to provide a means of dynamically tracking border risk of imported infection. Country risk level has the potential to change over time. However, as countries move up or down levels, different screening and quarantine policies aim to keep per-traveller risk within a theoretical range from 0 to 0.9 infections per $10^5$, but typically towards the low end of that range, at just 0.19 per $10^5$ during the period measured, relative to the current traveller risk of 3.6 per $10^5$. The online dashboard provides daily updated prevalence.

For countries with infection prevalence too high for Level 3—even though no relaxation of current controls have been proposed with a low volume of travellers—the estimated risk of imported infections exiting MIQ is high: currently, this risk is 5.3 per $10^5$ or one every four months at current rates. Therefore, even slightly more stringent controls on this group are likely to substantially reduce rates of infections across the border. Specifically, universal pre-departure PCR, combined with the other interventions proposed here, would reduce risk by 15% from the status quo while allowing over 55,000 more people a month to travel to New Zealand.

If this approach were to be enacted, there are many operational questions beyond the scope of this paper that would need answering. The quality, accessibility and reporting times of COVID-19 tests performed outside New Zealand would need to be assessed. The New Zealand MIQ system would have to be expanded. Although the total number of rooms across all New Zealand hotels and motels is around 63,000, the existing MIQ system has effective capacity for only 7,316.\textsuperscript{29,8} Tracking travellers and enabling contact with them during their stay would be highly desirable (eg, Bluetooth technology could facilitate more efficient contact tracing and further mitigate the risk of COVID-19 outbreak beyond the border).

Application of the proposed risk-based 1- and 5-night MIQ for pre-screened travellers from lower-risk countries could considerably increase the rate of travellers the MIQ system is able to process. Travellers from Level 2 countries could be processed more than twice as fast as in the current system, and travellers from Level 1 countries could be processed seven times as fast as travellers under the status quo. While changes like these would mainly benefit tourism, many other sections of society may benefit as well, such as workers for agriculture, horticulture and aged and residential care. Risk-based pathways would also benefit education providers. This benefit is countered by the marginal increase in risk of undetected infection.

Conclusion

Overall, we estimate the magnitude of ongoing risk of COVID-19 entering New Zealand under the status quo border policy. There is a small marginal risk of selectively opening New Zealand's border with risk-adjusted traveller protocols. A number of logistic arrangements to support this policy, and greater verification of up-to-date prevalence of COVID-19, would be necessary. A careful comparison of the model's sensitivity to variations of its assumptions, and a comparison of predictions with observed data, as they become available, with suitable adjustments to the model in response to discrepancies, would be essential for successful implementation of this model.
Addendum, 27 January 2021

Since this paper was written, the New Zealand Government has adopted policy consistent with our proposal to introduce universal pre-departure PCR testing. In terms of relaxation of border policy, the Cook Islands and Australia have been engaged to allow quarantine-free travel, which at present is only partially implemented and is fragile in the event of new outbreaks. Our belief is that the additional risk from relaxation of border policy discussed here is effectively mitigated by the introduction of universal pre-departure PCR testing.

The estimated prevalence of COVID-19 across incoming passengers, weighted by 2019 passenger volumes, has increased from 2 to 12 per 1,000, which is around a six-fold increase. Correspondingly, most locations have moved up one risk Level since the time of writing: several formerly COVID-free countries are generally now Level 1; some formerly Level 1 countries now have Level 2 prevalence. This is not entirely unexpected, as we observed fluctuations in prevalence while preparing this article. Prevalence in some countries has moved in the opposite direction. Vietnam, for example, now has substantially lower prevalence and has thus moved from Level 2 to Level 1 in our model. We emphasise that the orders of magnitude in source country prevalence, and consequently the effectiveness of implementing a risk-based system to manage risk, has not changed. The changes in prevalence from the time of writing to publication underscores the importance of updating risk assessment when implementing such a border policy. The model is expected to respond to changing epidemiological circumstances (eg, transmissibility of strains and impact of vaccines through changing country prevalence).
Appendix

Appendix Figure 1: Table of contents of Appendix to Estimating the effect of selective border relaxation on COVID-19 in New Zealand. Read the complete appendix online: https://uploads-ssl.webflow.com/5e332a62c703f6340a2fa44/601a08af102ff565f674add6_4886%20-%20appendix.pdf

Appendix to ‘Estimating the effect of selective border relaxation on Covid-19 in New Zealand’

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5. IATA Travel Centre. COVID-19 Travel Regulations Map (Powered by Timatic); 2020. https://www.iatatravelpcentre.com/world.php

COMPETING INTERESTS:
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August 7, 2020:e56. doi:10.1056/NEJMc2025203
Estimating the risk of outbreaks of COVID-19 associated with shore leave by merchant ship crews: simulation studies for New Zealand

Nick Wilson, Tony Blakely, Michael G Baker, Martin Eichner

ABSTRACT

AIM: We aimed to estimate the risk of COVID-19 outbreaks in a COVID-19-free destination country (New Zealand) associated with shore leave by merchant ship crews who were infected prior to their departure or on their ship.

METHODS: We used a stochastic version of the SEIR model CovidSIM v1.1 designed specifically for COVID-19. It was populated with parameters for SARS-CoV-2 transmission, shipping characteristics and plausible control measures.

RESULTS: When no control interventions were in place, we estimated that an outbreak of COVID-19 in New Zealand would occur after a median time of 23 days (assuming a global average for source country incidence of 2.66 new infections per 1,000 population per week, crews of 20 with a voyage length of 10 days and 1 day of shore leave per crew member both in New Zealand and abroad, and 108 port visits by international merchant ships per week). For this example, the uncertainty around when outbreaks occur is wide (an outbreak occurs with 95% probability between 1 and 124 days). The combination of PCR testing on arrival, self-reporting of symptoms with contact tracing and mask use during shore leave increased this median time to 1.0 year (14 days to 5.4 years, or a 49% probability within a year). Scenario analyses found that onboard infection chains could persist for well over 4 weeks, even with crews of only 5 members.

CONCLUSION: This modelling work suggests that the introduction of SARS-CoV-2 through shore leave from international shipping crews is likely, even after long voyages. But the risk can be substantially mitigated by control measures such as PCR testing and mask use.

Historically, shipping has been involved in the global spread of pandemics, and maritime quarantine has been used as a successful control measure (eg, in the 1918 influenza pandemic). Maritime quarantine was even used successfully to prevent the arrival of the 2009 influenza pandemic in some island jurisdictions, such as Tokelau.

The COVID-19 pandemic has also had an impact on maritime vessels during 2020, as well as spread to people on shore. On the Diamond Princess, 19% of the passengers and crew became positive with the pandemic virus (SARS-CoV-2) and there was spread to Japanese responders on shore. Similarly, on the Grand Princess, 17% of those tested had positive results. On a much smaller cruise ship with 217 passengers and crew onboard, 59% were reported to be test-positive. On a fishing vessel, 85%...
(104/122) of the crew were infected. In terms of merchant vessels, an outbreak on a container ship was reported as infecting 23% (5/22) of the crew. Other such outbreaks have been detailed in media reporting (referred to in a review).

In response to the COVID-19 pandemic, border controls have been widely used to limit pandemic spread. Such border controls are particularly relevant for two types of strategy for controlling pandemics: (1) the exclusion strategy, as successfully practiced by some Pacific Island nations (eg, Tonga and the Cook Islands), and (2) the elimination strategy, as used by New Zealand and other jurisdictions (eg, Mainland China, Taiwan, and Australia).

Some of these jurisdictions have completely prohibited maritime vessels arriving at their seaports from countries that are not COVID-19-free (eg, the Marshall Islands have prohibited such incoming ships). But time periods are also used to lower risk. For example, a minimum of 14 days at sea before being allowed to enter the Marshall Islands, or 14 days plus a negative PCR test to enter New Zealand. There is also the standard international requirement for pratique whereby any ‘illness during the voyage’ must be notified to health authorities at the destination port. Collectively, these control measures seem to be working fairly well, although in October 2020 New Zealand reported that a ship maintenance worker became infected with SARS-CoV-2 after spending time working on a ship that had recently arrived in the country. This worker then infected other workers and a household contact onshore (but with no further known subsequent spread). Genome sequencing has indicated that the source of infection was shipping crew flying into New Zealand to join their ship.

Also in October 2020, another island nation (Australia) faced outbreaks on two cargo ships in a port in Western Australia, where (in one case) two onboard workers left a ship before the outbreak was detected.

Given this background, we aimed to expand on previous modelling work for air transport spread of COVID-19, to determine the risk of merchant ships being the source of COVID-19 outbreaks in an otherwise COVID-19-free country: New Zealand.

**Methods**

**Model design and parameters for SARS-CoV-2 and COVID-19**

We used a stochastic SEIR type model with key compartments for susceptible [S], exposed [E], infected [I] and recovered/removed [R]. The model is a stochastic version of CovidSIM, which was developed specifically for COVID-19 (http://covidsim.eu; version 1.1). Work has been produced from previous versions of this model, and in two places we detail the relevant equations and their stochastic treatment. The model was built in Pascal, and the computer code is available on request from the authors.

We ran 100 million simulations for each set of parameter values. Such a large number of simulations was necessary due to the very high probability of zero infected crew members boarding a departing merchant ship, given the low assumed incidence of infection (see Table 1). The overall framework for the processes modelled is shown in Figure 1. The parameters were based on available publications and best estimates used in the published modelling work on COVID-19 (as known to us on 27 August 2020). We assumed that 71% of infected COVID-19 cases develop clearly detectable symptoms (Table 1). Another assumption was the contagiousness in terms of the effective reproduction number ($R_{eff}$), which was 3.0 among crew members on board the ship and 2.5 in the destination country (Table 1).

**Shore leave in the destination country**

We selected New Zealand as a case study destination country, as it has previously achieved elimination of community transmission of SARS-CoV-2 and appears to have successfully controlled subsequent cross-border incursions of the pandemic virus. Upon arrival of ships in New Zealand, we used a period of shore leave by all the crews of one day (the median time ships are in port, based on Ports of Auckland data, the port in New Zealand’s largest city).

**Potential control measures**

Potential control measures are detailed in Table 2 and Figure 1 and include a PCR test on all the crews on arrival and mask use by the crews during shore leave. If any
crew member tested positive, then the shore leave for that particular crew was assumed to be prohibited and therefore no risk of any community outbreak from shore leave was assumed. If a crew member on shore leave developed and self-reported symptoms and then tested positive, this case would be isolated, and this could also trigger contact tracing, which was assumed to identify 80% of the infected contacts within 48 hours. Identified contacts would be isolated after a delay of one or two days.

**Ongoing infection transmission in the destination country**

Untraced secondary cases who were infected by crew members in the destination country, and tertiary cases who were infected by traced secondary cases before they were isolated, were assumed to roam freely for the full length of their infectious period and to potentially trigger outbreaks in the community.

**Control measures assumptions**

The full details on the considered control measures are given in Table 2.

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**Figure 1:** Flow diagram of the assumed movements of merchant ship crews in the model including interventions (simplified and not showing all control measures (eg, the seeking of medical attention when symptomatic in the destination country and the associated isolation of identified cases and contact tracing as detailed in Table 2)).

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**Results**

The results suggest that, if no pandemic-related maritime controls were in place, the COVID-19-free destination country (New Zealand) would quickly experience an outbreak because of the arrival of ships with infected crew members taking shore leave. That is an outbreak after a median duration of 0.064 years (23 days), which is equivalent to a total of 355 port visits and 7,100 total days of shore leave (for international vessels with 20 crew members and one day of shore leave per person per port; Table 3). However, there is high uncertainty, with 95% of outbreaks likely to occur between 1 to 124 days (ie, 0.0023 to 0.34 years; Table 3).

The median time to an outbreak would increase markedly by obligatory PCR testing of crew members before shore leave is permitted (ie, up to 168 days (0.46 years), or after a total of 2,592 port visits). An even further reduction of risk would occur when requiring face mask use during shore leave (increased median time to 1.00 years). But, relatively little extra gain in risk reduction
would result from any sick crew on shore leave self-reporting symptoms and the associated contact tracing (Table 3). Using the base case value of $R_{\text{eff}}=2.5$ in New Zealand, a single untraced infection in the community leads to an outbreak in 88.2% of cases (78.5% for $R_{\text{eff}}=2.0$). When we considered super-spreading events in the community in a scenario analysis, the outbreak probability per person was actually reduced to 57.4%. This is because allowing for super-spreading events means that a smaller proportion of infected crew members transmit infection, even though those that do will typically infect more people (assuming the same overall value of $R_{\text{eff}}$).

In scenario analyses, a smaller crew size reduced the outbreak risk (eg, the median time to an outbreak would be 3.8 years for ships with a crew size of five; Table 4). The risk of outbreaks was also lower when making assumptions around lower contagiousness in the destination country (ie, $R_{\text{eff}}$ lowered to 2.0). The risk remained basically unchanged when contagiousness on the ship was assumed to be higher (ie, $R_{\text{eff}}$ increased to 4.0). Increasing the shore leave to either two or three days increased the risk of an outbreak (ie, it reduced the median time to this event). When super-spreading events were considered in the destination country, this led to the same average number of untraced infections caused by crew members in New Zealand, but as each one of them had a lower risk of leading to an outbreak, the overall outbreak risk was lower than in the baseline study.

### Table 1: Input parameters used for modelling the potential spread of SARS-CoV-2 infections via merchant shipping with the stochastic version of CovidSIM (v1.1).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value(s) used</th>
<th>Further details for parameter inputs into the modelling</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Incidence of SARS-CoV-2 infection (using the global average)</strong></td>
<td>Daily incidence = 0.00038 (ie, 2.66 infections per 1000 population per week)</td>
<td>We estimated the incidence of new infections globally for 15 August 2020 using the following data and assumptions: For the initial estimate of the numerator, we used the global reporting to WHO of new laboratory-confirmed cases of SARS-CoV-2 infection on 15 August 2020 (n=294,237 new cases). For the denominator, we used the UN global population estimate for 2020 (7,794,799,000). To adjust for under-estimating of actual infections (compared to reporting of cases), we used the estimate of a 10-fold difference between reported cases and infections based on Havers et al for the US (with this 10-fold factor still probably being an underestimate). We assumed that, prior to the ship leaving for the destination country, the crew members have 1 day of shore leave during which they can pick up the infection at the given probability.</td>
</tr>
<tr>
<td><strong>Percentage of infections that are asymptomatic</strong></td>
<td>29% (50% in scenario analysis)</td>
<td>We used the estimate from a very large Spanish survey of 61,075 participants. It found the proportion of individuals with a positive test who were asymptomatic was 32.7% (30.2–35.4) for the point-of-care test and 28.5% (25.6–31.6) for the immunoassay. Given the immunoassay is likely to be more accurate than the point-of-care test, we used the 28.5% result. This estimate is similar to that for a working-age adult population of healthcare workers in the UK, in whom 27% of all infections were asymptomatic.</td>
</tr>
<tr>
<td><strong>Latency period</strong></td>
<td>5 days</td>
<td>We used the best estimate from CDC in May 2020 of a mean of 6 days until symptoms (ie, the latency period plus the prodromal period). We used a standard deviation (SD) of 25% (1.25 days) (calculated using 16 stages; Erlang distribution).</td>
</tr>
<tr>
<td><strong>Prodromal period</strong></td>
<td>1 day</td>
<td>There was (at the time of writing) insufficient information on this prodromal period for COVID-19, so we used an assumed value for influenza (SD=25%; 0.25 days, Erlang distribution).</td>
</tr>
<tr>
<td><strong>Symptomatic period</strong></td>
<td>10 days (split into 2 periods of 5 days each)</td>
<td>The WHO-China Joint Mission report stated that “the median time from onset to clinical recovery for mild cases is approximately 2 weeks and is 3-6 weeks for patients with severe or critical disease.” But, given that mild cases may have been missed in this particular assessment, we used a slightly shorter total time period of 10 days (SD=25%; 2.5 days, Erlang distribution).</td>
</tr>
</tbody>
</table>
Table 1: Input parameters used for modelling the potential spread of SARS-CoV-2 infections via merchant shipping with the stochastic version of CovidSIM (v1.1) (continued).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value(s) used</th>
<th>Further details for parameter inputs into the modelling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative contagiousness in the prodromal period</td>
<td>100%</td>
<td>We used the best estimate from CDC in May 2020 of infectiousness of asymptomatic individuals relative to symptomatic individuals of 100%.</td>
</tr>
<tr>
<td>Contagiousness after the prodromal period</td>
<td>100% and 50%</td>
<td>In the first five days of symptoms, cases were considered to be fully contagious. In the second five-day period, this was assumed to be at 50%. The latter figure is still uncertain, but it is broadly consistent with one study on changing viral load.</td>
</tr>
<tr>
<td>Effective reproduction number (R&lt;sub&gt;eff&lt;/sub&gt;) on board the ship</td>
<td>3.0 (4.0 in a scenario analysis)</td>
<td>The enclosed nature of the ship environment (and shared sleeping quarters in smaller vessels of under 3,000 gross tonnage) would favour spread of infection, and so we used a higher value than for the community (see in the next row). Noting the fishing boat outbreak (detailed in the Introduction) where 85% of the crew became infected, we also used a higher value (R&lt;sub&gt;eff&lt;/sub&gt;=4.0) in a scenario analysis. We assumed no routine mask use on the ship or specific additional physical distancing behaviours by the crew.</td>
</tr>
<tr>
<td>R&lt;sub&gt;eff&lt;/sub&gt; in the destination country (New Zealand)</td>
<td>2.5 (2.0 in a scenario analysis)</td>
<td>We used the best estimate from the CDC of 2.5 for community transmission. We assumed for New Zealand that the social behaviour in the elimination period (since May 2020) was fairly similar to the pre-COVID-19 state (ie, relatively little additional physical distancing, normal occurrence of large social events and no routine mask use by the great majority of the population). Nevertheless, we also considered a value of 2.0 in a scenario analysis. We assumed a population with no specific immunity to SARS-CoV-2.</td>
</tr>
<tr>
<td>Super-spreading in the destination country (New Zealand)</td>
<td>Just in a scenario analysis</td>
<td>Given some evidence for super-spreading phenomena with this pandemic virus, we also considered a scenario where in New Zealand just 10% of the cases generated 10 times as many secondary cases as the other cases.</td>
</tr>
</tbody>
</table>

Shipping-related parameters

| Merchant ship visits to the destination country (New Zealand) | 108 per week | In the last three quarters of 2019 and the first quarter of 2020, there were 5,600 merchant ship port visits in New Zealand by vessels originating in overseas ports (counting each port visit separately where multiple ports were visited). This is 108 port visits per week for such vessels. These vessels include bulk carriers, container ships, reefer, tankers, vehicle carriers and a range of other types of cargo vessels. |
| Voyage length | 10 days (scenario analyses ranging from 1 to 30 days) | We calculated merchant ship travel times using a specific website for travel times between seaports (http://ports.com/) and using a typical travel speed of 24 knots (44km per hour). This gave the shortest trip to New Zealand (Sydney to Auckland) at 1,330 nautical miles (nm) (2,463 km) taking 2.3 days at sea. It gave the longest possible trip to New Zealand (Montreal to Auckland) at 17,100nm taking 29.7 days at sea. Also, it gave the trip from the world’s busiest container port (Singapore) to Auckland of 5,828nm taking 10.1 days at sea. It gave the trip from the busiest European container port (Rotterdam) to Auckland of 14,569nm taking 25.4 days at sea. Given the complexities, we did not consider port calls and shore leave on route between the original departure point and the first New Zealand port of call. Also, we note that slower voyages than these can sometimes arise (eg, from storms at sea, port congestion, etc). |
| Crew size | 20 (scenario analyses: 5, 10, 30) | This value varies for the type of merchant vessel, but we used a figure of 20, which is mid-range for the crew size of a container ship (range 10 to 30 crew). A wider range of values was used in scenario analyses. |
| Duration of shore leave | 1 day (scenario analyses: 2, 3) | We analysed Port of Auckland data (the port in New Zealand’s largest city) for the 140 merchant ship visits detailed on their website for 20 August 2020. This indicated a median stay in this port of 1 day (range 0.3 days to 6 days). However, 31% of these international merchant ships had most recently come from another New Zealand port prior to the Port of Auckland. |
Table 2: Control measures and their estimated efficacy.

<table>
<thead>
<tr>
<th>Control measure</th>
<th>Key value</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pratique</td>
<td>Not considered as PCR testing more accurate</td>
<td>Although some cases of SARS-CoV-2 infection will be asymptomatic (see above) and others fairly mild, it is likely that some proportion of onboard outbreaks of COVID-19 would come to the awareness of the ship’s captain. A small proportion of cases would also become seriously ill requiring immediate treatment and potentially the diversion of the ship to a nearby port (or removal of a case by helicopter). The captain would be then legally required to alert health authorities in the destination port as part of pratique. On the other hand, if a captain knows that the crew are in particular need of shore leave, then such information about onboard outbreaks might not always be divulged. The captain may also discount any cases of respiratory illness as being due to other causes (eg, respiratory infections such as the common cold) and any such cases may have been resolved at the time of arrival. Hence we assumed that port authorities should place little reliance on pratique as a control process and should require PCR testing of all crew wanting shore leave (as outlined in the next row).</td>
</tr>
<tr>
<td>Compulsory PCR test on arrival of all crew</td>
<td>Variable sensitivity based on time since infection</td>
<td>As per our previous modelling work, we used the results of a study that fitted a Bayesian hierarchical logistic regression model for test sensitivity. This meant, for example, that at day 4 after infection, 67% of test results were false negatives (95%CI: 27% to 94%). This decreased to 20% (95%CI: 12% to 30%) on day 8 and then increased after this (eg, up to 66% (95%CI: 54% to 77%) on day 21). For cases who already recovered before their PCR test, we use the final value reported by Kucirka et al (ie, 34% sensitivity). We assumed all crew would request shore leave and that port health authorities would prioritise the PCR testing of seafarers immediately on arrival to allow for a day of shore leave (eg, we note that, as per some airports, PCR test results can be obtained within a few hours). We also note imminent access to faster testing (eg, FDA approval of a 15-minute test, which may have different sensitivity and specificity from the PCR test).</td>
</tr>
<tr>
<td>Mandatory mask use by the crews during shore leave</td>
<td>85% efficacy but only two-thirds (66.7%) adherence (and one-third adherence in scenario analysis)</td>
<td>We used the efficacy value of 85% from a systematic review and meta-analysis (n=2647; adjusted odds ratio=0.15, 95%CI: 0.07 to 0.34). Adherence to mask use in social settings in New Zealand (where local citizens are not typically using masks, except on public transport where it was mandated in August 2020) was considered likely to be suboptimal at two-thirds. In a scenario analysis, we set adherence to mask use at one-third (33.3%).</td>
</tr>
<tr>
<td>Self-reporting of crew members whose sicknesses start shortly before or during shore leave (ie, they are among the 71% of infected individuals who become symptomatic)</td>
<td>50% (self-reporting, occurring on average 1 day after symptom onset)</td>
<td>We used the same estimated value as in our previous Australia to New Zealand air travel study. Such reporting can trigger contact tracing among the public in the destination country and therefore lower the risk of an outbreak (see the next row, Table 1). But due to the complexities, we do not consider backward contact tracing among the crew. Of note is that 39.5% of people in New Zealand with ‘fever and cough’ symptoms routinely seek medical attention, as reported by the New Zealand Flutracking surveillance system. This value is very similar to other estimates of people in high-income countries with influenza who seek medical attention (eg, at 40% as used in other modelling).</td>
</tr>
<tr>
<td>Contact tracing if crew members develop symptoms in New Zealand, seek medical attention and are confirmed by PCR (see above)</td>
<td>80% of infected contacts are traced and isolated within 48 hours</td>
<td>We used performance data for the cluster of cases in Auckland in August 2020 where the official estimate was 80% of contacts contacted within 48 hours (as reported by the Prime Minister). We divided this into 60% within the first 24 hours and 20% in the next 24 hours. Of note is that variable performance for contact tracing has been reported for New Zealand at other times in August 2020, with 86% of contacts traced in 48 hours at one point.</td>
</tr>
</tbody>
</table>
Figure 2 shows that voyage duration is a key determinant of outbreak risk in the destination country, and this risk is especially high once voyages are longer than five or so days (ie, once the latent period is typically over and crews have become infectious). Onboard spread can maintain this risk over subsequent weeks, leading to more infected individuals on board; but this also increases the detection probability by testing on arrival in New Zealand. It can take a long time for the onboard epidemic to come close to ‘burning out’. Indeed, the outbreak risk in the destination country when there are no controls only starts to decline after a voyage time of three weeks, and even then it declines quite slowly (Figure 2). For larger crew sizes of 10 to 20 people, the risk of community outbreaks is still increasing slightly after three to four weeks of voyaging when no controls are used (Figure 3 and Figure 4). Interestingly, if PCR tests are implemented, the effect of longer travel durations generates results that are the inverse: the more the infection can spread on board, the more likely it will be detected. As none of the crew members were assumed to be allowed to go to shore if any one of them tested positive, the probability that infected people being allowed to enter New Zealand decreases as the number of infected people on board the ship increases. Adding additional interventions like wearing masks, self-reporting symptoms and contact tracing further improves the results; but the main effect is obtained by PCR testing prior to shore leave being permitted. With the full set of interventions, the median time to an outbreak increased, but this time varied widely by length of voyage and size of the crew (Figure 3 and Figure 4).

Discussion

Main findings

In this modelling work, we found that it might only be a matter of a few weeks before crew from international trading maritime vessels would trigger COVID-19 pandemic outbreaks in the destination country, if no control measures were in place. Of particular note is that even small five-person crews appear to contribute a risk after voyages of several weeks, and this risk only declines slowly thereafter. Fortunately, however, the risk of such outbreaks can be substantially reduced with the available interventions. In particular, PCR testing before leaving the vessel appears to be a valuable intervention, though this benefit still comes with high uncertainty as indicated by the wide range for 95% of the simulation results (shown in Table 3).

The results for our case study country (New Zealand) are likely generalisable to most countries that have seaports and maritime trade. Nevertheless, the risk could be somewhat less for some nations on a per population or per gross domestic product (GDP) basis because New Zealand’s economy is particularly trade orientated and especially dependent on sea trade. That is, it has no international trade by land routes and only a small proportion of trade volume is by air cargo. With a population of five million, New Zealand has 1,120 port visits from vessels with an international origin per million population per year.

### Table 3: Results of the simulations without interventions and with multi-layered interventions (with these being for a base case of 10 days at sea and 108 merchant ship visits per week, 20 crew per ship, one day of shore leave each per port visit in New Zealand, and with 100 million stochastic simulations being run for each set of parameters).

<table>
<thead>
<tr>
<th>PCR test upon entry</th>
<th>Wearing face masks when on shore leave (by the crew)</th>
<th>Self-reporting of symptoms (when in New Zealand)</th>
<th>Contact tracing for self-reported cases</th>
<th>Median duration until outbreak in New Zealand (years)</th>
<th>95% of outbreaks are likely to occur in this time interval (years)</th>
<th>Probability that outbreak occurs within 1 year</th>
</tr>
</thead>
<tbody>
<tr>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>0.06</td>
<td>0.002–0.34</td>
<td>100.0%</td>
</tr>
<tr>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>0.46</td>
<td>0.017–2.47</td>
<td>77.5%</td>
</tr>
<tr>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>1.00</td>
<td>0.037–5.53</td>
<td>49.9%</td>
</tr>
<tr>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>1.02</td>
<td>0.037–5.41</td>
<td>49.4%</td>
</tr>
<tr>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>1.02</td>
<td>0.037–5.43</td>
<td>49.3%</td>
</tr>
</tbody>
</table>
Study strengths and limitations

This is the first study (to our knowledge) to explore the risk of COVID-19 outbreaks arising from shore leave of maritime ship crews. Another strength is that the work builds on an established model that has been used to also study air transport and other aspects of SARS-CoV-2 transmission (see Methods).

But, as with all modelling, there are important limitations. Some of these relate to parameters. A particularly critical one is the daily incidence of SARS-CoV-2 infection in the source country that the ship leaves from. We used a global average for this incidence to account for the diverse maritime trading patterns that New Zealand has and also because the crews are internationally diverse (often flying in from another country just prior to the ship’s departure, which may expose them to higher risks via air terminals and on aircraft). Yet there are likely to be highly variable risks of infection between different source countries that the ship leaves from and countries that the crew come from, and these will change with the evolving global pandemic of COVID-19.

Other examples of parameter limitations are the $R_{\text{eff}}$ onboard such vessels and the $R_{\text{eff}}$ for shore leave by crew. The former is likely to vary by different designs of merchant vessels (container ships vs tankers vs bulk carriers etc) and also by size (eg, it is likely that, in vessels of under 3,000 gross tonnage, the crew are in shared sleeping rooms). However, we did not have sufficient data to model such heterogeneity. We also didn’t account for prior immunity among crew members from past exposure to the SARS-CoV-2 virus, which is likely to increase over time with global progression of the pandemic. Given the data limitations, we did not consider port calls and shore leave on route between the original departure point and the first New Zealand port of call. Such port calls may either increase the risk for New Zealand (if the visited port city on route has a higher incidence of infection than the origin country), or they may decrease the risk (by extending the time length of the voyage, if the origin country had a higher incidence of infection than the visited city). We also did not model risk of transmission to port workers who might go onto arriving ships (eg, pilots and health workers conducting PCR tests on board vessels), given the assumption that they would take appropriate precautions with physical distancing and use of personal protective

Table 4: Results of the scenario analyses for 108 merchant ship visits per week and the full set of interventions taking place (see last line of Table 3) with 100 million stochastic simulations run for each set of parameters. (For further information, see text and Table 2.)

<table>
<thead>
<tr>
<th>Scenario (compared to base case)</th>
<th>Median duration until outbreak in New Zealand (years)</th>
<th>95% of outbreaks are likely to occur in this time interval (years)</th>
<th>Probability that outbreak occurs within 1 year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base case with all interventions (for comparison purposes)</td>
<td>1.02</td>
<td>0.037–5.43</td>
<td>100.0%</td>
</tr>
<tr>
<td>5 crew members instead of 20</td>
<td>3.81</td>
<td>0.139–20.27</td>
<td>16.6%</td>
</tr>
<tr>
<td>10 crew members instead of 20</td>
<td>2.02</td>
<td>0.074–10.74</td>
<td>29.1%</td>
</tr>
<tr>
<td>30 crew members instead of 20</td>
<td>0.68</td>
<td>0.025–3.63</td>
<td>63.9%</td>
</tr>
<tr>
<td>2 days of shore leave instead of 1</td>
<td>0.28</td>
<td>0.010–1.51</td>
<td>91.3%</td>
</tr>
<tr>
<td>3 days of shore leave instead of 1</td>
<td>0.14</td>
<td>0.005–0.74</td>
<td>99.3%</td>
</tr>
<tr>
<td>$R_{\text{eff}}$ in New Zealand is 2.0 instead of 2.5</td>
<td>1.38</td>
<td>0.050–7.34</td>
<td>39.5%</td>
</tr>
<tr>
<td>$R_{\text{eff}}$ on board the ship is 4.0 instead of 3.0</td>
<td>1.07</td>
<td>0.039–5.68</td>
<td>47.8%</td>
</tr>
<tr>
<td>Super-spreading events can occur in New Zealand</td>
<td>1.61</td>
<td>0.059–8.54</td>
<td>35.1%</td>
</tr>
<tr>
<td>50% of infections are asymptomatic instead of 29%</td>
<td>1.01</td>
<td>0.037–5.36</td>
<td>49.7%</td>
</tr>
<tr>
<td>Mask use adherence during shore leave is one third (33%) instead of two thirds (67%)</td>
<td>0.64</td>
<td>0.023–3.41</td>
<td>66.1%</td>
</tr>
</tbody>
</table>
Figure 2: For ships with five-member crews, the median duration (log-scale in years) until a COVID-19 outbreak occurs in the destination country because of merchant ship crews taking shore leave. We assumed there were 108 cargo ships arrive each week. In the country of origin, each member can become infected at a rate of 0.00038 per day. Infections spread on board with an effective reproduction number $R_{eff}$ of 3.0 and in New Zealand with $R_{eff}$ of 2.5. Note that a voyage duration of 1 day is not applicable to New Zealand. Full black curves: no interventions are taken; full grey curves: all crew members are prevented from entering the country if one of them is PCR positive upon arrival; dotted grey curves: full set of interventions as outlined in Table 3. For each combination of crew size and voyage duration, 100 million voyages were simulated.

Figure 3: For ships with 10-member crews, the median duration (log-scale in years) until a COVID-19 pandemic outbreak occurs in the destination country because of merchant ship crews taking shore leave (other details as per Figure 2).
equipment. Yet people don’t always follow rules and accidental events may reduce the effectiveness of preventive measures.

Possible implications for future research and policy
Future research is needed to replicate this study (eg, using simulation models with a different structure and for a wider range of destination countries). The routine collection of international shipping transponder data, which is currently underway by other New Zealand-based researchers (funded by the Ministry of Business, Innovation and Employment), may also more precisely identify ship movements, travel times and also unusual events (such as ships exchanging supplies or crew at sea). Research could also explore the acceptability of, and adherence to, mask use by crews on shore leave in different settings.

As detailed above, the results in Table 2 and Table 3 might make some health authorities decide that the risk of allowing shore leave for crew is tolerable with control interventions such as PCR testing and mask use. But for small low-income island states (eg, the nations in the Pacific that were COVID-19-free in November 2020), the risk might still be considered too high, especially if they have limited surveillance and outbreak control capacity. In these states, either all shore leave could be denied (ie, cargo movement is performed without the crew leaving the vessel), or the ships that recently visited countries where COVID-19 transmission is occurring could be completely prohibited (eg, until a vaccine against COVID-19 is in use). Other policy options for risk reduction might include:

- Working with source countries to ensure that departing shipping crew get routinely tested for SARS-CoV-2 just prior to departure, and that any infected crew member is immediately replaced.
- Testing the crew twice with PCR tests in the destination country. Firstly, at the initial port visited in the destination country but with no shore leave permitted at this port. Then a second test at the second port visit in the country, at which point shore leave

**Figure 4:** For ships with 20-member crews, the median duration (log-scale in years) until a COVID-19 pandemic outbreak occurs in the destination country because of merchant ship crews taking shore leave (other details as per Figure 2).
leave could be permitted if all rounds of test results are negative. Also, once rapid tests are considered reliable enough and cost-effective enough, then crew could potentially be tested daily after their first port contact and until they leave the country.

• Ensuring that any shore leave is highly supervised or otherwise constrained to specific settings. Supervision by port authorities could be used to ensure high adherence with mask use and attendance at only designated settings (eg, specific seafarer clubs). Settings where super-spreading events could potentially occur (eg, restaurants, bars and night clubs) could be prohibited as part of shore leave.

• Limiting shore leave to just a particular port in the country in a town or city where there is particularly intensive routine PCR testing of port workers and in relevant parts of the community (to facilitate early outbreak detection). Such community testing, combined with testing all people hospitalised with respiratory symptoms, can potentially accelerate early outbreak detection.19

• Prioritising the provision of vaccination to shipping crews once vaccines against SARS-CoV-2 infection are available in the relevant countries.

Conclusions

Using simulation modelling, we estimated the risk of COVID-19 outbreaks in COVID-19-free settings as a result of merchant ship crews infected at the source of their voyage taking shore leave. Our results can potentially inform policymaker decisions about regulations regarding shore leave for crews and the use of various control measures such as PCR testing and mask use to minimise the risks if shore leave is permitted.

Competing interests:
Nil.

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URL:

REFERENCES


Referral for investigation: a redundant SNOMED-CT chief presenting complaint

Peter G Jones, Mark Gardener

ABSTRACT

AIM: The Ministry of Health has mandated that all emergency department (ED) presentations are coded using the Systematised Nomenclature of Medicine – Clinical Terms (SNOMED-CT) from 2021. The current ED reference set contains the non-specific term ‘Referral for investigation’ in the list of available chief presenting complaints (CPCs). The aim of this study was to determine the rate of use of this term and how often a more specific (and therefore more clinically useful) term was used.

METHOD: This was a cross-sectional audit of routinely collected presenting complaint data, supplemented by a retrospective case note review.

RESULTS: ‘Referral for investigation’ was used for 497/9,067 (5.5%, 95%CI 5–6%) presentations, with increased use for urgent cases. An alternative CPC was available in 467/497 (94.0%, 95%CI 92–96%) of cases from the existing reference set. Of 98 different CPCs, the common alternatives were: ‘Chest pain’ (6.4%), ‘Shortness of breath’ (4.2%) ‘Abdominal pain’ (3.8%), ‘Altered mental status’ (3.4%) and ‘Postoperative complication’ (3.2%). Six of 13 cardiac arrests and eight of 63 of multiple trauma cases were coded as ‘Referral for investigation’. With the addition of two new terms to the New Zealand reference set (‘Abnormal blood test’ and ‘Radiology request’), each of the remaining 30 presentations would have an alternative and more accurate CPC.

CONCLUSION: ‘Referral for investigation’ should be removed from the New Zealand emergency department reference set for chief presenting complaints to improve data quality.
sets is that they draw upon concepts from different hierarchies within SNOMED-CT that are clinically meaningful.

A previous audit at our site found that the SNOMED-CT concept ‘Referral for investigation’ was being used as the CPC for many primary care referrals to ED.2 As this implies the source of referral rather than what the patient presented with, this CPC lacks clinical relevance. Approximately 5% of ED presentations were being coded this way, with an alternative CPC evident from the clinician’s notes in 86% of cases.10 However, this data was limited by the small sample size of 43. If ‘Referral for investigation’ is being used when an alternative CPC is available, then the usefulness of CPC coding is reduced. This may limit the usefulness of CPC coding for surveillance of emerging viral diseases, emerging trends in recreational drug toxicity and mental health presentations.11–13 It also means that audit or research of any condition using CPCs will require a manual search of all cases of ‘Referral for investigation’ to ensure that the CPCs of interest is not missed, which would be a waste of time and resources.

The primary aim of the current audit was to find out how often a more specific CPC could have been used for those cases coded as ‘Referral for investigation’. The secondary aim was to explore which types of cases were more likely to be coded this way.

Method
This was a cross-sectional audit of routinely collected presenting complaint data, supplemented by a retrospective case note review.

Setting
Auckland City Hospital is an urban tertiary academic centre that has an annual census of approximately 76,000 patients 15 years of age or older.

Case selection
Consecutive presentations to ED were selected between 1 March and 30 April 2020. Two months was chosen to give a sample size of approximately 600 cases of ‘Referral for investigation’, based on our usual annual presentations (5% x 76,000 annual presentations / 6).

Data collection
Real-time CPC ‘Referral for investigation’
Real-time CPCs were recorded by triage nurses for all ED presentations except those ambulance patients requiring immediate resuscitation or primary care referrals to inpatient teams. Clerical staff recorded the CPCs for patients referred from their primary care provider or patients requiring immediate resuscitation (while clinical staff provided immediate care).

The following data was retrieved from the hospital data warehouse by one author (MG): event number, National Health Index (NHI), date/time of presentation, age, sex, ethnicity, Accident Compensation Corporation (ACC) status, triage code, arrival mode, real-time CPC and free-text triage comments fields. This was stored on a password protected USB stick.

Auditor CPC
The triage comments fields were scanned manually for text that mapped to the current SNOMED-CT CPC reference set.1 If there were multiple CPCs recorded in the triage comments field, the first CPC recorded was used. If there were no CPCs recorded in the triage comments field, the clinical records system Concerto (Orion Health, Auckland, New Zealand) was accessed using a password protected virtual private network connection on a password protected computer. One author (PJ) recorded CPCs based on the first treating clinician’s clinical notes. The first treating clinician was either an independent nurse practitioner or doctor. When there was more than one presenting complaint recorded by the first treating clinician, the first recorded presenting complaint was used.

Data handling
All data were entered into a purpose-built electronic data collection form in Microsoft Excel (Microsoft Corporation, Redmond, Washington, US) on a password protected USB stick.

Data analysis
The CPCs recorded were tabulated and described using number and proportion with a 95% confidence interval (95%CI). The 95%CI was calculated using Graphpad QuickCalcs (https://www.graphpad.com/quickcalcs/confInterval1; San Diego, CA, US).
Ethics

As an audit of the data quality undertaken by staff in the department where this data was collected, and as no identifying data would be reported, this study did not meet the threshold to require ethical approval. Institutional approval was obtained from the Auckland District Health Board Research Review Committee, A+8901.

Results

Over the period of the audit, there were 9,067 presentations to ED. ‘Referral for investigation’ was used for 497 presentations: 497/9067=5.5% (95%CI 5–6%). Table 1 shows the baseline demographics of this group compared to those cases with other CPCs. Those with ‘Referral for investigation’ as their CPC were more likely to be older or male or to have arrived by ambulance and have higher triage acuity compared to other patients.

In 467/497 (94.0% (95%CI 92–96%)) cases there was a more specific CPC from the current ED reference set recorded in the triage comments, primary care referral letter or clinical notes. In total, 98 different CPCs were used; these are shown in Figure 1.

The most commonly used alternative CPCs were: ‘Chest pain’ (32, 6.4%), ‘Shortness of breath’ (21, 4.2%), ‘Abdominal pain’ (18, 3.6%), ‘Altered mental status’ (17, 3.4%) and ‘Postoperative complication’ (16, 3.2%). Six of 13 cardiac arrests (46%) and eight of 63 of multiple trauma cases (13%) were coded as ‘Referral for investigation’.

Table 1: Demographics of sample population.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Referral for investigation</th>
<th>All other CPC</th>
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</thead>
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<tr>
<td></td>
<td>n, % (n=497)</td>
<td>n, % (n=8570)</td>
</tr>
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<td>Age</td>
<td>Mean (SD)</td>
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</tr>
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<td></td>
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<td>5760, 71.5</td>
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<tr>
<td></td>
<td>11, 2.2</td>
<td>37, 0.5</td>
</tr>
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</table>

CPC=chief presenting complaint; SD=standard deviation; CI=confidence interval; *4 missing triage categories from ‘Referral for investigation’ and 17 missing overall.
Figure 1: Specific CPCs.

CPC=chief presenting complaint; UTI=urinary tract infection.
The 30 cases where no specific CPC was available were: nine referrals for treatment of a specific condition, eighteen abnormal blood tests (seven hyperkalaemia, three abnormal liver function, two anaemia and one each for hypercalcaemia, d-dimer, creatinine, hypoglycaemia, hyponatremia and polycythaemia) and three were for specific radiology tests (one computerised tomography (CT) scan and two ultrasound).

Discussion

This comprehensive audit of use of the CPC ‘Referral for investigation’ in a New Zealand ED found that approximately 5% of all ED presentations were coded as ‘Referral for investigation’. This is consistent with a previous audit in our department in 2019. In nearly every case, an alternative and more specific CPC was available from the triage comments, primary care referral letter or clinical notes.

The cases where this non-specific CPC was used were more likely to be those arriving by ambulance and in the most urgent triage categories. This means that our data on the sickest patients are of lower quality than that of other patients. The need to rapidly load urgent cases onto the hospital information system and focus clinical staff on patient care immediately on arrival means that this CPC was used for expediency by some staff. However, as most urgent cases were being coded with a more specific CPC, this was likely due to individual variation in practice rather than intrinsic to the urgency of the situation.

We identified this issue with use of ‘Referral for investigation’ in 2019 and have attempted to reduce its use by a process of education and feedback for triage nurses and clerks. This process included departmental presentations, engagement of the opinion leaders within each craft group, email reminders and individual feedback. Despite these efforts, there has been no change over time. It is likely that other hospitals introducing SNOMED-CT as part of the Ministry of Health’s requirements may encounter similar problems. We therefore believe that the simplest solution to improve data quality is to remove the CPC ‘Referral for investigation’ from the New Zealand reference set. We also suggest that the following codes be added for presenting complaints that are not currently available in the reference set: ‘Abnormal blood test’ (151271000119102) and ‘Radiographic imaging procedure requested’ (168495003). The alternative to this change is to improve the delivery and uptake of education about more appropriate use of the ‘Referral for investigation’ CPC. This may be feasible in smaller departments with a limited number of staff involved: in our setting, the time and resources required to embark on further efforts at education for the more than 150 staff potentially entering this information would be considerable, especially when there is no guarantee of success. We believe the most efficient and practicable solution is to make the changes suggested above.

Conclusion

‘Referral for investigation’ was used for 5% of all cases presenting to our ED, particularly for the most urgent cases, despite more accurate and specific presenting complaints being readily accessible. ‘Referral for investigation’ should be removed from the New Zealand emergency department reference set for chief presenting complaints to improve data quality.
REFERENCES


Stereotactic ablative radiotherapy for early stage lung cancer and lung metastases in a New Zealand population

Rebecca Geary, Nur Azri Bin Haji Mohd Yasin, Frank Lin, Deborah Whalley, Ziad Thotathil, Charles DeGroot

ABSTRACT

AIM: Stereotactic ablative radiotherapy (SABR) involves the delivery of high doses of precisely targeted radiation in a shorter time period than conventional radiotherapy. The aim of this study was to compare the outcomes of lung-based SABR in a New Zealand cohort to the global literature.

METHODS: A single-institution retrospective analysis was performed on all patients who received lung-based SABR between May 2015 and September 2019 at Waikato Hospital, New Zealand. The study included both early stage lung cancer and lung oligometastases that measured less than 5cm.

RESULTS: 102 patients received SABR to 116 lesions. Median follow-up was 19 months. The three-year rate of local control in the primary and metastatic cohorts was 85% and 82%, respectively. This reflects the three-year local control rate of 86% for primary lung cancer in the SPACE trial and the two-year local control rate of 81% for pulmonary oligometastases in a German study. Central primary lung cancer was associated with a higher risk of local recurrence (HR 6.4 (1.3–31.5) p=0.02). The three-year progression-free survival rate in patients with early stage lung cancer and oligometastases was 56% and 26%, respectively. Māori patients with primary lung cancer had a significantly worse progression free survival (HR 2.4 (1.1–5.1) p=0.03). There were no reported grade three toxicities.

CONCLUSION: The use of lung-based SABR in a typical radiotherapy setting in New Zealand mirrors global outcomes.

Stereotactic ablative radiotherapy (SABR) involves the delivery of high doses of precisely targeted external beam radiation in a shorter time period than conventional radiotherapy. Leksell first described the concept of stereotactic radiosurgery in 1951. Initially, however, its use was restricted to intracranial targets. With advancements in linear accelerator technology, the use of stereotactic techniques was expanded to extracranial targets in the 1990s.

Lung cancer remains the leading cause of cancer death in New Zealand. Only 16.5% of lung cancer in New Zealand is diagnosed at an early stage. Māori patients are more likely to be diagnosed at a later stage and less likely to receive curative surgery than non-Māori patients.

Early international studies investigating the use of SABR for inoperable patients with early stage lung cancer demonstrated a local control rate of >85% at three years with a grade three or higher toxicity rate of <4%.

Meanwhile, increased interest and evidence in treating oligometastatic disease with curative intent has led to the application of SABR in the metastatic setting. SABR is sometimes considered more favourable than pulmonary metasstasectomy due to its non-invasive nature and low morbidity. Two-year local control rates for...
pulmonary metastases have been found to be in the region of 80% internationally. The aim of our study was to compare the outcomes of lung-based SABR treatment in a New Zealand cohort to the global literature.

Methods

Study design

A retrospective analysis was performed on all patients who received SABR to a lung mass between May 2015 and September 2019 at Waikato Hospital, New Zealand. The study included patients treated in the primary and metastatic setting. Data on patient demographics, tumour characteristics and dosing schedules were collected from electronic medical records. Outcomes, including recurrence and toxicity rates, were collected by review of clinical letters and imaging reports. Toxicities were graded as per the RTOG 0236 schema.

Patient selection

All patients were discussed through the lung cancer multidisciplinary meeting (MDM), and their eligibility for SABR was based on the departmental guideline. Patients with T1N0M0 or T2aN0M0 (<5cm) non-small cell lung cancer who had an expected survival of more than one year and were not fit for or refused surgery were assessed for SABR. Each patient's performance status was considered in the context of the underlying morbidity and life expectancy. Patients with oligometastatic lung disease with ≤2 lesions ≤5cm in size with stable extra-thoracic disease were included. Staging with PET-CT was performed less than six weeks prior to SABR. Attempts were routinely made to obtain a histologic diagnosis, unless that was deemed not possible for safety or other technical reasons.

Procedures

Patient immobilisation was achieved using an extended vacuum bag with the patient in the supine position with elevated arms. A planning scan with a 4D CT and standard 3D CT without contrast was performed. An internal target volume (ITV) was directly contoured at maximal intensity projection. The planning target volume (PTV) was defined by adding a 5mm margin to the ITV.

The default dosing schedule was 54Gy in three fractions. If the PTV included the chest wall, a dose of 48Gy in four fractions was selected, and if the PTV was within 2cm of the central mediastinal structures, a dose of 60Gy in eight fractions was utilised. This reflects the protocols in the CHISEL study and a Dutch study, respectively. Deviation from this guideline was permitted at the discretion of the treating radiation oncologist. Dose constraints to at-risk organs were defined as per the RTOG 0618 protocol.

Outcomes

Follow-up time was defined as the time from completion of SABR to the latest clinic visit or thoracic imaging (whichever was more recent). The primary outcome measured was the local control rate. Secondary outcomes were progression-free survival (PFS), overall survival and toxicity profile. Local failure was determined on serial CT chest imaging every three to six months. Local failure was defined as an enlarging lesion with radiological features consistent with recurrence, such as an enlarging solid or necrotic component or a bulging margin. Progression-free survival was defined as the time from completion of the SABR treatment to progression or death from any cause. Overall survival was defined as the time from treatment completion to death from any cause.

Statistical analysis

Statistical analysis was executed using Microsoft Excel and IBM SPSS Statistics Subscription version 1.0.0.1327. The Kaplan–Meier method was used to report overall survival and progression-free survival. Univariate Cox regression analysis was performed to investigate the association of survival time with other variables. Age and tumour size were analysed as continuous variables. ECOG (<2; ≥2), smoking status (current smoker; not current smoker), ethnicity (Māori; non-Māori) and tumour location (central; peripheral) were analysed as categorical variables. A central tumour was defined as that with a PTV within 2cm of central mediastinal structures.

Results

Baseline characteristics

Between May 2015 and September 2019, 102 patients (116 lesions) received SABR treatment. One patient received treatment to four lesions. This patient had sequential treatment to two lesions followed by
concurrent SABR to a further two lesions at relapse. Eleven patients received SABR to two lesions: seven concurrently, three sequentially and one at relapse. The mean age of the cohort was 70 years (interquartile range: 63–75). Median follow-up was 19 months (95% CI 17–22; range: 0–52 months). Table 1 details the baseline patient characteristics.

Following discussion at MDMs, 86 (74%) of the lesions were considered early stage lung cancer and 30 (26%) were considered metastatic disease to the lung. The number of lesions that measured less than or equal to three centimetres was 101 (87%). Of those considered lung cancer primaries, 45 (52%) did not have confirmative histology. Tumour characteristics are detailed in Table 2.

Twenty-two patients received SABR treatment to 30 oligometastatic lung lesions. The majority of patients (13, 59%) had a colorectal primary. Two patients had metastatic melanoma, and there was one case each of breast cancer, liposarcoma, pancreatic cancer (neuroendocrine), mixed follicular/papillary thyroid carcinoma, lung cancer (squamous cell carcinoma), meningioma and pheochromocytoma. Eight (27%) of the metastatic lesions had confirmative histology.

Of all early stage lung cancer lesions, 64 (74%) were considered medically inoperable and 11 (13%) were considered clinically inappropriate for surgery. Eleven (13%) patients were offered surgery but opted against it. Patients were considered clini-

Table 1: Patient characteristics.

<table>
<thead>
<tr>
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<th>Primary (n=80)</th>
<th>Oligometastases (n=22)</th>
<th>Total (n=102)</th>
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<td><strong>Sex</strong></td>
<td></td>
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<tr>
<td>Male</td>
<td>21 (26%)</td>
<td>12 (54%)</td>
<td>33 (32%)</td>
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<tr>
<td>Female</td>
<td>59 (74%)</td>
<td>10 (45%)</td>
<td>69 (68%)</td>
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<td><strong>Ethnicity</strong></td>
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<tr>
<td>NZ European</td>
<td>44 (55%)</td>
<td>12 (54%)</td>
<td>56 (55%)</td>
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<td>Māori</td>
<td>26 (32%)</td>
<td>2 (9%)</td>
<td>28 (25%)</td>
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<tr>
<td>Other</td>
<td>10 (12%)</td>
<td>8 (36%)</td>
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<td><strong>ECOG status</strong></td>
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<td>10 (45%)</td>
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<td><strong>Lung comorbidities</strong></td>
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<td>2 (9%)</td>
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<tr>
<td>No</td>
<td>17 (21%)</td>
<td>20 (91%)</td>
<td>37 (36%)</td>
</tr>
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</table>
cally inappropriate for surgery at MDM if there were multiple suspicious pulmonary nodules, a history of another active malignancy or prior thoracic surgery. A PET-CT was used in the diagnostic work-up of 96% of all primary lesions.

Radiotherapy treatment

The most common dose, received by 50% of the cohort, was 48Gy in four fractions with two fractions per week. Thirty percent of the cohort received 60Gy in eight fractions and 10% received 54Gy in three fractions. The other 10% were prescribed a different dosing schedule. Table 3 details the dosing schedules used. One patient abandoned treatment after one fraction due to the progression of the disease noted during the planning process. Five patients in the primary lung cancer cohort received a biologically effect dose (BED) of <100Gy. A BED of >100Gy (p=0.68) was received by 93% of Māori and 95% of non-Māori. There was no observed difference in local control with increased BED (HR0.99 (0.95–1.04) p=0.88).

Table 2: Tumour characteristics.

<table>
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<tr>
<td>Right upper lobe</td>
<td>21 (24%)</td>
<td>9 (30%)</td>
<td>30 (26%)</td>
</tr>
<tr>
<td>Right middle lobe</td>
<td>2 (2%)</td>
<td>3 (10%)</td>
<td>5 (4%)</td>
</tr>
<tr>
<td>Right lower lobe</td>
<td>13 (15%)</td>
<td>4 (13%)</td>
<td>17 (15%)</td>
</tr>
<tr>
<td>Left upper lobe</td>
<td>37 (43%)</td>
<td>7 (23%)</td>
<td>44 (38%)</td>
</tr>
<tr>
<td>Left lower lobe</td>
<td>13 (15%)</td>
<td>7 (23%)</td>
<td>20 (17%)</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peripheral</td>
<td>55 (64%)</td>
<td>19 (63%)</td>
<td>74 (64%)</td>
</tr>
<tr>
<td>Central</td>
<td>31 (36%)</td>
<td>11 (37%)</td>
<td>42 (36%)</td>
</tr>
<tr>
<td>Chest wall contact</td>
<td>44 (51%)</td>
<td>14 (47%)</td>
<td>58 (50%)</td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤1cm</td>
<td>8 (9%)</td>
<td>10 (33%)</td>
<td>18 (15%)</td>
</tr>
<tr>
<td>&gt;1cm, ≤2cm</td>
<td>30 (35%)</td>
<td>14 (47%)</td>
<td>44 (38%)</td>
</tr>
<tr>
<td>&gt;2cm, ≤3cm</td>
<td>34 (39%)</td>
<td>5 (17%)</td>
<td>39 (34%)</td>
</tr>
<tr>
<td>&gt;3cm, ≤4cm</td>
<td>12 (14%)</td>
<td>0</td>
<td>12 (10%)</td>
</tr>
<tr>
<td>&gt;4cm, ≤5cm</td>
<td>1 (1%)</td>
<td>1 (3%)</td>
<td>2 (2%)</td>
</tr>
<tr>
<td>&gt;5cm, ≤7cm</td>
<td>1 (1%)</td>
<td>0</td>
<td>1 (1%)</td>
</tr>
<tr>
<td><strong>Presentation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Symptomatic</td>
<td>33 (38%)</td>
<td>1 (3%)</td>
<td>34 (29%)</td>
</tr>
<tr>
<td>Incidental</td>
<td>47 (55%)</td>
<td>6 (20%)</td>
<td>53 (46%)</td>
</tr>
<tr>
<td>Follow-up imaging</td>
<td>6 (17%)</td>
<td>23 (77%)</td>
<td>29 (25%)</td>
</tr>
<tr>
<td><strong>Histology of primary</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No histology</td>
<td>45 (52%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adenocarcinoma</td>
<td>21 (24%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Squamous cell</td>
<td>17 (20%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>3 (3%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Local control
Local failure developed in 9% (8/86) of lesions in the primary lung cancer cohort and 13% (4/30) of lesions in the metastatic disease cohort. The median time to local failure was 16 months (95%CI: 8–19). Figure 1 details the local control for all lesions. The actuarial three-year rate of local control was 85% (95%CI: 73–97%) in early stage lung cancer and 82% (95%CI: 66–98%) in oligometastatic disease. Central early stage lung cancers had a significantly higher risk of local recurrence than peripheral lesions on univariate Cox regression analysis (HR6.4 (95%CI: 1.3–31.5) p=0.02). Table 4 details the rate and type of locoregional recurrence in each cohort at end of follow-up.

Survival outcomes in early stage lung cancer
The first site of recurrence in patients with early stage lung cancer was local in 22% and regional or distant in 78%. Of the patients originally treated for a primary tumour, 11 (14%) had developed distant metastasis and 16 (20%) had died at end of follow-up. The actuarial three-year rate of progression-free survival and overall survival in early stage lung cancer was 56% (95%CI: 40–72%) and 71% (95%CI: 57–85%) respectively. Figure 2 demonstrates the progression-free survival and overall survival in this cohort. There was no difference in progression-free survival with tumour size (HR1.3 p=0.18), increased age (HR1.02 p=0.46), smoking status (HR0.8 p=0.61) or ECOG performance status (HR1.4 p=0.46).

Māori ethnicity
Māori patients with early stage lung cancer had a worse progression-free survival compared to non-Māori patients (HR2.4 (95%CI: 1.1–5.1) p=0.03). Median PFS in Māori and non-Māori patients was 24

Table 3: Dosing schedules.

<table>
<thead>
<tr>
<th>Dosing schedule</th>
<th>BED †</th>
<th>Total (n=115)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>48Gy/4#</td>
<td>105Gy</td>
<td>57</td>
<td>50%</td>
</tr>
<tr>
<td>60Gy/8#</td>
<td>105Gy</td>
<td>34</td>
<td>30%</td>
</tr>
<tr>
<td>54Gy/3#</td>
<td>151Gy</td>
<td>12</td>
<td>10%</td>
</tr>
<tr>
<td>44Gy/4#</td>
<td>92Gy</td>
<td>3</td>
<td>3%</td>
</tr>
<tr>
<td>52Gy/8#</td>
<td>86Gy</td>
<td>2</td>
<td>2%</td>
</tr>
<tr>
<td>55Gy/8#</td>
<td>93Gy</td>
<td>2</td>
<td>2%</td>
</tr>
<tr>
<td>36Gy/3#</td>
<td>79Gy</td>
<td>2</td>
<td>2%</td>
</tr>
<tr>
<td>50Gy/5#</td>
<td>100Gy</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>45Gy/5#</td>
<td>85Gy</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>54Gy/8#</td>
<td>90Gy</td>
<td>1</td>
<td>1%</td>
</tr>
</tbody>
</table>

† Biologically effective dose.

Table 4: Locoregional recurrence.

<table>
<thead>
<tr>
<th></th>
<th>Primary (n=86)</th>
<th>Percentage</th>
<th>Metastatic (n=30)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>8</td>
<td>9%</td>
<td>4</td>
<td>13%</td>
</tr>
<tr>
<td>Lobar</td>
<td>6</td>
<td>7%</td>
<td>1</td>
<td>3%</td>
</tr>
<tr>
<td>Nodal</td>
<td>9</td>
<td>10%</td>
<td>1</td>
<td>3%</td>
</tr>
<tr>
<td>Any</td>
<td>15</td>
<td>17%</td>
<td>5</td>
<td>17%</td>
</tr>
</tbody>
</table>
There was no significant difference in overall survival between Māori and non-Māori Māori patients: median 42 months (95% CI: 21–62) vs 46 months (95% CI: 32–59), respectively (HR1.6 (95%CI: 0.6–4.2) p=0.34). The mean primary lung cancer lesion size in the Māori and non-Māori cohorts was 2.3cm and 2.18cm respectively (p=0.78). Central tumours accounted for 40.7% and 34.5% of the Māori and non-Māori cohorts respectively (p=0.58).

Confirmative histology
The presence of confirmative histology in patients with primary lung cancer was not associated with a difference in local control (HR3.2 (95%CI: 0.6–15.8) p=0.16) or overall survival (HR1.6 (95%CI: 0.6–4.2) p=0.35).

Survival outcomes in the oligometastatic cohort
Of the metastatic cohort, 8/22 patients (36%) had developed further distant metastasis and three patients (14%) had died at end of follow-up. The actuarial three-year progression-free survival and overall survival rates were 26% (95%CI: 3–49%) and 73% (95%CI: 46–100%), respectively. Figure 3 illustrates the corresponding Kaplan–Meier curves. Median progression-free survival was 19 months (95%CI: 10–27). Of the twelve patients who progressed after receiving SABR for metastatic disease, eight proceeded to further antineoplastic therapy and four did not. Colorectal malignancies represented 7/12 (58%) of those that progressed. The median time to subsequent therapy was 13 months.

Toxicity profile
There were no reported grade three side effects. The most common toxicity reported was chest wall pain (9%). Two patients developed a grade two rib fracture (2%). All five patients who developed grade two chest wall pain or rib fracture had received SABR to a peripheral lesion. The rate of pneumonitis was 4.7% in central lesions and 1.3% in peripheral lesions.

Discussion
This single-centre retrospective study evaluated the use of SABR in a typical radiotherapy setting in New Zealand. This is the largest series to date on the use of SABR in New Zealand. Reflecting its typical use, the study included SABR treatments to both early stage lung cancer and pulmonary metastases.

Surgery is generally considered the treatment of choice in medically operable early stage lung cancers. The American Society for Radiation Oncology guidelines state that SABR is not recommended for patients with standard operative risk.7 To date, there are no completed randomised controlled trials that directly compare the outcomes of surgery and SABR in
Figure 2: Progression-free survival and overall survival in early stage lung cancer.
Figure 3: Progression-free survival and overall survival in oligometastatic disease.
the treatment of early stage lung cancer. However, Chang et al combined data from two such trials that closed early (due to slow accrual) and reported no significant difference in local or distant control between the surgical and SABR cohorts.\textsuperscript{17} A meta-analysis that examined 40 SABR studies and 23 surgery studies demonstrated no difference in estimated overall or disease-free survival after adjustment for the proportion of operable patients and age.\textsuperscript{18} After discussion at MDM, 13% of our primary cohort were deemed medically operable but opted against surgery.

Two randomised studies, the CHISEL and SPACE trials, compared SABR and conventional external beam radiotherapy (EBRT) for the treatment of inoperable early stage lung cancer.\textsuperscript{13,19} The CHISEL trial demonstrated a significant improvement in local control with SABR compared to EBRT: the two-year rates were 89% and 65%, respectively. The SPACE trial demonstrated a local control rate of 86% in both arms at the end of a three-year median follow-up. Our study demonstrates a reproducible local control rate of 85% at three years in patients who were treated with SABR for early stage lung cancer.

Fifty-two percent of our cohort who were treated for an early stage lung cancer proceeded to SABR without confirmative histology. There was no significant difference in local control or overall survival when confirmative histology was available. A Dutch study, with a larger cohort, has also demonstrated no difference in local control or overall survival in patients who had a pathological or clinical diagnosis of early stage lung cancer.\textsuperscript{20} The clinical diagnosis was based on a new or increasing FDG avid mass on PET-CT. Ninety-six percent of all primary lesions had a PET-CT as part of their diagnostic work-up in our study.

National statistics report that the incidence of lung cancer in Māori is over three times higher than in non-Māori and that Māori are more likely to be diagnosed at a later stage.\textsuperscript{5} Māori also have a significantly higher risk of cancer-specific mortality, even after the statistics are adjusted for age and stage at diagnosis. In our study, progression-free survival was significantly worse in the Māori cohort with early stage lung cancer, and although it was not statistically significant, overall survival was lower in the Māori cohort. This raises the question of possible differences in tumour biology or a genetic susceptibility to aggressive disease. Further research to evaluate this variability may ultimately guide clinical practice.

The site of first recurrence was outside the local treatment field in 78% in our study and 55% in the CHISEL trial.\textsuperscript{13} No patient or tumour factor, other than ethnicity, was associated with a worse progression-free survival.

Hellman and Weichselbaum first described the term ‘oligometastases’ in 1995 as an intermediate tumour state between localised and widely metastatic disease, with limited metastatic capacity and the potential for treatment with curative intent.\textsuperscript{21} The SABR-COMET trial demonstrated a significant improvement in progression-free survival and overall survival in patients with oligometastatic disease who were randomly assigned to SABR or standard palliative care.\textsuperscript{9} Median progression-free survival with SABR was 12 months in the SABR-COMET trial and 19 months in our study. At three years, approximately one quarter of patients in our cohort with oligometastatic disease had not developed progression. In patients who did develop progression, the use of SABR delayed the need for subsequent therapy by a median of 13 months.

A German study that investigated the use of SABR for pulmonary metastases in seven hundred patients reported a local control rate of 81% and an overall survival rate of 54% at two years.\textsuperscript{22} In this study, pulmonary metastases treated with SABR had a three-year actuarial local control of 82% and an overall survival rate of 73%.

The disparity between rates of local control and progression-free survival in both the primary and metastatic cohorts highlights the risk of distant metastasis despite achieving local control. Several practical aspects need to be considered with regard to pursuing systemic therapies after SABR in this population. First, there is currently insufficient evidence to support the use of adjuvant systemic therapy after definitive SABR for limited lung metastases or early stage lung cancer. Thus, subjecting patients to potentially toxic therapies may not be justified when the benefit is unclear. Second, in the absence of measurable primary disease, it is difficult to determine
whether an oligometastatic lesion is truly representative of an isolated single clone, or whether it is a part of a more widely disseminated disease process. For example, distant recurrences in breast cancer have been shown to have an evolutionary root from late drivers of resected primary tumours. Third, determination of histopathology and mutational profile is increasingly important in treatment decisions in early stage lung cancer, and there is emerging data to support the use of adjuvant targeted therapies after complete resection. Given many uncertainties remain unanswered, pragmatic trials should be designed to assess the benefits of systemic therapy after SABR in this heterogeneous, co-morbid population.

Timmerman et al demonstrated an 11-fold increased risk of severe toxicity when SABR was targeted to central compared to peripheral tumours. No grade three or higher toxicity was identified in our study. The adjustment of dosing schedules for central tumours may have contributed to this outcome. In contrast, the RTOG 0236 study reported a grade three to grade four toxicity rate of 16%. However, the toxicity rates in this RTOG study included a decline in pulmonary function tests, which were not routinely evaluated in our cohort.

The limitations of this study include its retrospective nature, the frequent absence of confirmative histology and the variability of the dosing schedules used. However, this variability reflects real-world use of SABR outside the clinical trial setting. This series demonstrates that the use of SABR in the New Zealand population largely mirrors the outcomes in the global literature. The challenges faced in the clinical decision-making of these patients stem from the scarcity of randomised trials available, the frequent failure to acquire confirmative histology and the complexity of detecting recurrent disease on imaging after treatment. Further randomised studies could determine whether the use of SABR is equivalent to surgery in early stage lung cancer or oligometastatic disease and define the threshold of both the number and size of lesions effectively treated with SABR.
Competing interests:
Nil.

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REFERENCES


New Zealand’s vocational Rural Hospital Medicine Training Programme: the first ten years  

Katharina Blattner, Rory Michael Miller, Rachael Lawrence-Lodge, Garry Nixon, Patrick McHugh, Joel Pirini

ABSTRACT

AIMS: The Rural Hospital Medicine Training Programme (RHMTP) was established in 2008 to develop New Zealand’s rural hospital medical workforce. This study evaluates the RHMTP’s first 10-year outcomes.

METHODS: A mixed-methods descriptive study. Database interrogation of: the Royal New Zealand College of General Practitioners records; University of Otago’s e-Vision; the Medical Council of New Zealand’s register of doctors. A survey of trainees who had graduated or withdrew from the programme. Survey questions included: current scope and place of employment; undergraduate rural experience; and trainee experiences.

RESULTS: From 2009–2018, 98 doctors entered the RHMTP: 29 graduated, 20 withdrew and 49 are active registrars. Of the graduates, more than half (17/29) also completed GP training. Overall survey response rate: 80% (39/49). Graduate response rate: 97% (28/29). 92% (24/26) of currently practising graduates are working in rural New Zealand, mostly (22/24) in rural hospitals. Trainees value the RHMTP’s flexibility and breadth of clinical exposure. The main challenges relate to a lack of alignment of training requirements and funding.

CONCLUSIONS: In its first decade, the RHMTP has been successful in generating a rural hospital workforce and the programme is steadily growing. Attention to existing barriers is needed to ensure the RHMTP can reach its potential to benefit all of New Zealand’s rural communities.

Targeted rural postgraduate training pathways are recognised internationally as playing a critical role both in recruitment and retention of a rural medical workforce and in reducing inequity of care and opportunity for people living away from urban centres.1-4

In New Zealand, though data are limited, indications are that people living rurally have poorer health outcomes than people living in urban areas, and this is accentuated for Māori.5,6 Around 19% of New Zealand’s population rely on rural health services, and around 15% rely on rural hospitals for their healthcare.5,7,8

In 2008, in response to serious rural hospital workforce shortages and the lack of any training pathway, rural hospital medicine (RHM) was recognised by the Medical Council of New Zealand (MCNZ) as a vocational scope of practice.9 The intention was to provide recognised training standards for the medical workforce and to encourage the development of systems, such as clinical governance, in rural hospitals.9 The scope of RHM is defined by its context, the rural environment including geographic isolation, and, in contrast to general practice (GP), is orientated to secondary care.10

Rural hospitals in New Zealand are small and geographically distant from a base hospital; they have acute bed capacity and limited diagnostics; and they have a predominantly generalist medical workforce.8 However, New Zealand’s rural hospitals are not homogenous (variations include governance, funding models and integration with primary care), nor do they fit seam-
lessly into either of the two tiers of the New Zealand health system (community–primary care or hospital services). The Rural Hospital Medicine Training Programme’s (RHMTP’s) history and development have been previously described. Though there have been early improvements in the rural hospital workforce since the RHM scope’s inception, serious staff shortages remain.

The RHMTP is New Zealand’s only rural-targeted vocational training programme. The professional body for RHM, the Division of Rural Hospital Medicine (DRHMNZ), sits as a chapter within the Royal New Zealand College of General Practitioners (RNZCGP) and reports directly to the MCNZ as the branch advisory body for the RHM scope. Factors considered in positioning the DRHMNZ in the RNZCGP included close ties and overlap with rural general practice and the small size of the RHM workforce.

The Fiscal Hospital Medicine Training Programme

The key programme principles include recognition of prior learning, competence-based assessment and a modular (rather than a linear) pathway. The academic component of the training programme is provided largely by the University of Otago’s (UoO’s) distance-taught Postgraduate Rural Programme (PGRP). Dual training with other specialties, particularly GP, is encouraged; however, there is no formal GP–RHM training pathway.

The requirements of the RHMTP, which cross primary–secondary, hospital–community and urban–rural settings, are outlined in Table 1 and detailed elsewhere.

The Rural Hospital Medicine Training Programme is subsidised by Health Workforce New Zealand (HWNZ) through the hospital specialties route via district health boards (DHBs), not the alternative HWNZ college-based route used for GP training. Some base and tertiary hospitals offer specific clinical rotations for RHM trainees. Some DHBs offer a scheme where all or most clinical rotations are available in a single region. Many rural hospitals and rural general practices offer accredited rotations, but not all have the same access to HWNZ funding. Difficulty accessing funding for accredited training posts, especially for rural hospital and rural general practice placements, has been reported at DRHMNZ council meetings.

The main aim of this study was to evaluate the outcomes of the first decade of the RHMTP. The study also aimed to determine the geographic spread of both graduates and trainees; to gain insights into the influence of undergraduate rural training exposure on subsequent rural career choice; and to explore trainee experiences of the RHMTP. The career choice of the first RHMTP graduate cohort is reported elsewhere.

Methods

Design

This was a mixed method descriptive study.

Sampling and data collection

Database interrogation

Data were extracted from: the MCNZ Register of Doctors; UoO student enrolment records (eVision); and the RNZCGP’s database. Data were sought on all individuals entering the RHMTP from December 2008 to December 2017. Records were reviewed through to 1 August 2019. The RNZCGP data was collected manually at the RNZCGP’s Wellington offices. The MCNZ and UoO databases were accessed electronically.

Survey

All trainees who had graduated or withdrawn from the RHMTP (before 1 August 2019) were invited by email to participate in an electronic survey. The survey was generated using Qualtrics (Provo, Utah, US). All potential participants were then separately emailed a unique link that gave them immediate access to the survey and the participant information and consent forms. The survey was open for 10 weeks.

The survey included questions about participants’ current employment and
locality as well as questions (free text) about the best aspects and greatest challenges of the training programme, self-funding the training and, where relevant, reasons for withdrawal from the programme. Participants were also asked to indicate (Yes/No) any rural undergraduate experience by year of training (during the 4th, 5th or 6th undergraduate year) and whether this was a ‘rural rotational run’ (not further specified) or one of the rural-specific undergraduate programmes (e.g., Rural Medical Immersion Programme (RMIP), UoO; Tairāwhiti Interprofessional Education programme, UoO; Pukawakawa: Northland Regional-Rural program, University of Auckland (UoA); Rural Health Interprofessional Education Programme, UoA). No definitions of ‘urban’ or ‘rural’, nor of ‘rural undergraduate training’, were provided.

Analysis

Database and survey data were separately collated and entered into respective Excel (Microsoft Corporation, Redmond, WA, US) spreadsheets. To maintain participant anonymity, all respondents were designated a number (1–XX) and were referred to throughout by this coding.

Table 1: Outline of the Rural Hospital Medicine Training Programme.*

<table>
<thead>
<tr>
<th>Academic components</th>
<th>GENA 724: Context of Rural Hospital Medicine†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GENA 725: Communication in Rural Hospital Medicine</td>
</tr>
<tr>
<td></td>
<td>GENA 726: Obstetrics and Paediatrics in Rural Hospitals</td>
</tr>
<tr>
<td></td>
<td>GENA 727: Surgical Specialties in Rural Hospitals, or</td>
</tr>
<tr>
<td></td>
<td>POPLPRAC 740: Urgent Primary Surgical Care; Auckland University</td>
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<td></td>
<td>GENA 728: Cardiorespiratory Medicine in Rural Hospitals</td>
</tr>
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<td></td>
<td>GENA 729: Medical Specialties in Rural Hospitals</td>
</tr>
<tr>
<td></td>
<td>GENA 723: Trauma and Emergencies in Rural Settings, or</td>
</tr>
<tr>
<td></td>
<td>The Emergency Medicine Certificate from the College of Emergency Medicine</td>
</tr>
<tr>
<td>Clinical attachments</td>
<td>Rural hospital medicine: (Two different locations, total 12 months FTE; At least one of the rural hospital runs must be in a Level 3 rural hospital.)</td>
</tr>
<tr>
<td></td>
<td>Rural General Practice: (6 months FTE)</td>
</tr>
<tr>
<td></td>
<td>General Medicine: (6 months FTE)</td>
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<td></td>
<td>Emergency Medicine: (6 months FTE)</td>
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<td></td>
<td>Paediatrics: (3 months FTE)</td>
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<td>Elective: (12 months FTE)‡</td>
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<td>Compulsory courses</td>
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</tr>
<tr>
<td></td>
<td>Advanced Paediatric Life Support (APLS), or</td>
</tr>
<tr>
<td></td>
<td>Paediatric advanced life support (PALS)</td>
</tr>
<tr>
<td></td>
<td>Emergency Management of Severe Trauma (EMST)</td>
</tr>
</tbody>
</table>

† GENA indicates papers administered through the University of Otago, rural post graduate programme.
‡ Can be used to gain advanced or extended experience and skills (e.g., in Anaesthetics or Obstetrics or for those dual training with GP used to complete GPEPI (intensive year of GP training).
Simple descriptive statistics were used to summarise gender, age, ethnicity, New Zealand citizenship status, the institution awarding the undergraduate degree, current practicing status and other postgraduate qualifications.

The location of compulsory training rotations and the primary place of graduates’ current employment were tabulated then mapped using R. The 2018 New Zealand Index of Deprivation decile for the Statistical Area (Level 2) where New Zealand rural hospitals were located was determined and overlaid in the map.

Free-text responses were reported as quotes, then coded and collated according to the survey categories. For data collected in the categories of ‘Best aspects’, ‘Challenges’ and ‘Other comments’, common themes were identified using an inductive thematic approach. Team members reviewed the analysis to ensure theme consensus. NVivo qualitative data analysis software (QSR International Pty Ltd, Version 12, 2018) was used to manage the analysis.

Ethics approval for this study was obtained from the University of Otago Human Ethics Committee, Reference D19/194.

Results

Database findings

Demographics

The records for 98 trainees who had entered the RHMTP were available for analysis in the RNZCGP database. Those graduating with a Fellowship in Rural Hospital Medicine (FDRHMNZ) made up under a third (29/98, 29.5%), half (49/98, 50%) were active trainees and a fifth (20/98, 20.4%) had withdrawn.

Detailed demographic information is summarised in Table 2.

Entry, completion or withdrawal

Intake into the RHMTP was between 6 and 10 trainees per year over the first four years, after which annual cohorts increased. The highest intake during the study period was 26 admissions in the tenth year. The first two trainees graduated in 2012. From 2013, between four and six trainees were awarded each year. The median time graduates spent in the programme was five years and seven months. Twenty trainees subsequently withdrew: five in 2015 and between one and six trainees per year from 2016 to 2019. For these trainees, the median time spent in the programme was two years and nine months.

Undergraduate training

Overall, 69/98 (70%) trainees had gained their undergraduate medical degree in New Zealand, and half (49/98, 50%) were awarded their degrees by the University of Otago.

Participation in other vocational training programmes and additional qualifications

Participation in other training programmes is described in Table 2. Most graduates (17/29, 59%), active trainees (39/49, 80%) and withdrawn trainees (17/20, 85%) are participating in or have completed another vocational training programme; nearly two-thirds of them participated in or completed general practice vocational training (62/98, 63.3%).

The majority of graduates had completed more than one postgraduate diploma or certificate (25/29, 86%). All 29 RHMTP graduates had completed a Postgraduate Diploma in Rural and Provincial Hospital Practice (PGDipRPHP), UoO, and more than half (17/29, 59%) had completed a Postgraduate Certificate in Clinician-Performed Ultrasound (PGCertCPU), UoO.

Geographical location of compulsory hospital training rotations undertaken by RHMTP graduates

As trainees, programme graduates had undertaken a total of 123 compulsory hospital rotations (71 in urban and 52 in rural hospitals) in New Zealand. (NB: One rural hospital rotation had been undertaken at Rarotonga Hospital, Cook Islands.) The majority of urban (48/71, 66.7%) and rural (38/52, 71.7%) rotations were undertaken in the South Island. The distribution and numbers of both rural and urban hospital rotations are shown in Figure 1.

Survey results

The survey response rate was 80% (39/49). Nearly all graduates (28/29, 97%), and over half 55% (11/20) of withdrawn trainees, responded.
Quantitative findings

Rural undergraduate training

Rural undergraduate experience is described in Table 3. More than half (25/39, 64%) of survey respondents indicated that they undertook a rural placement during their undergraduate training.

Current employment of RHMT graduates

The majority (26/28, 92.9%) of graduates are actively practising medicine, mostly (24/28, 85.7%) in rural locations. Of the four not currently practising in a rural location, half (2/4, 50%) indicated that they would work in rural practice in the future.

Most RHMT graduates (22/28, 78.6%) currently work in a rural New Zealand hospital. Nearly half, in addition to RHM, work in another area of practice (13/28, 46.4%): either general practice or emergency medicine. Two-thirds (14/22, 63.6%) of graduates currently practising in rural hospital medicine work in the South Island.

Table 2: Summary of graduates, withdrawals and active trainees of the Rural Hospital Medicine Training Programme between 2008 and 2017.

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Graduates</th>
<th>Withdrawn</th>
<th>Active</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number</td>
<td>98</td>
<td>29 (30%)</td>
<td>20 (20%)</td>
<td>49 (50%)</td>
</tr>
<tr>
<td><strong>Median (range), years</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at entry</td>
<td>30 (25-48)</td>
<td>29 (25-39)</td>
<td>29 (26-42)</td>
<td>30 (25-47)</td>
</tr>
<tr>
<td><strong>n(%)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>58 (59%)</td>
<td>15 (52%)</td>
<td>12 (60%)</td>
<td>31 (63%)</td>
</tr>
<tr>
<td>Male</td>
<td>40 (41%)</td>
<td>14 (48%)</td>
<td>8 (40%)</td>
<td>18 (37%)</td>
</tr>
<tr>
<td>Ethnicity*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NZ European/Pakehā</td>
<td>61 (62%)</td>
<td>18 (62%)</td>
<td>12 (60%)</td>
<td>31 (63%)</td>
</tr>
<tr>
<td>NZ Māori</td>
<td>6 (6%)</td>
<td>2 (7%)</td>
<td>1 (5%)</td>
<td>3 (6%)</td>
</tr>
<tr>
<td>Pacific</td>
<td>2 (2%)</td>
<td>1 (3%)</td>
<td>1 (5%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>British/Irish</td>
<td>17 (17%)</td>
<td>7 (24%)</td>
<td>4 (20%)</td>
<td>6 (12%)</td>
</tr>
<tr>
<td>Other</td>
<td>24 (24%)</td>
<td>7 (24%)</td>
<td>3 (15%)</td>
<td>14 (29%)</td>
</tr>
<tr>
<td>Citizenship</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NZ citizen</td>
<td>69 (70%)</td>
<td>18 (62%)</td>
<td>14 (70%)</td>
<td>37 (76%)</td>
</tr>
<tr>
<td>NZ permanent resident</td>
<td>26 (27%)</td>
<td>10 (34%)</td>
<td>5 (25%)</td>
<td>11 (22%)</td>
</tr>
<tr>
<td>Unknown †</td>
<td>4 (4%)</td>
<td>1 (3%)</td>
<td>1 (8%)</td>
<td>2 (4%)</td>
</tr>
<tr>
<td>University of undergraduate degree</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Otago</td>
<td>49 (50%)</td>
<td>16 (55%)</td>
<td>11 (55%)</td>
<td>22 (45%)</td>
</tr>
<tr>
<td>Auckland</td>
<td>20 (20%)</td>
<td>3 (10%)</td>
<td>3 (15%)</td>
<td>14 (28.5%)</td>
</tr>
<tr>
<td>Other</td>
<td>29 (30%)</td>
<td>10 (35%)</td>
<td>6 (30%)</td>
<td>13 (26.5%)</td>
</tr>
<tr>
<td>Participation in or graduation from other vocational training programmes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General practice</td>
<td>62 (63.3%)</td>
<td>17 (59%)</td>
<td>13 (65%)</td>
<td>32 (65%)</td>
</tr>
<tr>
<td>Other</td>
<td>16 (16.3%)</td>
<td>0 (0%)</td>
<td>4 (20%)</td>
<td>7 (14%)</td>
</tr>
</tbody>
</table>

* Participants can self-identify as more than one ethnicity.
† Data missing for these four participants.
predominately within the Southern DHB (10/22, 45.5%). The distribution of graduates employed in rural hospitals is shown in Figure 2.

**Additional professional roles of graduates**
A quarter (7/28, 25%) of graduates also held leadership positions: three (10.7%) were DRHMSNZ Council representatives, three (10.7%) were in clinical director roles and one (3.6%) held a senior academic position. Five (17.9%) other graduate respondents held other academic positions, and four (14.3%) held both leadership and academic positions.

**Qualitative findings**

**Trainee RHMTP experiences**
The key qualitative findings are summarised in five main themes. Illustrative participant quotes are presented.

**A fit-for-purpose training programme**
The RHMTP was perceived by most respondents (both graduates and those who withdrew) to be rural-practice specific with broad and varied clinical exposure and a relevant and complementary academic programme. The collegiality and networks built during the training programme, particularly the academic programme residentials, were highly valued:

“*A comprehensive fit for purpose generalist training programme for Rural Hospital Medicine. The breadth of training (both clinical and academic) was excellent. Collegiality in meeting, training with and working alongside others passionate about (and keen to work) rurally.*” R17

“The academic programme complemented the clinical training programme, especially bringing out the importance of the rural context through all of the papers. It was important to have rural doctors who understand the complexities of the rural environments facilitating the papers.” R11

**Figure 1**: Location of compulsory New Zealand-based rural and base hospital training rotations undertaken by graduates of the Rural Hospital Medicine Training Programme.
Navigation
While navigating the programme, most respondents experienced challenges, which mainly revolved around securing programme components and the accompanying funding in a timely way. Respondents reported ‘falling through funding gaps’ when moving across the country and between DHBs, or while completing programme-accredited clinical rotations in health services to ‘where HWNZ funding does not flow’:

“It was a bit confusing understanding and navigating the programme... understanding and then... accessing funding for runs and academic components. Especially in the smaller rural hospitals with limited funding. This was a real issue when choosing my final placements, when [there were] lots of costs involved.” R15

“Financial pressures regarding fees that are not covered when you are outside the hospital-based runs, as you need to find your own attachments.” R36

Flexibility
Respondents saw programme flexibility as integral to a fit-for-rural-purpose training programme, as flexibility allowed exposure across the whole healthcare system and provided opportunities to experience diverse contexts:

“Best aspects included the flexibility of the training programme to allow opportunities to experience rural medicine in many areas of NZ. Developing generalist skills and a broad

Table 3: Findings from surveying graduates/withdrawals of the Rural Hospital Medicine Training Programme, 2008 to 2017.

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Graduates</th>
<th>Withdrawn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survey respondents</td>
<td>39</td>
<td>28 (71.8%)</td>
<td>11 (28.2%)</td>
</tr>
<tr>
<td>Currently practising</td>
<td></td>
<td>n(%)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>36</td>
<td>26 (92.9%)</td>
<td>10 (90.9%)</td>
</tr>
<tr>
<td>No</td>
<td>3</td>
<td>2 (7.1%)</td>
<td>1 (9.1%)</td>
</tr>
<tr>
<td>Practising in a rural location</td>
<td>28</td>
<td>24 (85.7%)</td>
<td>6 (54.5%)</td>
</tr>
<tr>
<td>Practising scope</td>
<td></td>
<td>n*</td>
<td></td>
</tr>
<tr>
<td>Rural hospital</td>
<td>24</td>
<td>22</td>
<td>2</td>
</tr>
<tr>
<td>General practice</td>
<td>17</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>Emergency medicine</td>
<td>7</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Urgent care</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>7</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Undergraduate rural placement</td>
<td></td>
<td>n† (%)</td>
<td></td>
</tr>
<tr>
<td>Rural rotational run</td>
<td>25</td>
<td>16 (57%)</td>
<td>9 (82%)</td>
</tr>
<tr>
<td>Rural Medical Immersion Program</td>
<td>11</td>
<td>6 (21.4%)</td>
<td>5 (45.4%)</td>
</tr>
<tr>
<td>Pukawawa RRP</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Tairawhiti IPE</td>
<td>1</td>
<td>0</td>
<td>1 (9.1%)</td>
</tr>
</tbody>
</table>

* Can practice in more than one scope at a time.
† Can undertake more than one undergraduate rural placement.
‡ Rural Medical Immersion Programme, University of Otago.
§ Pukawawa Rural–Regional programme, Auckland University.
¶ Tairawhiti Interprofessional Education programme, Otago University.
# Also completed Rural Medical Immersion Programme, University of Otago.
scope of practice - a jack-of-all-trades doctor in a secondary care environment - and developing a ‘thinking outside the box’ attitude to challenging situations.” R11

At the same time, flexibility was perceived by many to be a major contributor to navigation difficulties:

“[The] RHM Training programme has lots of potential. For those who want it, a more structured training pathway with placement certainty would be an incentive. As would funding following the trainee e.g. meeting [payment] for exit exams or rural academic papers while doing GP placements etc.” R39

A new specialty

While there was a sense of excitement in forging a new vocational pathway, it came with challenges:

“...many other doctors/ departments did not understand what RHM was, or even recognised it as a valid training pathway. I felt like I spent considerable time and energy educating others (including GPs) about the programme and advocating for myself to get the training experience at I required.” R26

Respondents described a growing awareness of the wide variations, as well as fragility, of rural hospital services and systems. For graduates, the transition to employment in senior rural hospitals positions could be daunting:

“...the local rural context and rural practices may not complement the expectations of a RHM trainee. Rural hospitals in NZ remain fragile systems. Many new vocationally trained rural hospital doctors are asked to take on not only new senior doctor positions... but also senior leadership positions.” R22

Family

Many respondents struggled to find...

Figure 2: Location and number of graduates of the Rural Hospital Training Programme (2008–2017) who are working in New Zealand rural hospitals.

a balance between the programme's requirement and family needs. For some, moving around with family for clinical rotations was the biggest challenge, while others saw this as a programme highlight.

**Self-funding**
Half of the respondents (20/39, 51.3%) reported they had self-funded components of their RHMTP, including academic paper fees and costs associated with assessments (eg, final fellowship visit costs).

**Reasons for withdrawal**
Reasons for withdrawal from the RHMTP (11 respondents) fell into three categories: family/life related; programme related; and career related. Programme-related comments almost all related to navigation difficulties.

**Discussion**
This mixed methods study presents the first decade outcomes of New Zealand's Rural Hospital Medicine Training Programme. Through the provision of a targeted rural career pathway, the RHMTP is growing a cohort of highly qualified doctors, of which the majority (92% of graduates currently practicing) are working in rural New Zealand. Most have two specialist fellowships and multiple postgraduate university qualifications, and many are taking up leadership positions early in their careers. The findings concur with the literature: dedicated rural training pathways contribute to the rural medical workforce.1,3,20,21

This study provides the first evidence on actual postgraduate practice locality for rural career choice in New Zealand. These outcomes compare favourably with international postgraduate rural programmes.22,23

The number of doctors identifying as Māori (6%) is similar to other comparable programmes,24 has remained small (7% in graduate and 6% in active trainee cohorts) and needs attention.

Many RHMTP graduates report no rural undergraduate experience. It is likely too early to see the influence of rural–regional undergraduate programmes on RHMTP entry. However, the number of Rural Medical Immersion Programme (RMIP) students entering RHMTP training may be an early indication of the value of a rural training pathway.

Findings concur with previous research that confirms overseas trained doctors (OTDs) constitute a high proportion of doctors working rurally.15,22

Both the withdrawal rate and the uneven geographic spread of trainee rotations are noteworthy.

It is reassuring that a high proportion of trainees who withdrew began with the intention of doing GP and RHM training and, after withdrawal from the RHMTP, are continuing with training in GP, and many are working in rural GP. Withdrawal numbers will need further exploration as the programme grows, including the extent to which GP–RHM trainees are eventually opting to continue with just one training programme.

In addition to personal and family factors (known to be strong career drivers),25 findings point to programme-related factors (eg, access to funding, organisational placement aspects and institutional bureaucratic complexities) that are influencing trainees' decisions and impacting progress through the RHMTP for some trainees. The lack of a consistent mechanism within the current funding model to ensure that funding follows trainees into a critical proportion of their training (that undertaken in rural settings) seems particularly notable.

Although this study did not examine the reasons for geographic variations for trainee rotations, the specific local–rural context is probably an important contributing factor. Findings suggest that there are localities across New Zealand where RHMTP rotations with associated funding and supports have been streamlined. Naturally, trainees gravitate towards set-ups that work and are high quality. The gains for a rural hospital of a steady stream of senior doctors-in-training cannot be underestimated: not only does this result in much needed service provision, but it likely creates ripple effects for wider local capacity building. This would in turn contribute to the wider goals of the RHMTP in strengthening rural hospital services. It is important to note that many rural hospitals have not yet achieved the stability in their workforce that is required to enable the provision of a professional
environment that both supports and attracts RHMTP trainees.

Dual GP–RHM training is likely high value, given the need for a New Zealand rural medical workforce across the primary–secondary care spectrum, and it is clearly popular among trainees. With both training programmes situated within the RNZCGP, opportunities for reducing bureaucratic complexities associated with GP–RHM dual training should be within reach, as previously noted.26

Country-specific solutions have been found for postgraduate rural training. Recent Australian research has highlighted the importance of national rural faculties as a strategy to build and sustain a rural medical workforce.22

The overarching aim of rural-targeted training pathways, in providing a robust pathway to a rural-based employment, is the provision of health services to rural areas.1,20,25 The RNZCGP-DRHMNZ has a responsibility not only to its trainees, but, particularly in light of New Zealand’s wider policy context,11,27 to reduce chronic health-access inequities for all rural and remote communities. Although important gains have been made with many rural hospital vacancies across New Zealand being filled by RHMTP graduates, findings also indicate that many rural hospitals, including some serving communities with the greatest health-access inequities (particularly Māori communities), are not yet benefiting from the RHMTP.

Study findings highlight the knowledge gap (previously identified)28 regarding rural hospitals in New Zealand. International studies have shown rural hospitals to be important providers of healthcare that can benefit the health of rural populations,29 but similar research has not been undertaken in New Zealand.

Study strengths and limitations

The study's perspective is that of the RHMTP provider and its trainees and does not include the views of rural hospitals or communities. The study used mixed methods, and the findings corroborated across datasets. The study was limited by the quality of the RNZCGP database, which was incomplete (in particular, locality of the RHMTP general practice rotation). Although the survey response rate was high, the limitations of using a survey, which was conducted with the expectation of complete databases, is acknowledged. This survey method provided limited information on the influence of undergraduate rural programmes.

Policy implications and recommendations

It is well documented that rural-targeted vocational pathways require innovation and flexibility in order to be responsive to the clinical and structural requirements of rural practice.1,3,25 Study findings provide insights regarding what is working well and highlight issues requiring attention.

Recommendations based on the findings include:

- The RHMTP funding mechanism is reviewed to ensure alignment with the programme’s structure. A solution is needed that reaches across the two health system tiers, multiple organisations and geographical boundaries and balances regional versus national interests.
- The DRHMNZ’s governance structure within the RNZCGP is reviewed to ensure it facilitates optimal support for trainees and training sites and provides strong advocacy for all rural communities.
- General practice–rural hospital medicine training is recognised formally as a dual pathway, optimising operational efficiencies and aligning funding mechanisms.
- The RNZCGP and DRHMNZ continue to increase the diversity of graduates entering the RHMTP and, in particular, consider ways to support more Māori graduates through the programme.
- Diversity in rural health service exposure for RHM trainees is widened.

Other opportunities

The RHMTP provides just part of the solution to building rural workforce capacity. The critical role of other health professionals, particularly nurses, both in rural hospital and other rural health services roles, must be acknowledged. All rural health professionals should be supported to develop their own rural-specific training and continuing-education pathways.

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The RHMTP provides just part of the solution to building rural workforce capacity. The critical role of other health professionals, particularly nurses, both in rural hospital and other rural health services roles, must be acknowledged. All rural health professionals should be supported to develop their own rural-specific training and continuing-education pathways.
The RHMTP is contributing to building rural health academic capacity with dual clinical–academic roles based in rural locations. A national rural-centric academic structure would provide mechanisms that help early career academics thrive in active rural–clinical practice across all health-professional disciplines.

In aiming to improve health-access inequalities for all New Zealanders, consideration should be given to how the RHMTP could add value to the emerging general practice training programmes of two of New Zealand’s realm countries, the Cook Islands and Niue. These programmes already share academic components.16

**Future research**

Further and ongoing studies investigating future RHMTP outcomes, including recruitment and retention factors for RHMTP graduates and the influence of a coordinated rural-origin, rural-undergraduate and rural-postgraduate pathway for rural career choice in the New Zealand context, are required.

Wider research is needed into the current status and role of New Zealand’s rural hospitals and the extent to which all rural health services improve access to healthcare, improve health outcomes and improve health equity for New Zealand’s rural communities.

**Competing interests:**

Katharina Blattner and Garry Nixon have teaching roles in the RHMTP's academic component. Patrick McHugh has been involved in RHMTP governance.

Rory Miller is a graduate of the RHMTP and is involved in teaching of the RHMTP's academic component. Joel Pirini is a current trainee of the RHMTP.

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Patrick McHugh: Primary Care Practitioner, Turanga Health, Gisborne, New Zealand.

Joel Pirini: Rural Doctor, Kaitaia Hospital, Northland District Health Board, New Zealand.

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**URL:**


Anticoagulant-related intracranial haemorrhage: time to anticoagulant reversal improving but still slower than thrombolysis for ischaemic stroke

Holly J Mee, Hugh Carl Hanger, Tim Wilkinson, James Michael Beharry, Teddy Wu

**ABSTRACT**

**AIMS:** This study aims to determine whether door-to-needle times (DNT) for reversal of anticoagulant-associated intracerebral haemorrhage (ICH) (1) have improved over time, (2) differ between warfarin and dabigatran and (3) are comparable to ischaemic stroke (IS) thrombolysis DNT, and (4) whether reversal is monitored.

**METHODS:** Retrospective review of all warfarin- and dabigatran-associated ICH presenting to Christchurch Hospital over a 15-year period. DNT data from 2013–2018 were compared between warfarin-related ICH (WRICH), dabigatran-related ICH (DRICH) and IS thrombolysis.

**RESULTS:** 172 WRICH were identified. Over time there were significant reductions in door-to-first-reversal-agent (r=-0.21, p=0.01), scan-to-first-reversal-agent (r=-0.27, p=0.001) and scan-to-prothrombin-complex-concentrate (PCC) (r=-0.33, p=0.001) times. In the 2013–2018 cohort, WRICH had significantly slower DNT, door-to-scan time and scan-to-needle time compared to DRICH and IS thrombolysis (all p<0.001). There was no statistical difference between DRICH and IS. Median DNT was 183 minutes for WRICH, 72 minutes for DRICH and 52 minutes for IS. Median time to repeat international normalised ratio was 231 minutes, and the median time to repeat thrombin clotting time was 825 minutes.

**CONCLUSION:** Door-to-any-reversal-agent and scan-to-PCC times have improved over time, but they remain significantly longer than IS thrombolysis times. Monitoring of reversal is inadequate, particularly for WRICH receiving PCC.

**Anticoagulant-related intracerebral haemorrhage (ICH) is a life threatening and disabling event** with higher early mortality compared to non-anticoagulant-related ICH. Active bleeding is longer compared with non-anticoagulant-related ICH and results in larger growth and haematoma volume. American Stroke Association guidelines recommend correction of international normalised ratio (INR) in warfarin-related ICH (WRICH) (class 1 recommendation), but the optimal approach is uncertain. Observational data suggest there is a mortality benefit in patients receiving combination treatment with vitamin K, prothrombin complex concentrates (PCC) and fresh frozen plasma (FFP). The mortality benefit may be mediated in part by early, effective anticoagulant reversal, which is associated with smaller haematoma expansion. PCC rapidly replenishes deficient coagulation...
factors and is more effective at early reversal of INR when compared to FFP.9 We previously reported an improved survival in WRICH with PCC use and a trend to better outcomes with earlier reversal.8,10 Ongoing revision of a local WRICH reversal protocol has shown increased and sustained use of PCC with reduced time to computed tomography (CT) imaging and reversal.8

The increasing use of dabigatran since 2011 has highlighted the need for a rapid reversal agent.11 Idarucizumab, a humanised monoclonal antibody fragment that binds to dabigatran, works within minutes and is available in Canterbury District Health Board (CDHB) with haematologist approval.12 Rivaroxaban, an alternative oral anticoagulant, has no specific reversal agent available in New Zealand. It has only been available as a fully subsidised oral anticoagulant since August 2018.13 PCC is recommended for use in these patients in event of ICH.14

Ischaemic stroke (IS) patients are prioritised for review on hospital arrival—the ‘time is brain’ mantra is well established for the public, and streamlined IS protocols have led to reduced door-to-needle times (DNT) and improvements in mortality and morbidity.15–17 This study asks whether the same priority is applied in diagnosing and treating ICH patients.

The aims of this study are to assess whether (1) DNT for receiving reversal agent(s) in WRICH has improved over time, whether these times are comparable to (2) DRICH reversal times and (3) IS thrombolysis DNT in the same centre, and whether (4) reversal is being monitored appropriately.

Methods

We performed a retrospective analysis of all WRICH, DRICH and IS patients receiving intravenous thrombolysis at Christchurch Hospital, a tertiary hospital of an approximately 550,000 catchment population.

ICH cohort

Data were derived from patient information previously published between 2004 and 2013.8,10 This was supplemented with additional data from ICH patients admitted between 2013 and 2018, who were identified through several overlapping data sources. These included:

1. the Acute Stroke Unit (ASU) register—a prospective in-house stroke database for patients treated at Christchurch Hospital
2. discharge coding data—patients with International Classification of Diseases (ICD)-10 code ICH (161 or 162.9) were identified then cross checked against the ASU register
3. a review of the New Zealand Blood Service data for PCC requests, as well as local haematologist and pharmacy records for idarucizumab use.

For each ICH identified, electronic and clinical records were reviewed to establish whether the patient was listed as having taken warfarin or dabigatran at the time of bleed. If an ICH was confirmed on imaging and the patient was taking warfarin or dabigatran at the time of the stroke, then a WRICH was defined if the INR was elevated (>1.2) on admission, and a DRICH was defined if the thrombin clotting time (TCT) was elevated on admission.

We reviewed medical records to extract basic demographics, arrival time to the emergency department (ED), time of first brain imaging, reversal agents used (including time of reversal agent administration) and coagulation tests at the time of admission and following the reversal. Time of arrival was taken as the date/time stamp recorded in the ED notes. Time of stroke onset was not reliably recorded, so therefore it could not be used. The time of imaging was taken as the time recorded on the first scan image. Time metrics were calculated, including door-to-imaging time and DNT. DNT for ICH patients was defined as the time from arrival to the documented time that the reversal agent was administered. The time of blood tests (eg, post-reversal INR check) was taken as the time when the blood test was taken. A review of the adequacy of anticoagulant monitoring analysis was limited to the 2013–2018 cohort to reflect changes to local ICH reversal protocols and the recent availability of idarucizumab.18 ICH score was calculated by reviewing the radiological imaging in combination with the recorded Glasgow Coma Scale (GCS). ICH volume was
calculated was using the standard ABC/2 formula from acute CT scans.19

We excluded patients with ICH secondary to trauma, ruptured aneurysm, haemorrhagic transformation of cerebral infarction, tumour, arteriovenous malformation, thrombocytopenia or thrombolytic therapy. Patients who were palliated immediately after diagnostic imaging and received no reversal agents were excluded, as were patients on dabigatran before idarucizumab was available.

IS cohort

Data from 2013–2018 for thrombolysis DNT were derived from a prospective stroke thrombolysis registry, the details of which have been published elsewhere.20

Comparison

The initial analysis for improvement over time included the full 2004–2018 cohort. We then focussed analyses on the 2013–2018 data into three comparison groups:

1. those on warfarin at time of ICH
2. those on dabigatran
3. those with IS who were thrombolysed.

For group one, scan-to-needle times were calculated separately for vitamin K, PCC and FFP. Groups two and three's needle times were taken as time of administration of idarucizumab and thrombolytic agent, respectively. We then compared DNT, door-to-scan times and scan-to-needle times between these three groups.

Some patients had their coagulopathy reversed before imaging confirmed an ICH—this is outside the accepted protocol for ICH treatment, so these patients were excluded.13 Negative values for time from vitamin K to PCC administration (ie, PCC being given before vitamin K) were allowed (being within protocol) and fast access to PCC is to be encouraged. Scan-to-PCC time was considered the most relevant of warfarin reversal times to compare with idarucizumab times, as PCC is the most effective and rapid reversal agent.7 The adequacy of warfarin reversal was defined as an INR of less than 1.3 on repeat testing.9

Statistical analysis

We used standard descriptive statistics. Stroke type according to gender was compared using the Chi-square test. Age, times to interventions and ICH volume were not normally distributed, so non-parametric tests were used. Specifically, comparisons across three or more stroke subtype groups were undertaken using the Kruskall–Wallis test, and comparisons across two groups were undertaken using the Mann–Whitney U test. Comparisons between arrival date and intervention times were undertaken by using Pearson's correlation coefficient. Continuous data were described using mean or median interquartile ranges (IQR) or ranges. A p value of <0.05 was considered significant. All statistics were performed on SPSS version 24.

Results

During the 2013–2018 study period there were 63 anticoagulant-associated ICH. Eleven patients were excluded: three due to incorrect diagnosis; two were palliated from the outset; two had community scans preceding admission confirming ICH; two due to their INR results (one had an INR of 1.1 on arrival, and the other had a community INR of >20 leading to admission, which was reversed prior to their scan); and the final two were DRICH that occurred before idarucizumab was available for use.18

Seven of the 52 eligible patients included were taking dabigatran at the time of their ICH, and the remainder were on warfarin. The 45 WRICH from the 2013–2018 cohort were added to the previously published data of 127 patients with WRICH from 2004–2013 to give a total number of 172 WRICH patients for the 2004–2018 period.

The demographic characteristics of the warfarin and dabigatran arms of our later cohort are shown in Table 1. The patient demographics from 2004 to 2013 are available in previously published data and have been shown as a combined group for comparison.8 Median IS National Institutes of Health Stroke Scale (NIHSS) was 11 (IQR 6–19.5).

PCC was not received by any patient included in our study in the years 2004–2006. Figures 1 and 2 show temporal trends for DNT and scan-to-treatment time with PCC respectively. Scan-to-needle time significantly improved over the 15-year period (r=-0.33, p=0.001). Door-to-needle (PCC) time did not reach significance (r=-0.17, p=0.10). However, both scan-to-first-reversal-agent time (r=-0.27, p=0.001) and door-to-first...
**Table 1:** Demographic variables.

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Median age, years (IQR)</td>
<td>79 (72–86)</td>
<td>80 (77–82)</td>
<td>79 (73–83)</td>
<td>75 (62–83)</td>
<td>&lt;0.01 (Kruskall–Wallis test)</td>
</tr>
<tr>
<td>Female sex, no. (%)</td>
<td>19 (42%)</td>
<td>4 (57%)</td>
<td>51 (40%)</td>
<td>118 (42%)</td>
<td>NS^   (Chi-square test)</td>
</tr>
<tr>
<td>Median INR on presentation (range)</td>
<td>3 (2-5)</td>
<td>N/A</td>
<td>3 (1-12)</td>
<td>N/A</td>
<td>NS Mann–Whitney U test)</td>
</tr>
<tr>
<td>Deaths in hospital, number (%)</td>
<td>14 (31%)</td>
<td>2 (29%)</td>
<td>58 (46%)</td>
<td>16 (5.7%)*</td>
<td>NS (Kruskall–Wallis test; excluded ischaemic stroke)</td>
</tr>
</tbody>
</table>

^NS (Not significant).
*30-day mortality.

The IS thrombolysis cohort were younger on average compared to the other three groups listed (p<0.001). Otherwise, there was no statistically significant difference between the four groups for the variables listed in Table 1.

**Figure 1:** Door-to-needle time (ED-to-PCC time) for WRICH 2004–2018 (r=-0.17, p=0.10).
reversal-agent time ($r=-0.21, p=0.01$) did (graphs not shown). No other times analysed showed significant change over time.

The WRICH, DRICH and IS thrombolysis cohorts over years 2013–2018 were compared by key outcome measures listed in Table 2 and in Figures 3, 4 and 5. Times were also broken down by component for WRICH: the median time from scan to vitamin K was 39 minutes, from scan to PCC was 86 minutes and scan to FFP was 126 minutes. There were also further delays (median 35 minutes) between first reversal with vitamin K and PCC infusion beginning.

Figure 3 shows WRICH is significantly slower than both DRICH (difference between two medians of 111 minutes (IQR 86–132 minutes, $p <0.01$)) and IS thrombolysis (difference between two medians of 131 minutes (IQR 82–210 minutes, $p<0.01$)) DNT times. There is no statistical difference between DRICH and IS thrombolysis DNT.

WRICH is significantly slower than both these groups for door-to-scan and scan-to-needle times. WRICH is slower than DRICH for door-to-scan time by a difference between two medians of 86 minutes (IQR 36–88 minutes, $p<0.01$) and scan-to-needle time by 51 minutes (range 34–66 minutes, $p<0.01$). WRICH is even slower compared to IS thrombolysis: for door-to-scan time by a difference between two medians of 96 minutes (IQR 32–147 minutes, $p<0.01$), and for scan-to-needle time by 64 minutes (IQR 40–90 minutes, $p<0.01$). Again, there is no statistically significant difference in these variables when comparing DRICH and IS thrombolysis.

Tables 3 and 4 shows data relating to the adequacy of reversal for WRICH from the 2013–2018 cohort. The majority of WRICH patients received vitamin K as their first reversal agent. This was the only reversal agent received by four patients: for one patient the reasons for not giving further reversal agents were not documented, for two patients the reasons were a later change to palliative care and for the final patient it was due to an unclear duration of symptoms.
Table 2: Key outcomes for WRICH, DRICH and IS thrombolysis cohorts (2013–2018).

<table>
<thead>
<tr>
<th>Median times, minutes (IQR)</th>
<th>Warfarin n=41</th>
<th>Dabigatran n=5</th>
<th>Ischaemic stroke n=283</th>
<th>p (Kruskall–Wallis test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Door to scan</td>
<td>123 (50–192)</td>
<td>37 (14–104)</td>
<td>27 (18–45)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Scan to first (any) reversal agent or thrombolytic</td>
<td>42 (28–78)</td>
<td>35 (21–55)</td>
<td>22 (15–31)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Door to first (any) treatment or thrombolytic</td>
<td>174 (98–248)</td>
<td>72 (34–153)</td>
<td>52 (38–75)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Door to PCC</td>
<td>183 (120–285)</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3: Boxplot DNT comparison for 2013–2018 cohorts (WRICH, DRICH and IS thrombolysis).
There was large time variance from PCC administration to repeat INR testing, with a median time of almost four hours. Eight cases (18%) had no repeat INR despite reversal agents being given. However, for six of these patients, management changed to palliative care. One of the remaining two patients was initially palliated then recovered, and the other did not have documented reasons for no monitoring. Of the 16 patients whose INRs had not normalised on repeat testing, only one received further PCC dosing to achieve normal INR.

Protocol adherence for vitamin K, PCC and/or FFP dosing was followed in 29% of cases. However, in 43% of cases, vitamin K dosing was doubled from protocol 5mg to 10mg, which was unlikely to have a significant clinical impact.

Five (71%) of the DRICH cohort received idarucizumab, and one did not receive monitoring following reversal. Repeat TCT normalised in the other four cases. The median time from idarucizumab to first repeat TCT was 825 minutes (IQR 573–989 minutes).

Table 3: Adequacy of warfarin reversal for WRICH, 2013–2018 (N=45).

<table>
<thead>
<tr>
<th>Treatment received</th>
<th>Number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reversal agents given (at any time)</td>
<td></td>
</tr>
<tr>
<td>Vitamin K</td>
<td>44 (98%)</td>
</tr>
<tr>
<td>Prothrombin complex concentrates (PCC)</td>
<td>36 (80%)</td>
</tr>
<tr>
<td>Fresh frozen plasma (FFP)</td>
<td>26 (58%)</td>
</tr>
<tr>
<td>First reversal agent given</td>
<td></td>
</tr>
<tr>
<td>Vitamin K</td>
<td>35 (78%)</td>
</tr>
<tr>
<td>Prothrombin complex concentrates (PCC)</td>
<td>8 (18%)</td>
</tr>
<tr>
<td>Fresh frozen plasma (FFP)</td>
<td>2 (4%)</td>
</tr>
</tbody>
</table>

Table 4: Adequacy of monitoring of warfarin reversal for WRICH, 2013–2018 (N=45).

<table>
<thead>
<tr>
<th>Outcome measure</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Median door-until-first-INR time, minutes* (IQR)</td>
<td>30 (16-54)</td>
</tr>
<tr>
<td>Median time from PCC (or FFP) to first repeat INR monitoring, minutes (IQR)</td>
<td>231 (102-783)</td>
</tr>
<tr>
<td>Number of patients who did not receive any monitoring following any reversal agent</td>
<td>8 (18%)</td>
</tr>
<tr>
<td>INR normal (&lt;1.3) on first testing following reversal</td>
<td>21 (57%)</td>
</tr>
</tbody>
</table>

* INR should be taken on admission, but a result is not required before giving PCC if a scan shows ICH while taking warfarin.

Table 5: Average ICH volume size comparison across the three cohorts.

<table>
<thead>
<tr>
<th></th>
<th>WRICH 2004–2013 (n=118)</th>
<th>WRICH 2013–2018 (n=43)</th>
<th>DRICH 2013–2018 (n=7)</th>
<th>p (Kruskall-Wallis test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ICH volume, ml (median)</td>
<td>28 (13)</td>
<td>18 (7)</td>
<td>32 (18)</td>
<td>0.041</td>
</tr>
</tbody>
</table>
Eleven patients were excluded from ICH volume calculations as they were primarily intraventricular haemorrhages (two from the WRICH 2013–2018 cohort and nine from the WRICH 2004–2013 cohort). ICH volume showed no correlation between increasing volume size and a faster door-to-needle time \((p=0.156)\), time to CT imaging \((p=0.087)\) or time to first repeat INR \((p=0.956)\).

**Discussion**

A key finding of this study is that door-to-any-reversal-agent time in WRICH has improved over time. This supports previous studies in Christchurch Hospital that have showed improvements, particularly following protocol improvements emphasising early PCC administration. Scan-to-PCC-administration (ie, diagnosis-to-treatment) time has also improved over time. Although this is encouraging, our second key finding is more disconcerting, as it shows that these times are significantly longer (by 1–3 hours) than equivalent IS DNT in the same centre.

We treated WRICH differently to those related to dabigatran. Although the sample size is very small (and so may account for no significant difference with IS), DRICH received imaging within almost a third of the time of warfarin patients. They also received their reversal agent more rapidly, though they still had significant delays to repeat TCT testing despite idarucizumab’s rapid action. Idarucizumab, vitamin K and thrombolysis are each administered via a single injection and thus easy to give when the patient is still in the CT scanner, unlike PCC/FFP that require ordering from a blood bank and a return to the ED. ICH occurs much less commonly than IS, and the subset of ICH related to anticoagulants even less commonly. However, DRICH were treated within a much shorter time frame than WRICH, so rarity of exposure does not completely explain delays in treatment. Also, recently published data shows patients on dabigatran who received thrombolysis in IS had even faster DNTs than dabigatran patients with ICH. Door-to-scan time for WRICH was particularly slow, despite these patients still being potential thrombolysis candidates if ischaemic stroke is confirmed and INR <1.7. ICH volume was not associated with time to receive imaging or reversal agent, so this does not appear to be a factor. In this centre, systemic quality improvements have been made to the WRICH protocol to remove some of the barriers to treatment, but clearly some barriers persist and require further exploration.

This study has also highlighted considerable shortcomings in adequately reversing warfarin. Vitamin K is routinely the first agent given, and there is often a delay before patients receive the more effective PCC. There are large delays in repeat INR testing following administration of PCC despite 43% remaining elevated and requiring consideration of repeat treatment. Once vitamin K is administered, it appears that the other steps of the reversal pathway are not followed with urgency. This is of particular concern due to the link between anticoagulant-associated ICH and haematoma volume expansion over hours and a therefore higher risk of worsening disability. Delays in PCC administration are also likely to impact on patients with ICH on rivaroxaban, although these patients were not specifically included in this study. Another potential cause of delay is inadequate handover—for instance, if vitamin K or PCC is given in ED and ongoing treatment/monitoring is left to the acute inpatient teams. It must be clearly communicated which reversal agents have been given, and when repeat testing is required, to maintain the urgency of reversal.

Another possible reason for slower treatment of ICH is the patients’ removal from the acute code stroke pathway in Christchurch Hospital once ICH is confirmed. The acute stroke team were no longer involved with ongoing management (PCC administration) via the emergency department. This has now been changed so that acute stroke nurses stay with the patient as they return to ED for PCC.

Our DNT appear to be longer compared to other published studies. One US centre developed a pharmacist-driven protocol for PCC dosing, preparation and delivery that showed improvement in median scan-to-PCC-administration time from 70 minutes (IQR 34–89 minutes) to 35 minutes (IQR 25–62 minutes). A UK centre removed the requirement of haematology pre-approval for PCC, moved PCC stock to the ED and introduced point-of-care INR testing, which showed a reduction in median
scan-to-needle time from 127 minutes (IQR 111–208 minutes) to 58 minutes (IQR 50–91 minutes). A real-world-based study showed times more in line with our findings: median DNT for vitamin K and PCC administration were 3.6 and 5.2 hours, respectively. However, even these post-protocol DNT times remain slower than our centre’s IS thrombolysis times. We believe the ‘time is brain (lost)’ mantra is valid, and therefore our anticoagulant-related ICH reversal times should be similar to thrombolysis times for IS patients.

These results raise questions such as whether ICHs are given lesser priority than IS, or whether the lack of randomised control trial (RCT) evidence of better outcomes with prompt reversal is causing a degree of therapeutic nihilism. There may be systemic as well as possible attitudinal differences in the ‘time is brain’ principle when a person presents with an ICH compared with an IS, and again when presenting with DRICH compared with WRICH. These areas require further investigation.

A strength of this study is that it is complete data from a single centre. Multiple sources were used to generate the cohorts and, as a result, are likely to have fully captured the appropriate data. Compared to other South Island centres, this centre has a highly developed stroke service with reasonable and increasing rates of thrombolysis, endovascular clot retrieval and telestroke. However, this is a single-centre, observational study and therefore generalisability is limited.

A limitation of this study is its retrospective nature—our data were based primarily on clinical notes. The decision to focus on the more recent cohort in regards to anticoagulant monitoring and comparison to IS thrombolysis times reduced our sample size and, consequently, the study’s statistical power. However, with significant changes including ‘code stroke’ pre-hospital notification being introduced in mid-2017, some of the data from over five years ago may not reflect contemporary practice. A separate analysis of the 2013–2018 cohort also reflects the impact of the previous study in Christchurch Hospital involving implementation of education regarding the existing ICH protocols. These protocols have had ongoing refinement over time and put emphasis on urgent reversal using the most effective agents (PCC and idarucizumab).

Another limitation of this study is that we reviewed adherence to Christchurch Hospital’s protocol for ICH reversal, not the clinical outcomes. However, previous studies in this centre have suggested early warfarin reversal may improve patient outcomes. Our study was limited by the small number of dabigatran patients—only nine over the four-year period, which include two prior to the availability of idarucizumab. The significantly lower intracranial haemorrhage incidence with dabigatran (compared to warfarin) in this group is supported by the RE-LY trial findings as well as real-world population data from New Zealand.

A vital step for further quality improvement has been re-engaging with key stakeholders in ED, radiology and stroke service to identify any additional barriers. We have already recommended changes in our hyper-acute stroke pathway, including acute ICH reversal management remaining with the code stroke team in the initial phases. All patients with a stroke syndrome who are on oral anticoagulants will also be included as code stroke calls. Education programmes have been implemented and discussed previously. Due to the high number of staff in ED, it may be better to focus additional education efforts on the numerically smaller group of acute stroke nurses.

In conclusion, door-to-any-reversal-agent and scan-to-PCC times have improved in this centre over time. However, improved DNT is the target, and these times fall well short of IS DNT. Reversal monitoring was also outside of recommended guidelines. ‘Time is brain’ does not apply to IS alone. All strokes—both ischaemic and haemorrhagic—need urgent imaging and treatment.
Competing interests:
Nil.

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The clinical workforce caring for emerging adults with diabetes in New Zealand is under resourced

Ryan Paul, Vickie Corbett

Diabetes is one of the most common chronic disorders in emerging adults (15–25 years of age), and the prevalence of both type 1 diabetes (T1D) and type 2 diabetes (T2D) in New Zealand continues to increase in this age group. Tight glycaemic control in both T1D and T2D is well known to reduce diabetic microvascular and macrovascular complications and improve survival. However, in New Zealand and worldwide, emerging adulthood is typically the period of worst glycaemic control in the lifespan due to the high prevalence of psychosocial stressors and increased insulin resistance of puberty and risk-taking behaviours. In addition, the glycaemic control of emerging adults with diabetes in New Zealand often deteriorates due to the loss of support from family and friends from moving regions, the failure of support from paediatric services to extend to emerging adulthood and the loss of public funding for insulin pump therapy as glycaemic targets are no longer met. Given the high prevalence of psychosocial stressors and the loss of support, the International Society for Paediatric and Adolescent Diabetes’s (ISPAD) guidelines recommend that emerging adults with diabetes receive ambulatory care from a dedicated multidisciplinary team consisting of 0.75 full time equivalent (FTE)/100 patients of an endocrinologist, 1-1.25 FTE/100 patients of a diabetes nurse specialist, 0.5 FTE/100 patients of a dietitian, 0.3 FTE/100 patients of a psychologist and 0.3 FTE/100 patients of a social worker or youth worker.

Although the multidisciplinary clinical resources caring for children with diabetes in New Zealand in 2012 has been published, the national clinical resources available for emerging adults with diabetes is yet unknown. The New Zealand Diabetes Young People Special Interest Group was formed in 2016 with the aim of improving the care of emerging adults with diabetes nationally. Through this group we aimed to characterise the clinical workforce and resources available for the care of emerging adults with diabetes in New Zealand.

Methods

In October 2018, lead clinicians or representatives of the New Zealand Diabetes Young People Special Interest Group from each of the 20 district health boards (DHBs) in New Zealand were invited via email to participate in a national survey on the clinical workforce caring for emerging adults with diabetes. These contacts were encouraged to discuss with other team members and service managers as required to complete the survey to determine the numbers of staff caring for emerging adults with diabetes, including endocrinologists, general physicians, general practitioners, nurse practitioners, diabetes nurse specialists, dietitians, psychologists, social workers, youth workers or kaiāwhina/health navigators. Staffing is expressed as number of FTE per 100 patients for comparison. Dietitian, psychology, social work, youth workers and kaiāwhina FTE are defined by whether these staff are dedicated (ie, they are embedded within the diabetes team) or only accessible (ie, they are not embedded within the team). The distinction of dedi-
cated emerging adult diabetes teams and staff were determined by each DHB. Only FTE of staff in dedicated multidisciplinary teams (MDTs) caring for emerging adults with diabetes is presented, because either the numbers of patients weren’t known or it was impossible to separate specific FTE for the care of emerging adults from that of older adults. Indeed, many of the smaller centres without a dedicated MDT did not have a database of their patient numbers, so these MDTs were asked to provide their best estimate of numbers. Clinical nurse specialist FTE in smaller, dedicated MDTs was often over-estimated because their FTE also involved care of children or older adults, so this data are presented as median values.

DHBs were also asked about the age of transition from paediatric services, whether registrars worked within emerging adult teams and whether their service that cares for emerging adults had a database of current patients with or without clinical data (eg, HbA1c), was interested in contributing towards a national database for emerging adults, provided specialist out-of-hours care for their emerging adults with diabetes or had an intervention programme for emerging adults with T2D. The authors confirmed with each survey responder that all information was correct.

**Results**

Responses were received from all 20 DHBs, who together provide care for approximately 2,300 emerging adults with diabetes in New Zealand. The median age of transfer from paediatric services to emerging adult services was 16 years (range 15–18 years), and all DHBs offered flexibility in their transition depending on clinical circumstances (see Table 1). Emerging adults with diabetes were cared for by a dedicated MDT in twelve DHBs (60%), by general adult diabetes services in five DHBs (25%), by general medicine in two DHBs (10%) and by primary care in one DHB (5%). The median number of emerging adults cared for by a dedicated MDT was 177 (range 40–370), and all MDTs contained at least one endocrinologist and one diabetes nurse specialist (see Table 2). Two dedicated MDTs also contained nurse practitioners, and the FTE per 100 patients for all team members are outlined in Table 2. Eight of the twelve MDTs (67%) had dedicated dietitian tenths, and all DHBs had access to a dietitian. Only three MDTs (25%) had dedicated psychology tenths, and six DHBs had no access to psychology services. Only one MDT (8.5%) had a dedicated social worker, and three MDTs (25%) had a dedicated kaiao āwhina or health navigator.

Only one DHB provided training for registrars in the care of emerging adults with diabetes. Twelve DHBs (60%) had a database of their emerging adults, but only four DHBs (25%) had a database with clinical information such as recent HbA1c levels. All DHBs were keen for a national database, and 18 DHBs (90%) were keen for increased collaboration to improve the care and transfer of emerging adults between DHBs. Only one DHB provided specialist out-of-hours care for their emerging adults with diabetes. No DHB had an intervention programme for emerging adults with T2D.

**Discussion**

Although it is pleasing that more than half of DHBs have a dedicated multidisciplinary team caring for emerging adults with diabetes, it is concerning that the staffing of these teams is significantly under resourced compared to international guidelines. Indeed, in comparison to international guidelines, the median FTE/100 patients were more than seven-fold less for endocrinologists, three-fold less for diabetes nurse specialists, ten-fold less for dietitians and thirty-fold less for psychologists. Emerging adulthood is recognised as the period with the greatest psychosocial stressors in a person’s lifespan, so it’s particularly concerning that only three MDTs had a dedicated psychologist, only one MDT had a dedicated social worker and six DHB teams had no access to a psychologist. It is also concerning that only three MDTs had access to a kaiao āwhina or health navigator, when there are marked inequities in diabetic outcomes between Māori and non-Māori in this age group.

The lack of clinical multidisciplinary resources available for the care of emerging adults with diabetes is further emphasised by comparison to the resources available to paediatric diabetes teams in New Zealand. The median FTE/100 paediatric patients with diabetes for the 20 DHB
teams in 2012 was approximately two-fold greater for both endocrinologists and diabetes nurse specialists compared to our data for emerging adults; and, similarly to our study, there was a wide variation in medical and nursing staff numbers between DHBs and a scarce number of dedicated dietitians and psychologists within diabetes teams, which highlights the inequities in care between regions, or the ‘postcode lottery’ effect. The wide variation in staffing FTE is likely due, at least in part, to overestimations of FTE in smaller centres, which could be explained by FTE being unable to be differentiated from FTE caring for children or older adults with diabetes. Nevertheless, the reduced clinical resources available to teams caring for emerging adults, compared to the resources available to teams caring for children with diabetes, is worrying given that emerging adulthood is the period of life when it is most difficult to obtain good glycaemic control in New Zealand and worldwide.

In addition to lower staff numbers, MDTs caring for emerging adults with diabetes in New Zealand often have reduced access to social support services and non-govern-

Table 1: Demographic details of the care of emerging adults with diabetes by DHB region.

<table>
<thead>
<tr>
<th>DHB</th>
<th>Number of patients</th>
<th>Care provided by</th>
<th>Age of transfer (years)</th>
<th>Flexible transfer</th>
<th>Database</th>
<th>Mean HbA1c</th>
<th>Intervention programme for T2D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>169</td>
<td>Dedicated team</td>
<td>16</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>370</td>
<td>Dedicated team</td>
<td>16</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>40</td>
<td>Dedicated team</td>
<td>17</td>
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<td>Yes</td>
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<td>9</td>
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<td>18</td>
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<td>20</td>
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<td>16</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
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</table>

*In DHBs without databases, patient numbers were often approximated due to the difficulty of knowing exact numbers at one point in time.
DHB=district health board; T2D=type 2 diabetes.
mental organisations compared to their paediatric colleagues. Notably, emerging adults lose the childhood disability allowance that many families used to fund flash or continuous glucose monitoring, which would significantly improve their glycaemic control. Therefore, it is likely that the reduced availability of resources contributes to the deterioration in diabetes outcomes in the transition from paediatric to emerging adult diabetes care.

The lack of training opportunities, the discharge of patients to primary care in one DHB region and the lack of benchmarking with low database use suggests that the care of emerging adults continues to not be recognised as a subspecialty of diabetes care in New Zealand. Indeed, of particular concern is that no DHB provided an intervention programme for emerging adults with T2D, despite that T2D in emerging adults is greatly increasing in prevalence, and it is a much more aggressive disease than it is in adults. Further, the greater burden of complications and diabetes distress from T2D in this age group emphasises the need for their care to be provided by a specialised multidisciplinary diabetes team. The development of a specialised multidisciplinary team may not be feasible for many smaller DHBs, but access to a psychologist and dietitian with knowledge of diabetes remains important and may require referral to a tertiary centre.

This study has several limitations. Firstly, it is not known whether the ISPAD guidelines are directly applicable to the New Zealand setting, particularly in the ‘ideal and culturally appropriate care’ of Māori and Pacific emerging adults with diabetes. This is important because, although Māori and Pacific emerging adults are less likely to have T1D (the most common type of diabetes in this age group), they are more likely to have less healthy glycaemic control and a greater burden of diabetic complications. Moreover, it is concerning that many DHBs were unable to provide any ethnicity data.

Table 2: Staffing of dedicated teams caring for emerging adults with diabetes by DHB region.

<table>
<thead>
<tr>
<th>DHB</th>
<th>Number of patient</th>
<th>Endocrinologist FTE/100 patients</th>
<th>Nursing FTE/100 patients</th>
<th>Dietitian FTE/100 patients or accessible</th>
<th>Psychologist FTE/100 patients or accessible</th>
<th>Social worker FTE/100 patients or accessible</th>
<th>Health navigator FTE/100 patients or accessible</th>
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<tr>
<td>Recommendations*</td>
<td>0.75</td>
<td>1-1.25</td>
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<td>Not accessible</td>
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<tr>
<td>2</td>
<td>370</td>
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<td>0.38</td>
<td>0.50</td>
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<td>0.01</td>
<td>Not accessible</td>
</tr>
<tr>
<td>3</td>
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<td>1.00</td>
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<tr>
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<td>0.35</td>
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<td>0.007</td>
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<td>0.27</td>
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<td>Median</td>
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<td>0.46</td>
<td>0.05</td>
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</table>

*Recommendations are from ISPAD guidelines and are for 0.3 FTE/100 patients for social worker or health navigator.
†Service provided registrar training.
‡Multidisciplinary team contained nurse practitioners.
for emerging adults for the different types of diabetes and glycaemic control, which is also not currently possible from national diabetes registers. This data is urgently required to identify and then reduce the inequities among emerging adults with diabetes in New Zealand, which may include the development of models of care that differ from those used internationally. A further limitation of this study, as with any survey, is the potential for response bias. To reduce bias, each DHB was de-identified, and responders were instructed to discuss their survey answers with other team members and managers before replying. But it is likely some bias is still present, given that some answers were ‘best-estimates’ and some questions may have been seen as leading questions, such as those enquiring about the flexibility of transfers and willingness to collaborate. Nevertheless, despite the limitations, this study has considerable value in identifying the national shortfalls in the resourcing of care of emerging adults with diabetes.

In conclusion, our study shows that the care of emerging adults with diabetes is significantly under resourced in New Zealand. If we are to address the inequities in the care of emerging adults with diabetes between regions, between paediatric care and emerging adult care, and between Māori and non-Māori, then adequate resourcing is urgently required. In particular, there needs to be a focus on increasing the delivery of care by specialised multidisciplinary teams with dedicated dietitian, psychologist, social worker and kaiāwhina or health navigator team members.

Competing interests:
Nil.

Acknowledgements
The authors wish to acknowledge the New Zealand Diabetes Young People Special Interest Group and all those who contributed data from their region, including Rose Fifield, Dr Wendy Hunter, Pauline Giles, Fiona Seekup, Associate Professor Ben Wheeler, Paula Nilsson, Gilli Lewis, Jo Naylor, Leslie Manning, Dr Rob Leikis, Cate Fleckney, Claire O’Brien, Dianne Fairhall, Lisa Smith, Sasini Wijayaratna, Dorothy Larsen, Shelley Rose, Tania Bailey, Louise Farmer and Trina Martin.

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REFERENCES


Pacific peoples and alcohol: a review of the literature

Vili Nosa, Gemma Malungahu, Janine Paynter, Dudley Gentles, David Newcombe

ABSTRACT

AIM: To present a review of recent research exploring alcohol use by Pacific peoples in New Zealand. The review builds on a comprehensive narrative review of research and literature on Pacific peoples and alcohol use, Pearls Unlimited (2009).

METHOD: We conducted a scoping review of published and grey literature written and published between 2009 and 2019. Research was included if the study population, or a clearly identified subgroup of the study population, included one or more Pacific ethnicities and addressed alcohol use.

RESULTS: There were 30 relevant articles covering a large range of aspects of alcohol consumption by Pacific youth and adults. Alcohol consumption by Pacific men has declined significantly to 60% from 70% in 2006/07. However, of those who consume alcohol, 46% meet the threshold for hazardous consumption. Alcohol consumption by Pacific youth has also declined.

CONCLUSION: While there has been some notable research and in-depth exploration of alcohol use and Pacific people, persistent inequity in hazardous alcohol consumption indicates that an evaluation of the current interventions to prevent and service unmet needs of Pacific peoples are overdue.

In 2009, Pearls Unlimited was published in order to draw together disparate information on Pacific peoples and alcohol use. This paper provides an update on research on alcohol use by Pacific peoples since that report was published.

Previously highlighted gaps in the research

Pearls Unlimited identified a number of gaps in research that fell across different areas of alcohol use. These were the broad areas:

1. Motivations, reasons and context for drinking by Pacific peoples: these include the history of alcohol use in different Pacific communities, cultural expectations and obligations relating to alcohol, life challenges that may lead to alcohol use (eg, unemployment), resiliency and risk factors in each different Pacific ethnicity, relationships between sporting culture and alcohol consumption in the Pacific youth population and, finally, the aspects of acculturation contributing to greater alcohol consumption.

2. Treatment and prevention options, such as the role the church can play in prevention or treatment of alcohol problems, what treatment models are most successful for Pacific users of alcohol and other drug treatment services, the most effective mechanisms for dealing with alcohol abuse and alcohol related violence in Pacific communities, gender focused interventions and assessment of primary care models.

3. Up-to-date trends in alcohol use and consumption, particularly for different Pacific ethnicities. Related to this was research to make the Alcohol Use Disorders Identification Test (AUDIT) more culturally appropriate.

Methods

This was a scoping review to give an update on the developments in research that have happened since *Pearls Unlimited* was published.¹ A broad Google search of ‘Alcohol New Zealand’ was done to establish the current context for alcohol literature relating to Pacific peoples in New Zealand. This was also a starting point for the grey literature search. Two other searches were ‘Pacific people health New Zealand’ and ‘Pacific people alcohol’. Documents from these searches contributed to the literature review if they met the criteria or were used to identify other eligible literature.

The databases used were Ovid Medline, Embase, Scopus, Kiwi Research Information Service, Cochrane, Index New Zealand, PubMed, Google Scholar and ProQuest. Targeted health website searches were also conducted (Table 1).

Literature was included if it was published during the period of 2009–2019, written in English, included the Pacific population in New Zealand and had a primary focus on alcohol use. Some earlier studies (pre-2009), or studies undertaken outside of New Zealand, are cited to provide context for the included studies. Searches yielded 846 items. Following removal of duplicates and exclusions based on titles and abstracts (by authors GM and JP), thirty resources were eligible for this study. These included journal articles (n=19), reports (n=10) and a book (n=1).

Results

Prevalence of past-year alcohol consumption

The New Zealand Health Survey provides recent data on alcohol consumption in New Zealand.² In 2017/18, around 79% of New Zealand adults reported consuming alcohol in the past year. This is similar across age groups from 25–64 years. Prevalence is higher for the 18–24 age group and lower for older age groups (65+ years). After adjusting for age, results show that Pacific adults are significantly less likely to have consumed alcohol in the past year (34%) compared to 85% of non-Pacific ethnicities (eg, European/other).

There has been a significant decline in alcohol consumption by Pacific males when comparing 2017/18 (60.0%) with 2006/07 (70.5%). There was minimal change in alcohol consumption among Pacific women from 2006/07 (49.2%) to 2017/18 (49.4%). Over the same period, there was a significant decline in proportions of both European men and women who consumed alcohol.

Table 1: Targeted health websites searched.

<table>
<thead>
<tr>
<th>Organisation or resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol &amp; Public Health Research Unit</td>
</tr>
<tr>
<td>Centre for Social and Health Outcomes Research and Evaluation</td>
</tr>
<tr>
<td>Centre for Applied Cross-cultural Research (CACR)</td>
</tr>
<tr>
<td>Health Services Research Centre</td>
</tr>
<tr>
<td>Health Research Council of New Zealand</td>
</tr>
<tr>
<td>Le Va</td>
</tr>
<tr>
<td>Matua Raki National Addiction Treatment Workforce Development Programme (NATWDP)</td>
</tr>
<tr>
<td>Mental Health and Wellbeing Commission</td>
</tr>
<tr>
<td>Ministry of Health</td>
</tr>
<tr>
<td>New Zealand National Drug Policy</td>
</tr>
<tr>
<td>New Directions in Pacific Health</td>
</tr>
</tbody>
</table>
Prevalence of hazardous alcohol consumption

Hazardous drinking in people aged 15 years or older is measured using the 10-question Alcohol Use Disorders Identification Test (AUDIT) developed by the World Health Organization, and in the New Zealand Health Survey a score of eight or more is considered hazardous drinking. While Pacific adults were less likely than European adults to have consumed alcohol in the past year, those who did drink were significantly more likely to have been hazardous drinkers (36%) than European adults (25%). Among Pacific men who drink, 46% reported hazardous drinking compared to only 25% of women.

Unmet need

The 2007/08 New Zealand Alcohol and Drug Use Survey measured the proportions of people who wanted help within the last 12 months to reduce their level of alcohol or drug use but did not receive it. Pacific peoples (4.8%) and Māori (4.2%) were more likely than European/other (1.7%) to have wanted help to reduce their level of alcohol or drug use in the past year but not received it.

Pacific users of alcohol and drug treatment services report making repeated, unsupported and unsuccessful attempts to cease alcohol and substance abuse before finally connecting with a treatment service. A study exploring conceptualisation of deliberate self-harm among Pacific populations in New Zealand was conducted because current clinical definitions of deliberate self-harm (DSH) do not incorporate a Pacific perspective. Nineteen semi-structured interviews were conducted with Pacific health professionals. It was felt that the current definition of DSH was too narrow. From a Pacific perspective, indirect and longer-term self-harm, such as alcohol and drug abuse, should be considered as part of the concept. Conceptualising alcohol abuse as an attempt to self-harm may provide a pathway to healing or reconciliation via development of church or community initiatives promoting the cohesion of Pacific people’s families, culture and spirituality.

Youth alcohol consumption, behaviours and harms

The two best sources of current data on alcohol consumption by youth are the New Zealand Health Survey (2016/17) and the Youth’12 The Health and Wellbeing of Secondary School Students in New Zealand survey. The New Zealand Health Survey, as reported online, does not provide data broken down by ethnicity.

A report by Fa’alili-Fidow and colleagues based on the Youth’12 The Health and Wellbeing of Secondary School Students in New Zealand survey provides the most up-to-date details on youth drinking by ethnicity. Secondary school students aged 12–18 years were invited to participate. The Pacific Island ethnicities represented in the survey are Samoan, Tongan, Cook Island, Niuean, Tokelauan, Fijian and a small number of other Pacific Island ethnicities. The specific ethnicities within this survey that are large enough to provide reliable subgroup estimates are Samoan, Tongan and Cook Island. The other Pacific Island ethnicities are combined.

In 2012, the proportion of Pacific students who reported that they consumed alcohol weekly or more often was 5.9% (95% CI 3.9–7.9). The proportion of Pacific students who reported binge drinking within the previous four weeks was 18.4% (95% CI 15.1–21.6). There has been significant declines in the proportions of Pacific students who report regular alcohol consumption or binge drinking since 2001 and particularly since 2007. Pacific students were less likely to report drinking alcohol weekly or more often compared to their European counterparts (5.9% (95% CI 3.9–7.9) versus 9.5% (95% CI 8.2–10.8), respectively). Pacific students are also less likely to report binge drinking in the previous four weeks compared to European students (18.4% (95% CI 15.1–21.6) versus 24.9% (95% CI 22.8–27.0), respectively). Comparisons between the specific Pacific ethnic groups found that Cook Island students were slightly but significantly more likely to report binge drinking compared to Samoan students.

Most students (Youth’07 survey) who reported binge drinking got their alcohol from friends (71%), someone else who bought it (43%), brothers and sisters (34%), another adult they know (29%) or their parents (26%), or they bought it themselves (22%), took it from home (17%) or stole it
Equivalent data from the Youth'12 survey specifically for Pacific students has not been reported on; however, a report that focused on students with problem substance use from the Youth'12 survey found that friends were still the main source of alcohol for students with very high substance use (51%) and for students with lower levels of substance use (42%). Around 46% of students with high substance use report that they get someone else to buy it for them. This is lower (25%) for students with lower levels of substance use.

Students in the 2007 survey reported that they normally drank alcohol with friends (88%), followed by family (52%), other people (40%) and lastly 'by myself' (11%). What was concerning was that one in four Pacific students reported experiencing alcohol-related harm. The most common harms for Pacific students was doing things that could get them into trouble (29%), having unsafe sex (28%), having friends and family talk with them about reducing their alcohol consumption (26%) and getting an injury because of their alcohol use (25%).

**Protective factors for youth**

Factors associated with a lower risk of binge drinking were age (younger pupils were less likely to binge drink), culture and parenting style. Students with parents able to speak a Pacific language were less likely to report binge drinking. Students whose parents knew where they were after school or at night were less likely to report binge drinking. Weekly church attendance was a protective factor after controlling for other variables. The majority of Pacific people are affiliated with at least one religion and the use of alcohol is discouraged in alignment with religious beliefs.

A qualitative study explored factors that support abstinence and responsible drinking behaviour among Pacific youth living in Auckland. Young people highlighted three main communities that helped support abstinence and responsible drinking. These communities are family (including extended family), peers and church. Most of the participants referred to their practices of toka'i (respect and honouring others) and the social shame that would be directed towards their parents if they were to drink and behave drunk. This was associated with feelings of guilt when they were not able to fulfil their obligation of taking their families (specifically their mothers) to church on Sunday due to drinking heavily the night before. Their Pacific value systems and their holding of at least a bicultural or multicultural identity, their affiliation with church and their family ties give rise to the protective factors that neutralise the negative risks, such as alcohol related harm, associated with heavy drinking.

**Risk factors for youth**

Teevale et al found that binge drinking occurs more frequently among Pacific students from relatively well-off neighbourhoods. This may reflect the transitional nature of Pacific communities in New Zealand with “the more affluent and middle-class adopting mainstream use of alcohol.” This trend has not emerged among Pacific adults. People living in the most deprived quintile are significantly more likely to report hazardous drinking or binge drinking. This measurable inequality by deprivation is stronger for young men.

Frequent supply of alcohol by parents, friends or others was also a significant predictor of all drinking measures among teenagers. Most participants in Greenaway’s evaluation on the social environment of alcohol supply in Māngere, Auckland, identified as Cook Island, Niuean, Samoan, Tongan and Māori. Parents reported feeling helpless, due to the constant social supply of alcohol. This influenced some parents to supply alcohol to their young adults in an environment where they could monitor them. Some of the participants reported underage access to alcohol was inevitable and had become accepted and normalised. This was compounded by the high number of alcohol outlets in the neighbourhood and the lowering of the purchase age to 18 years old.

A 2011 study investigated the impact of recent migration and acculturation on cigarette, alcohol and marijuana use by youth. Pacific youth were less likely to consume alcohol frequently compared to European youths. Experiencing ethnic discrimination was associated with a higher risk of frequent alcohol consumption. First generation migrants were less likely to report more frequent alcohol consumption compared to youth born in New Zealand. However, acculturation seemed to attenuate this
association, and youth who reported that they felt more comfortable in New Zealand European social settings and spoke English at home were less likely to report more frequent alcohol consumption.\textsuperscript{16}

**Gender and alcohol**

A report examining women, alcohol use and harm was published in 2013.\textsuperscript{17} The report draws out specific Pacific perspectives on woman and alcohol where literature is available and with specific Pacific focus groups. Although Pacific women have in general and historically consumed less alcohol than men, this has changed. The proportion of young women (16–17 years) who reported harmful alcohol consumption exceeds the proportion of young men who reported harmful drinking in 2011. Pacific women were more likely than New Zealand European women to be non-drinkers or drink less often, but they consumed more on a typical occasion. These factors vary by ethnicity among Pacific women. Pacific women participating in focus groups reported that they had observed increasing alcohol consumption and more drunkenness among women. Alcohol marketing, outlet density, low prices, social inequity and trauma were all considered influences on alcohol consumption. The women felt that alcohol consumption eroded family cohesion and cultural wellbeing, and they specifically mentioned sexual abuse, unplanned pregnancies, fighting by young women and expulsions from tertiary education.\textsuperscript{17}

In many cultures, including Pacific ones, alcohol is “one of the more powerful symbols of gender roles and identities.”\textsuperscript{18} For Pacific cultures, there is a gender-based double standard. For example, it is acceptable for males to go out at night and engage in alcohol drinking, whereas for females this is less acceptable.\textsuperscript{19} This double standard may provoke a rebellion among females, particularly Pacific females born in New Zealand, who then drink in defiance, with or without parental consent.\textsuperscript{19}

Hutton and Wright\textsuperscript{20} conducted an ethnographic study of Māori and Pacific women’s drinking practices. The findings indicate that Pacific women often drink as a group, where the notion of peers belonging to the same sex and ethnicity provided a sense of safety and security for the young women.\textsuperscript{20} The women in the study reported drinking more when they were with their Pacific peer group, which was related to feeling comfortable ‘letting their hair down’, having fun, excitement and the desire to achieve ‘the buzz’ for relaxation and socialisation.\textsuperscript{20} This uptake of the New Zealand drinking culture by young Pacific women is still challenged by Pacific cultural opposition to female drinking, such that Pacific women who avoid drinking around family, particularly elders and men.\textsuperscript{20} This has been observed in studies of Niuean women\textsuperscript{9} and Tongan women,\textsuperscript{21} Hutton and Wright\textsuperscript{20} did not indicate whether Pacific women in the study were born in New Zealand or in the Pacific. Future research needs to identify whether the cultural pressure opposing drinking is different for Pacific-born women compared to women born in New Zealand born.\textsuperscript{9}

Research by Manuopangai\textsuperscript{21} investigated the consumption of alcohol among Tongan females aged 16–25 years in Auckland. The qualitative study included interviews with 20 Tongan females that attended a Tongan Methodist church. The study revealed five key themes related to alcohol use by the Tongan women: contemporary drinking style, cultural and religious influences, gender roles, knowledge of alcohol use and the associated harm experienced by the women. A key finding from the study indicated how the brother–sister relationship restricted women’s alcohol consumption in the presence of their brothers and male cousins. The Tongan value faka’apa’apa (respect) in the brother–sister relationship inhibited alcohol consumption among the female cohort, whereby women did not consume alcohol in front of their male brothers and cousins as a sign of respect and dignity.\textsuperscript{21} The females in the study perceived drinking as both good and bad.\textsuperscript{21} ‘Good’ was perceived as everyone having a good time and enjoying themselves, whereas a ‘bad’ time was when one or more drinkers became annoying, noisy, caused trouble and behaved in a shameful manner.\textsuperscript{21} Most of the participants from the study viewed a ‘cool drinker’ as a person who could consume a lot of alcohol but still control their behaviour, socialise and have a good time with others.\textsuperscript{21} Similar to other findings,\textsuperscript{21} this may in part be seen as an incentive to act like a ‘cool drinker’ and not become the drinker who becomes annoying and shameful.
The church's disapproval of drinking did not always lessen alcohol use by females affiliated with the church. For example, study participants reported that attending church with a hangover from the night before was common among the young people. In addition, conversations about previous drinking events were common among the young females. Drunk culture among some groups of females affiliated with the church had become normalised and accepted. In turn, this indicates how for this group of females religion was not a protective factor against alcohol consumption.

An initiative within the church, an annual four-day camp for youth, was provided to help reduce alcohol and drug consumption ('Apitanga Tapu Inukava Malohi Faito'o Konatapu & Tapaka). However, it was perceived by the females as ineffective in reducing their alcohol intake. The camp was attended primarily to socialise with their peers from other churches; despite this, the females in the study recommended that the camps should include inspirational speakers to share their experiences of alcohol use and their successful restriction of alcohol consumption. Other recommendations were to incorporate more information in English about the definition of a standard drink and to define moderate drinking.

Parenting, family and alcohol

The New Zealand Alcohol in Pregnancy Study was a representative sample of New Zealand women aged 16–40 years and included Pacific Island participants. This study explored awareness of the safety of alcohol consumption during pregnancy and opinions of warning labels as a source of information on the dangers of alcohol consumption during pregnancy. Pacific Island women were significantly more supportive of warning labels on alcohol (OR 2.13, 95% CI 1.13–4.01) compared to European/other ethnicities. They were also significantly less likely (OR 0.53, 95% CI 0.30–0.93) to consider it safe to consume alcohol during pregnancy compared to European/other ethnicities.

A qualitative study of Samoan and Cook Island fathers from the Pacific Islands Family Study explored broader influences on mental health and risky behaviour, including alcohol consumption. The Samoan fathers all reported making a conscious effort to educate their children about risky health behaviour such as alcohol use and smoking. Acculturation (loss of some Pacific Island culture in the process of fitting in to or adopting New Zealand culture) is generally associated with increases in risky health behaviour, such as harmful alcohol use and smoking. However, Tautolo reported that Pacific Island culture for one participant was connected negatively with harmful alcohol consumption, due to an alcoholic and abusive grandfather. Many participants reported that they curbed their alcohol consumption as part of their efforts to be good fathers.

Unfortunately, the New Zealand Health Survey doesn't provide data on alcohol consumption disaggregated by Pacific ethnicity. Two studies provide disaggregated Pacific ethnic data on alcohol consumption, and one of them found significant differences. Tongan parents generally had lower rates of alcohol consumption compared to Samoan and Cook Island Māori. Prevalence of harmful drinking was significantly higher among Cook Island parents compared to Tongan and Samoan parents. This survey found lower rates of alcohol consumption compared to the New Zealand survey, and that both mothers and fathers moderated their drinking in response to parenthood. The authors also suggested a need for alcohol and drug service interventions meeting specific ethnic and parent needs.

Family influence on substance use was explored in a qualitative study of users enrolled in drug treatment services. Sixteen participants provided detailed narratives (talanoa) of their lives and substance abuse. A dysfunctional family or family member was often the source of alcohol and contributed to persistent use. However, their own new family connections, children and supportive partners, and the desire to create stability and healthy relationships in contrast to their past, were strong motives to cease substance use.

Public policy and inequities

Liberal alcohol policy changes (eg, price decreases) and increases in accessibility (eg, increased outlet density) have been associated with increases in alcohol-related harm in other countries, such as Scandi-
navia and the United States. Access to and promotion of alcohol has increased in New Zealand in the last three decades, and during this time there have been measurable increases in alcohol-related harm. However, our review did not find much research that explored the influence of these policy changes on Pacific people’s attitudes and behaviour towards alcohol and alcohol-related harm. A recent survey of attitudes to local alcohol policy had minimal Pacific representation. A report by the New Zealand Medical Association (2015) states that alcohol-related harms do not only reflect existing inequalities between ethnic groups but are also driving inequalities. Their stance therefore is to advocate for improved policies to reduce alcohol-related harms, as stated in their 2011 position statement on equity:

13 Clause 32 “[u]rges clinical doctors and public health specialists to work together more closely in shaping services and developing programmes to promote and protect people’s health, prevent ill health and tackle health inequities, and address the broader social and environmental factors that are influencing individuals’ health, choices and behaviour.”

The impact of alcohol-outlet density and the distance to the nearest alcohol outlet in New Zealand communities was examined in a 2014 study. Data on alcohol outlets were obtained from liquor licensing authorities and linked with alcohol consumption data from the 2006/07 New Zealand Health Survey. New Zealand’s most deprived neighbourhoods had the highest density, at 15 alcohol outlets per 10,000 people. This study had reasonable Pacific ethnicity representation. Young Māori and Pacific males living further from alcohol outlets were significantly less likely to report hazardous alcohol consumption, even when the data are adjusted for deprivation compared to those living closer. There was a gradient (ie, as the distance from alcohol outlets gets longer, reports of hazardous consumption get significantly lower) culminating in a 70% reduction for those living the farthest distance from an alcohol outlet compared to those living closest.

Law and research on interventions that target or include Pacific peoples

In recent years, there has been an increased effort to reduce alcohol-related harm in New Zealand through the Sale and Supply of Alcohol Act 2012 (which regulates the supply of alcohol in New Zealand), the Local Government Act 2002 and a recent national commitment to reducing alcohol-related harm, the National Drug Policy 2015 to 2020. Despite these interventions, there has been no significant decrease in hazardous drinking among Pacific men and women since 2012/13. The National Drug Policy sets out the government’s approach to alcohol and other drug issues, with the overarching goal of minimising alcohol and other drug harm and promoting and protecting health and wellbeing. In addition to the National Drug Policy, there is a guide to priority outcomes, specifically for Pacific health and wellbeing.

Alcohol Healthwatch and Women’s Health Action say wide consultation with Pacific peoples is needed to identify how policies and services can better meet their needs and expectations and address inequities. A key recommendation of the organisations was to increase funding and support for alcohol-related research, programmes and services that address the needs of Pacific communities.

Screening tools within a primary care context can be an important mechanism to connect people who have problematic alcohol use with treatment services. Newcombe et al tested the validity of Alcohol, Smoking and Substance Involvement Screening Test (ASSIST) with Samoan, Tongan, Niuean and Cook Island Māori participants. ASSIST is recommended for use as a screening tool with Pacific people in a New Zealand context.

Injury is a large contributor to New Zealand’s alcohol-related burden of disease, and alcohol is a lead risk factor for injury. Therefore, trauma care settings offer an opportunity for screening and brief interventions aimed at reducing hazardous alcohol consumption. These settings may be useful for engaging Pacific Island people who may not access primary care as frequently. At present, screening in trauma care settings is not routine in New
Zealand, due to lack of resources and training for health professionals. To remedy this, a mobile text messaging intervention to reduce alcohol-related harm was developed and tested in New Zealand.36 Pacific Island participants (Cook Islands n=1, Niuean n=1, Samoan n=3) were represented in the qualitative evaluation and were interviewed by a Pacific Island researcher. Two positive features of the intervention from a Pacific perspective were the tailored greeting and the privacy afforded by the intervention.36

“Different greetings... Because it’s just the sense of them knowing who you are and where you’re from. They’ve done the research in terms of understanding what ethnic background you are.” (Male, Samoan, inpatient, hazardous drinker)

“... Pacific Island culture in general it’s like there are a lot of things that you don’t talk about... so I think people would sign up for this because it seems like something you can do personally that you don’t have to tell people about. So you don’t have to talk about it... I think getting the texts would be helpful cause then it would be like a way for you to kind of like reflect and then like cut down.” (Female, Samoan inpatient, hazardous drinker)

If youth remain consistently engaged with support services after their initial contact, there is a high probability of resolving their alcohol- and drug-abuse problems.38 Research has been done to investigate factors associated with successful engagement. One of these studies—a retrospective study of engagement of youth with an outpatient service in Auckland, New Zealand, for reducing alcohol and drug harm—found that, once connected with the service, Pacific Island youth were more likely than European youth to remain engaged in the service. For Pacific youth, remaining connected with family (eg, living at home), especially for older youth (16–19-year-old age range), also predicted longer engagement with the service.38

Limitations
The search was limited to literature that was published since 2009. This was a scoping review and not a critical review of the studies conducted.

Conclusion
Cagney and Alliston1 identified a number of gaps in research on alcohol use and Pacific peoples. Some of the gaps have been addressed since 2009, such as the data on consumption patterns in adults and youth. These are provided by the New Zealand Health Survey and the Adolescent Health Research Group’s Youth2000 Survey Series. They also provide some insight into differences between New Zealand’s larger Pacific groups, such as Tongan and Samoan. Deeper qualitative exploration of alcohol and drinking culture among Pacific women, and particularly young women, has been added to the discourse.

Surveys on alcohol consumption show limited improvements in hazardous alcohol consumption by Pacific men and women. Pacific men and women are more likely to report hazardous drinking compared to non-Pacific ethnicities. There have been promising declines in Pacific youth alcohol consumption and binge drinking. Gender differences in alcohol use, particularly by women, have featured in research on Pacific ethnicities and alcohol use from 2009 to 2017.

However, there are still some gaps to be addressed:
What is the role of prejudices and oppression due to gender, racism, colonisation and different sexual orientation or gender identity (eg, LBGT and fa’afine (or fakaleiti)) in both the uptake of harmful alcohol consumption and access to support services?

What are the specific attributes of New Zealand Pacific men’s alcohol consumption, such as the link between masculinity, sport and consumption?

What are the inherent protective factors, particularly those that can be drawn from pre-colonial Pacific and spiritual culture, that had no place for alcohol? Such factors can include, but are not limited to, family dynamics and obligations and cultural and religious practices, such as church attendance.

Finally, a critical examination is needed of health system services, the accessibility of alcohol and alcohol and drug services for Pacific peoples from specific Pacific ethnicities, genders and generational perspectives (eg, New Zealand born versus Pacific born).
Competing interests: Nil.

Acknowledgements:
We would like to thank the Health Promotion Authority for reviewing early drafts of this article.

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COVID-19 outbreak management in a hospital ward: lessons learned to prevent, prepare for and respond to infectious disease outbreaks in healthcare settings

Catherine Habel, Jerome Ng, Phil Shoemack, Kate Grimwade, Fiona Miller, Jen Boryer, Hayley Bennett, Stephanie Chisholm

The COVID-19 pandemic has triggered an international public health response that has stretched the limits of many healthcare systems, including those in high-income countries. Aotearoa New Zealand has taken the path towards elimination and has been largely successful in limiting the spread and impact of the COVID-19 pandemic on its territory so far.¹

Despite this general success, several COVID-19 clusters occurred during the first few months of 2020.² One COVID-19 outbreak associated to a known COVID-19 cluster (Hereford Cattle Conference, Queenstown) occurred at Bay of Plenty District Health Board (BOPDHB) in the acute mental health ward. A total of four cases were identified over a period of seven weeks: three staff members and one patient. The outbreak was declared after the fourth case was identified. It is most likely that transmission occurred in the ward, although no definitive source was identified for the last two cases. Two staff members who had been symptomatic could potentially be the missing link. No further linked cases have been identified despite extensive contact tracing as well as surveillance testing of the staff and patients connected to the mental health ward. The outbreak was officially closed 28 days after the end of the isolation period of the fourth case. The detailed timeline of the outbreak is described in Figure 1.

This outbreak has provided an opportunity to critically reflect on our response and better prepare for future outbreaks.

We asked ourselves: how can we strengthen our district health board (DHB) to develop and maintain its resilience over time? Health system resilience has been defined by Kurt et al (2017) as the capacity of health actors, institutions and populations to prepare for and effectively respond to crises, maintain core functions when a crisis hits and, informed by lessons learned during the crisis, re-organise if conditions require it.³

More specifically, Nuzzo et al (2019) discuss 16 attributes that a health system needs to develop and maintain to achieve resilience.⁴ From our reflection emerged suggestions on seven of these specific attributes: leadership and command structure, surge capacity, infection and prevention control, health workforce, communications, core public health capabilities for the DHB and a commitment to quality improvement.

In this article, we provide our suggestions to help other DHBs further refine their outbreak prevention and response. Like other jurisdictions who have experienced outbreaks in healthcare settings, we wish to share what we have learned.⁵⁶⁷
Leadership and command structure

Roles, responsibilities and the outbreak response structure should be described and agreed upon prior to an outbreak. More specifically, there should be clarity on who leads the response and why.

For this specific outbreak in the mental health ward, an outbreak management team was promptly formed at the request of the medical officer of health. Members of this team included the infection prevention and control team, an infectious disease consultant, the manager and lead physician of the mental health ward and Māori health services, as well as contact tracing staff from the public health unit (PHU) and the COVID-19 occupational health team.

However, we were unable to reach agreement around leadership roles and responsibilities. In particular, while the medical officer of health expected the service management team to take leadership for the overall response, the managers did not feel it was their role nor that they were the right people to do so. Furthermore, the emergency operations centre of the DHB did not have access to a written plan, protocol or procedure stating who should lead the outbreak response in the hospital and be accountable for its outcome. As this outbreak involved multiple areas of uncertainty (new disease, missing link) in a complex and vulnerable setting (mental health ward), this lack of clarity was a significant hindrance to an effective response.

From our experience, we suggest that oversight and accountability of the outbreak response should be held by the medical officer of health. The medical officer of health needs to be in a position where he or she has all information needed to pose a judgement related to the capacity of the outbreak team to provide a satisfactory outbreak response to protect the public. This includes two aspects: the capacity of the service to implement prevention and control measures, and the capacity of the public health unit to obtain and analyse information about the cases and contacts to inform the response.

Figure 1: Timeline and overview of the COVID-19 outbreak.
The leadership of the implementation of the control measures on site should be delegated to the management of the service. Both the infection prevention and control (IPC) team and the occupational health team should work closely with the management of the service. The IPC team are the technical experts on the ground, and they should be available seven days a week to join the response as early as possible. On the other hand, the service responsible for staff safety (in our case, the occupational health team) should be the first place for staff to obtain information about their own wellbeing in the context of an outbreak. Therefore, the service responsible for staff safety need to have strong capacity to scale up as needed.

Service coordination is required all throughout the response for these roles to be played effectively—and not only for specific outbreaks like this one in the mental health ward. Instead of establishing an outbreak response team for this episode only, the establishment of a hospital outbreak management team for the whole COVID-19 response would have provided a structure to position these roles early on and have more agility to scale up as needed. The DHB outbreak policy should be adopted and known by all key players and highlight objectives, roles, responsibilities, mandates and triggers for action. This document should be the foundation to enable effective coordination.

Surge capacity of contact tracing
Contact tracing must always be high quality and equitably offered to all groups of the affected population. Contact tracing is a skill. It involves appropriate assessment of the person, a thorough questionnaire and the application of clinical judgement to evaluate the completeness and validity of the information obtained. The interviews need to be done in a culturally and clinically safe way. We suggest that all contact tracing should be done under one team and structure with clear and accessible clinical leadership. Ideally, the public health unit should be responsible for all contact tracing. If the task is delegated to another team, role definition, reporting lines, communication channels and training requirements should be documented and approved by all parties.

Responding to COVID-19 highlighted a historical division of the contact tracing work within the DHB that was not documented or agreed upon by the various services. While the public health unit quickly organised to scale-up with dedicated, trained staff, a small COVID-19 occupational health nursing team was also created to fill a gap and perform hospital-based contact tracing. Unfortunately, coordination of the overall workload was suboptimal.

During our outbreak, the possibility of a missing link in transmission, and the change of the date of the onset of symptoms of one case, generated significant additional contact tracing workload. The new structure had challenges in coping with the workload, which, at times, threatened the quality of the investigations. The follow-up of some contacts, including some mental health patients, was delegated to a staff member who had received insufficient training in contact tracing. Moreover, because of the organisational structure, neither the COVID-19 occupational health team nor the staff from the mental health ward had direct access to clinical support from the medical officer of health during this period.

We believe this situation revealed issues that result from having multiple teams responsible for contact tracing in different parts of the DHB.

Health workforce: adequate, trained and willing
We suggest that DHBs should identify which of its staff members will be involved in an outbreak response and receive appropriate training.

Some teams and individuals struggled in their capacity to step up to the challenges associated with the COVID-19 outbreak in the mental health unit. Although working under an emergency response structure is not common, new and emerging infectious diseases that will continue to pose a threat to healthcare settings are a reality of the twenty-first century.

As for other events that require emergency response preparation, training
(including table-top exercises and simulations) should be considered to maintain and enhance staff competencies in responding to outbreaks in a multidisciplinary team. This should be offered and adapted to staff in all services, including the mental health ward.

**Infection prevention and control**

To provide a strong foundation for an effective response, we suggest that each service should have a pre-prepared outbreak management plan (covering both the outbreak response and business continuity) and ongoing, up-to-date training in emergency management for key staff. This is an opportunity for the services to examine different potential scenarios and assess their capacities to respond. All plans should have the same foundations and be developed under the leadership of the hospital outbreak management team.

In our case, the mental health service reacted promptly and effectively to control the outbreak and prevent further transmission. They had to take difficult decisions: the ward was closed to new admissions, and an agreement with neighbouring hospitals to re-direct admissions was put in place. Facing a potential staff shortage, a ‘ward bubble’ was created to ensure business continuity. Staff volunteered to work in the ward bubble while being isolated from their household members.

However, these decisions were taken in a context of limited information. For example, the management team did not know how many staff members of their service could provide some of the most specialised and essential care, as their rosters are based on roles and not on individual skillsets. As described above, the management team of the service was also uncertain of their role and who they should seek support from.

**Clear communication and early support for staff**

Although the emphasis is often on external communication in a situation of crisis, communication to staff is also vital and should be a priority. A communications plan covering internal and external audiences should be included as part of any outbreak management plan. Internal communications should aim to support the affected service, as well as communicating to the staff across the organisation to maintain a culture of transparency and trust.

During the response, communication with the staff directly involved in business continuity (the ward bubble) was clear, regular and supportive. The staff were supported by both their senior managers and Māori health services as they continued to provide care to the patients in a stressful and high-risk situation. Accommodation and food were provided for staff, and regular karakia were held, which provided an opportunity to reflect and bring people together.

However, around this outbreak, general communication with staff was, at times, contradictory and delayed. Managers quickly encouraged their staff to get tested before they were interviewed by the COVID-19 occupational health nurse, which created confusion in the identification of the contacts. It generated increased workload for the COVID-19 occupational health team, which was already under pressure.

**The importance of information management**

We suggest that a public health analyst should be dedicated to the outbreak management team at the beginning of each outbreak.

Analysing and understanding an outbreak as it unfolds is difficult. This was accentuated in our mental health unit outbreak due to poor documentation (including missing data) and the use of three different databases and PDF documents. The first days of an outbreak response are critical to ensure uniform data collection and storage, especially when staff are seconded to help with the response.

The role of the analyst is also to contribute to analysis and interpretation of the data. Sharing data between all the involved parties maintains transparency and allows for appropriate and timely decisions.
Core public health capabilities for the DHB

We suggest that a district health board needs to invest in public health expertise to ensure that they can deliver services based on public health principles and fulfil their responsibilities for the health of the population.

Part way through, a public health physician was assigned to lead the outbreak response. For a period of three weeks prior to the arrival of this public health physician, the emergency operations centre functioned without dedicated public health technical. Although DHBs need to be prepared to activate its outbreak management team, it is important to stress that the required public health technical expertise should always be available to advise as needed.

Consolidating public health expertise in a DHB should be done at multiple levels: create and support open communication channels with the public health unit, establish positions for public health physicians and other public health professionals and ensure public health expertise is available at all levels of decision-making. This would contribute to building stronger public health expertise in the DHB, so it is better placed to face emergencies of a public health nature, like outbreaks in healthcare settings during a pandemic.

Following this situation analysis, our DHB has engaged in improvement processes: consolidation of contact tracing under the public health unit leadership, strengthening of both the infection prevention and control team and the occupational health team under clinical leadership and adoption of an outbreak response structure with clear roles and responsibilities, as well as the development of outbreak management plans by all wards. It is likely that further opportunities for improvement might have been realised had the improvement work started in parallel to the response.

Conclusion

Overall, this outbreak remained small, with low morbidity and no mortality associated. However, this is an example of how the COVID-19 pandemic has tested the resilience of our health system to respond and exposed some of its challenges.

We hope that our suggestions can help other regional hospitals and district health boards to better prepare for infectious disease outbreaks in healthcare settings. While Aotearoa New Zealand is doing well to limit the spread of COVID-19 so far, let’s take this as an opportunity to engage in quality improvement processes before the next episode. It is an important aspect of the recovery phase of emergency management, and it will ultimately contribute to increasing the resilience of our healthcare system to future threats.

Commitment to quality improvement

This reflective exercise is our contribution to quality improvement. We suggest that reflective practices should be incorporated into the emergency response processes, as disruption can often create a fertile environment for change and improvement. This requires allocation of quality improvement resources to work alongside the response from its initiation.
Competing interests: Nil.

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Cobalt toxicity: a preventable and treatable cause for possibly life threatening cardiomyopathy

Gabriella Giacon, Ken Boon

ABSTRACT

Mr BH was a 53-year-old gentleman who presented to hospital in November 2019 with decompensated heart failure, new-onset paroxysmal atrial tachycardia and increasing left hip pain. Imaging of his hip demonstrated radiographic evidence of bony changes, suggestive of an adverse reaction to metal debris (ARMD), along with a non-traumatic left peri-prosthetic neck-of-femur fracture. Clinically, he had concurrent decompensated cardiomyopathy requiring dopamine and furosemide infusions. His serum cobalt (sCo) levels were 5244nmol/L (normal<12nmol/L).

He had previous bilateral total hip arthroplasties using the Birmingham Hip Resurfacing (right side 2006, left side 2012). As part of routine metal-on-metal arthroplasty follow-up, Mr BH had sCo level checks. In 2013, these levels rose to 1981nmol/L. Although there has been no direct correlation between sCo levels and toxicity, levels above 119nmol/L are concerning. Unfortunately, Mr BH moved to a different health district and was subsequently lost to follow-up.

In 2015, Mr BH was diagnosed with dilated cardiomyopathy, presumed secondary to viral myocarditis. Despite successful chelating therapy and heart failure treatment, he passed away secondary to cobalt-toxicity induced cardiomyopathy (CTCM).

T otal joint arthroplasty is a commonly performed orthopaedic procedure with the aims of relieving pain, restoring joint function and improving quality of life for patients. Last year in New Zealand, over 9,000 hip arthroplasties were performed. The Birmingham Hip Resurfacing (BHR) (Smith and Nephew, Memphis, TN) is manufactured using as-cast cobalt chrome and is classified as the world’s most successful metal-on-metal (MoM) hip resurfacing system, with over 140,000 people globally having received this implant. Prevalent use of these elements in MoM hip arthroplasty accounted for <1% of cases in 2018.

In MoM constructs, cobalt and chromium form the basis of the bearing surface, as opposed to a traditional arthroplasty construct where both femoral and/or acetabular components involve ceramic or polyethylene as part of their bearing surfaces. Revision rates of BHR occurred in 8% of cases, and the commonest cause of failure is adverse reaction to metal debris (ARMD). Despite several cases confirming cobalt-toxicity induced cardiomyopathy, there remains a paucity of high-quality research linking the cause with the effect. This makes fulfilling the Bradford Hill criteria difficult, thereby delaying the diagnosis of this potentially life threatening, yet easily preventable situation.

One in every three diagnosed cases of cardiomyopathy in general have been found to be non-ischaemic in origin. Given the established cardio-toxic effects of cobalt and its prevalent use in joint replacements, more robust systems of monitoring should be considered, especially for those at risk. Cobalt-toxicity induced cardiomyopathy is defined as both biventricular dilatation with systolic dysfunction in the presence of raised
sCo levels. It also requires normalisation of both structure and function of cardiac tissue once the insult has been removed (explanation of prosthesis or reduction of sCo levels).4

Case report

Mr BH initially presented to Timaru Hospital in 2015 with progressively worsening dyspnoea and associated bilateral peripheral oedema, with preceding flu like symptoms. His history included bilateral BHR (right side 2006, left side 2012). His brain natriuretic peptide was 512ng/L (normal<40ng/L), with elevated serial troponin T (TnT) levels. A chest x-ray revealed cardiomegaly (Figure 1).

The transthoracic echocardiogram (TTE) performed showed mildly dilated ventricles with severe biventricular failure. Diagnostic coronary angiography revealed only mild diffuse atheroma. Therefore, he was diagnosed with probable viral myocarditis.

As his serial TnT levels remained elevated despite treatment with appropriate therapy, cardiac magnetic resonance imaging (cMRI) was performed to further investigate the cause of his cardiomyopathy. Unfortunately, the results were inconclusive, showing patterns of enhancement suggestive of both myocarditis and a possible infiltrative condition (Figures 2, 3 and 4).

Due to his persistently elevated serial TnT levels, a repeat cMRI was performed in 2019. This revealed progressive deterioration of his left ventricular function with ongoing features suggestive of an infiltrate condition.

Figure 1: Chest x-ray showing mild cardiomegaly.

The possibility of amyloidosis was raised due to the persistent nature of the findings. Myocarditis or sarcoidosis was felt to have been less likely.

As amyloidosis was felt to have been clinically unlikely, Mr BH continued with

Figures 2, 3 and 4: cMRI showing possible delayed enhancement indicating possibility of myocarditis and sarcoidosis.
optimal medical therapy for his heart failure. He was subsequently referred for an implantable cardiac defibrillator in May 2019 due to his risk of malignant ventricular arrhythmias.

Mr BH presented back to hospital in November 2019 with an acute decompen-sation of his cardiomyopathy with paroxysmal atrial tachycardia. TTE demonstrated dilated cardiomyopathy with severe biventricular impairment (Figures 5 and 6). He was commenced on dopamine, furosemide and amiodarone.

Coincidentally, over the few months prior to his readmission, Mr BH had been experiencing left hip pain. Left hip imaging demonstrated features consistent with ARMD with a non-traumatic peri-prosthetic neck-of-femur fracture (Figure 7). An urgent orthopaedic review had been requested.

Repeat sCo level testing yielded a result of 5244nmol/L. Upon review of his clinical notes, we discovered that his previous sCo levels in 2013 were already elevated at 1981nmol/L. This had been requested as part of his orthopaedic follow-up historically. Unfortunately, he was lost to follow-up following his move to a different health district. Based on these results, best practice would dictate that Mr BH should undergo revision arthroplasty (rAP). However, Mr BH had become too unwell and was unfortunately deemed unfit for surgery.

Following a literature review, Mr BH was commenced on daily infusions of the chelating agent ethylenediamine-tetraacetic acid (EDTA). The improved sCo level of 1806nmol/L while on the chelating therapy (ChT) suggested that the therapy was having a positive biochemical effect.

Unfortunately, despite the biochemical improvements, Mr BH passed away while on treatment. The post-mortem review by a forensic pathologist indicated that death was due to decompensated CTCM.

Discussion

Cobalt has been used in the medical industry for years. It has been used to increase production of erythropoietin and suppress the activity of the thyroid gland. These effects commonly occur at lower blood concentrations. Therefore, CTCM can commonly be preceded by polycythaemia and hypothyroidism. However, exceptions do occur. Other contributing risk factors for CTCM include thiamine deficiency, alcoholism and a reduced protein diet. These features were not present in Mr BH.

The exact mechanism and effect of chronically elevated metal ion exposure on cellular function remains unclear. The effect of cobalt ions and their interplay with the cardiovascular system remains largely unknown. However, there have been reports of correlation between elevated sCo levels and cardio-toxic outcomes. New research around the effect of cobalt on chromosomal breaks via inhibition of DNA repair shows promising signs of shedding light on this medical enigma.

Even though the outcome of our case was unsatisfactory, key learning points should raise awareness of cobalt toxicity (CoT) and...
hopefully serve as a deterrent for future events. Timely recognition of CoT would have made rAP a potentially lifesaving venture for Mr BH. Viral myocarditis was a reasonable diagnosis for this presentation in 2015. However, background of bilateral BHR and the raised sCO levels could have raised alternative possibilities. The absence of the usual supportive features and predisposing factors of CoT would have made the diagnosis of CTCM more difficult if it was not actively considered.

The absence of a cardiac biopsy as part of the gamut of investigations performed did not help with the clarification of his presumed diagnosis. The cMRI provided an inconclusive result. These findings, together with the persistently elevated TnT levels, should have led to a cardiac biopsy.

Although endomyocardial biopsies can provide additional information, it is important to note that the findings are often non-specific and may not have altered his initial diagnosis. CoT-specific findings on histopathology may not always be present on biopsy. However, all of the findings in combination may have led to a trial of ChT and rAP, thereby possibly providing life-saving intervention.

In light of these considerations, it would be important to note that this was not an isolated case. Looking further into CTCM, a study published in 2019 comparing 23 case reports revealed that rAP was required to extract the source of cobalt ions. Of the 23 cases, 15 had normalised cardiac function following the removal of a problematic hip joint. Six had chronic cardiac impairment. Despite receiving ChT, three of these cases still resulted in death.

ChT can be used as an adjunct or as an isolated mode of treatment if the patient is unfit for surgery. ChT can also be used before operative treatment while optimisation remains underway. Despite the increasing number of case reports being published regarding CoT and its consequences, there are still no internationally recognised and accepted guidelines on management of these patients.

Based on the literature review, there have been several studies reviewing the effects of ChT in managing elevated sCO. A study by Smith et al performed on rats investigated and compared different chelating agents, including glutathione, N-acetyl-L-cysteine, 2,3-dimercaptosuccinic acid (DMSA), diethylenetriaminepentaacetic acid and EDTA. Their results suggest that all except DMSA were effective at reducing sCO levels. There were no formal investigations specifically on the myocardium.

A study performed by Lainiala et al in 2015 explored the effects of joint revision on serum cobalt and chromium ion levels. The explantation of the MoM prosthesis resulted in a reduction of sCO levels in all cases involving unilateral hip revisions. There

Figure 7: Left hip x-ray demonstrating new subluxation likely secondary to ARMD.
was also clear evidence that explanting a MoM hip arthroplasty increased the survival rate in patients with established CTCM. Therefore, the gold standard of management would seem to be rAP.

However, despite reducing whole blood levels, rAP cannot reverse tissue deposition of cobalt ions that has already occurred, such as in the myocardium. Explantation also requires the patient to be fit for surgery, which emphasises the importance of detecting CoT early, before irreversible cardiomyopathy and decompensation occurs.

The disparity between Lainiala et al’s review and our case was the mean time of presentation. Our patient was lost to follow-up despite raised sCO levels historically. In the two years it took for Mr BH to become symptomatic from his declining cardiac function, there was no formal surveillance undertaken for his hip and sCO levels.

Our centre has comprehensive systems and processes in place to monitor all patients with MoM bearing prostheses. As per the Ministry of Health, there are updated guidelines from 2012 that provide recommendations for management of patients with MoM replacements. This includes regular blood metal ion testing and imaging. In conjunction, regular TTE may be of assistance. Significant new abnormalities detected on TTE could potentially lead to further investigations with a cMRI and ultimately a cardiac biopsy.

Patients should also be educated around the potential risks involved with MoM arthroplasties. This should be highlighted and clearly acknowledged on their medical records. In our case, the realisation that Mr BH had bilateral BHR was only noted towards the final year of his life, when the records were thoroughly reviewed. This emphasises how such systems can at times leave patients with a lack of appropriate follow-up. Mechanisms must thus be in place to enable ongoing care for all patients with cobalt implants. The New Zealand Joint Registry that is already in place should be optimally used to track these patients. All surgeries should be accurately recorded and appropriately placed into categoric pools.

A pool specifically for patients with cobalt implants could then be strategically used to ensure appropriate annual follow-ups are obtained. Naturally, there will always remain a risk of human error, even with accurate systems in place Only accurate education in conjunction with knowledge around cases like Mr BH can aid in reducing such risk.

Conclusions

From the discussion above it is clear that not all MoM arthroplasties cause metal toxicity and subsequent cardiomyopathy. These procedures directly correlate with CTCM in some cases, but in many cases there is no correlation. Therefore, it is paramount that all patients who have a MoM-bearing arthroplasty enter a surveillance programme and be monitored with a multidisciplinary approach. Annual blood tests should continue to be performed, and there should be appropriate follow-ups for any abnormal results.

High sCO concentrations should at least trigger alarm bells leading to the appropriate subsequent investigations. Delays in diagnosing CoT reduces the chance of successful interventions and outcomes. If such protocols were in place and followed, it may have been sufficient to alter and avoid the subsequent death of Mr BH.
Competing interests:
Nil.

Acknowledgements:
We would like to sincerely thank Mr BH and his family, who’s strength and resilience was an inspiration to us all.

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REFERENCES
As medical knowledge is not complete or stationary at any one time, it follows that the medical curriculum must undergo frequent changes and can hardly ever be satisfactory. There are many critics of medical education, but few whose criticism is constructive, and it is little wonder that this is so, because the curriculum must be adaptable enough to provide for frequent and drastic alterations. The lowering of the standard of general education which has taken place in the entrance examination is a retrograde step. If the practice of medicine is to remain a learned and liberal profession, doctors must be men of general culture, for which a good knowledge of the mother tongue and of English literature is undoubtedly essential. A mind devoted purely to science is as ill-balanced as one absorbed in the humanities. We believe that the subjects of physics, chemistry, botany, and zoology should be taught to students before they enter on the medical course proper, because these subjects are subordinate and tend to overload the medical curriculum. Sir James Mackenzie says that the present defects in medical knowledge are fully apparent only to those who are actually engaged in the work of general practice, and they have the knowledge necessary to remedy these defects, but unfortunately the general practitioner has little authority. Probably every doctor in practice can recall how at his medical school physiology or chemical physiology, or pathology, or bacteriology, or some other study was given prominence far beyond its merit in the curriculum. Sir James Mackenzie says that the present defects in medical knowledge are fully apparent only to those who are actually engaged in the work of general practice, and they have the knowledge necessary to remedy these defects, but unfortunately the general practitioner has little authority. Probably every doctor in practice can recall how at his medical school physiology or chemical physiology, or pathology, or bacteriology, or some other study was given prominence far beyond its merit in the curriculum. No subjects except anatomy, practice of physic, surgery, and obstetrics should be advanced beyond a moderate standard, and advanced courses should be post-graduate and adapted for such as wish to specialise. If it is to be otherwise, six years will not suffice for a course of study for graduation, for it will be easy to provide a ten years’ course to attempt to satisfy the demands of specialists who think that their own particular spoke is the most essential part of the wheel. When a student has survived all this his diffused knowledge will not make him readier to combat the ordinary ailments with which he will contend in practice. A great amount of time is wasted, too, by attendance at systematic lecture which can be curtailed with great advantage in favour of clinical instruction. There are many excellent text-books quite as useful as systematic lectures which are an anachronism. If these defects were removed a five years’ course of study would not be too short. The Medical School of New Zealand has now instituted a six years’ course of study. Might not the sixth year be made a compulsory post-graduate course with advantage?

We have before us a highly instructive memorandum written by Sir James Mackenzie and the staff of the St. Andrew’s Institute for Clinical Research. This memorandum shows the classification of disease is at present based largely upon morbid changes which have been discovered and studied after death, and these changes do not indicate the real nature of disease, but are only the terminal changes of a long preceding illness. Physicians look in the living for the physical signs to correlate them during life with the morbid state found at death. A majority of sick people have not such gross pathological and structural changes. There is a tendency, too, in orthodox teaching to take the most prominent symptom or sensation and consider it to be the disease. Sir James Mackenzie advocates research by general practitioners into the early stages of disease, and the keeping of records. A case should be records in such a way as this: Chief complaint. Associated sensations. Physical signs. Provisional diagnosis. Treatment. After-history. The St. Andrew’s Institute is adapted for the teaching of general practitioners. “It is a remarkable fact,” writes Sir James Mackenzie, “that though the vast majority of medical students become general practi-
tioners, no attempt is made to teach them how to make use of their opportunities in general practice, and no hint is ever given them that the phases of disease which they will meet will be different from that which they have seen in the hospitals. There is an urgent need for a definite course of teaching and training students in their last year how they should conduct their practices.”

The profession in New Zealand is justly proud of its Medical School, which has now attained a high degree of efficiency, and it might be to the advantage of the School and the Faculty, and of the profession throughout New Zealand, if questions relating to medical training could be discussed occasionally at the annual meeting of the Medical Association.

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