Te Whatu Ora
Health New Zealand

Critical Care Infrastructure National Service Plan

For Aotearoa New Zealand 2021-2035

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Version	Date	Summary of Changes
1	June 2022	Final Plan approved by Steering Group – for Te Whatu Ora approval

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Section 1: Background

Critical care services provide care for people with life-threatening conditions in an intensive care unit, high dependency unit, or other high-acuity area.

The national critical care service plan lays a foundation for the future development of critical care services across Aotearoa New Zealand. It has been developed in partnership between the Te Whatu Ora – Health New Zealand Infrastructure and Investment Group and the critical care sector. It is the first step towards achieving a sustainable critical care service over the next five to 15 years.

While Aotearoa provides high quality critical care services[1,2,3], the existing system is under constraint, and we need increased capacity. New beds and physical infrastructure will contribute capacity, alongside other system wide changes also need to be made.

This document describes current service utilisation and flow and identifies system-level opportunities. The plan outlines a future-focused national delivery framework, and provides a demand forecast for infrastructure over the next 15 years to meet future service needs. We also describe the broader system changes which are needed to deliver high quality critical care across Aotearoa.

Introduction

Critical care is an essential service which saves lives. Aotearoa has 25 units in public hospitals to provide critical care to our population of approximately five million. Over the past 10 years, there have been approximately 210,000 admissions related to over 13 million hours of care.

Critical care is provided in multiple settings. This may be in an intensive care unit (ICU), high dependency unit (HDU) or paediatric intensive care unit (PICU).[4] Critical care is also

[1] Mortality Related to Severe Sepsis and Septic Shock Among Critically Ill Patients in Australia and New Zealand, 2000-2012. Kaukonen et al; JAMA. 2014;311(13):1308-1316.
[2] Goal-Directed Resuscitation for Patients with Early Septic Shock: ARISE Investigators and the ANZICS Clinical Trials Group; New England J Med 2014; 371:1496-506.
[3] Trial of Early, Goal-Directed Resuscitation for Septic Shock; Mouncey et al, New England J Med 2015;372:1301-11.
[4] National planning for Neonatal Intensive Care Units (NICU) is excluded from this service plan. NICU planning includes different population needs, service models and options for future service delivery. Also, infrastructure is not linked with these other critical care services, and national NICU planning has a separate service planning process. Refer: Review of neonatal care in New Zealand January 2019.

provided by specialist teams in hospital wards and during transport of critically ill people. A well-resourced critical care service improves safety across the whole health system.

Additional capacity is required for critical care. The system is under significant pressure with existing physical and workforce constraints. We are unable to meet the increasing demand due to population growth and aging, clinical complexity, and changing models of care. Planned care services are often cancelled, and patients are transferred to hospitals further away from their home for treatment due to capacity constraints.

Critical care in Aotearoa delivers good care, however, access criteria, bed availability, and service models are inconsistent within and across regions. Infrastructure planning and service development have been the result of local decision making without a national approach. Inequity in critical care outcomes also remains an issue in Aotearoa. Māori present with more comorbidities at the time of ICU admission, have higher severity of illness, and a higher risk of dying than non-Māori.[5,6] A national service plan with data-informed modelling and decision making at national level will enable us to identify and address unwarranted variation and improve access.

This plan takes a whole system view to enhance opportunities across the entire patient journey as each person interacts with each part of the system — from before admission to a critical care unit, through to after discharge from the unit. The three essential enablers identified in the plan are workforce, the patient transport system, and technology. While all three are essential, the development of a workforce pipeline to support critical care is a particularly high priority for Aotearoa.

To achieve maximum system efficiency will mean that every critical care admission is appropriate each person will receive the highest level of care required and will remain in a critical care unit only for the duration that a higher level of care is required.

Strategic context

Health and disability system review

A major reform of the health and disability system in Aotearoa is currently underway aiming to change the way health services are structured and delivered. National service

[5] Outcomes for Māori and European patients admitted to New Zealand intensive care units between 2009 and 2018. Reid et al. The New Zealand Medical Journal 2022; 135(1550): 26-46.
[6] Māori Health Outcomes in Intensive Care Following Cardiac Surgery in New Zealand, New Zealand. Slim et al. Heart, Lung, and Circulation 2022; S1443-9506(21) 01399-8.

planning has been identified as a priority in the new system to ensure equity of access and outcome, quality improvement and long-term sustainability of services.

The critical care service plan has been developed with an infrastructure focus and is an example of planning for services at national level. In the future, wider service planning is expected to guide national system-wide developments and underpin the development of mature networks of service delivery across hospital sites. The Infrastructure and Investment Group will continue its focus on service planning to inform infrastructure planning.

This document supports the health and disability system reforms by providing an evidence-based national service plan informed by a network of leaders from across Aotearoa. In partnership with the critical care sector, we have collated and analysed available information and data to understand the current system and applied demand projections and scenario testing to identify future options. The plan proposes an efficient, integrated and networked national framework for critical care.

We acknowledge that service planning is an ongoing process. Health systems and service models evolve, and service plans need to be regularly updated to reflect change and maintain future-focused national service delivery. This is the first phase of national planning for critical care services in Aotearoa. The next phase can be strengthened with the establishment of Te Whatu Ora – Health New Zealand and Te Aka Whai Ora – Māori Health Authority.

Strategic frameworks

The Ministry of Health's Tā Tātou Rautaki 2020 strategy provides direction for this plan which aims to ensure Pae Ora — healthy futures for everyone in Aotearoa.

Other strategic frameworks supporting this plan are:

- Ministry of Health's Te Tiriti o Waitangi (Te Tiriti) Framework
- The Māori Health Strategy, He Korowai Oranga
- Whakamaua: Māori Health Action Plan 2020–2025
- Ola Manuia: The Pacific Health and Wellbeing Action Plan 2020–2025.

Government and sector priority

Developing a national overview to ensure that the best possible critical care services are available to everyone in Aotearoa is a current government priority. There have been several national emergencies over recent years. These, along with COVID-19, have

highlighted the need for a comprehensive national service plan for critical care. The limited formal strategic planning at national level has been barrier to the development of an effective networked critical care system.

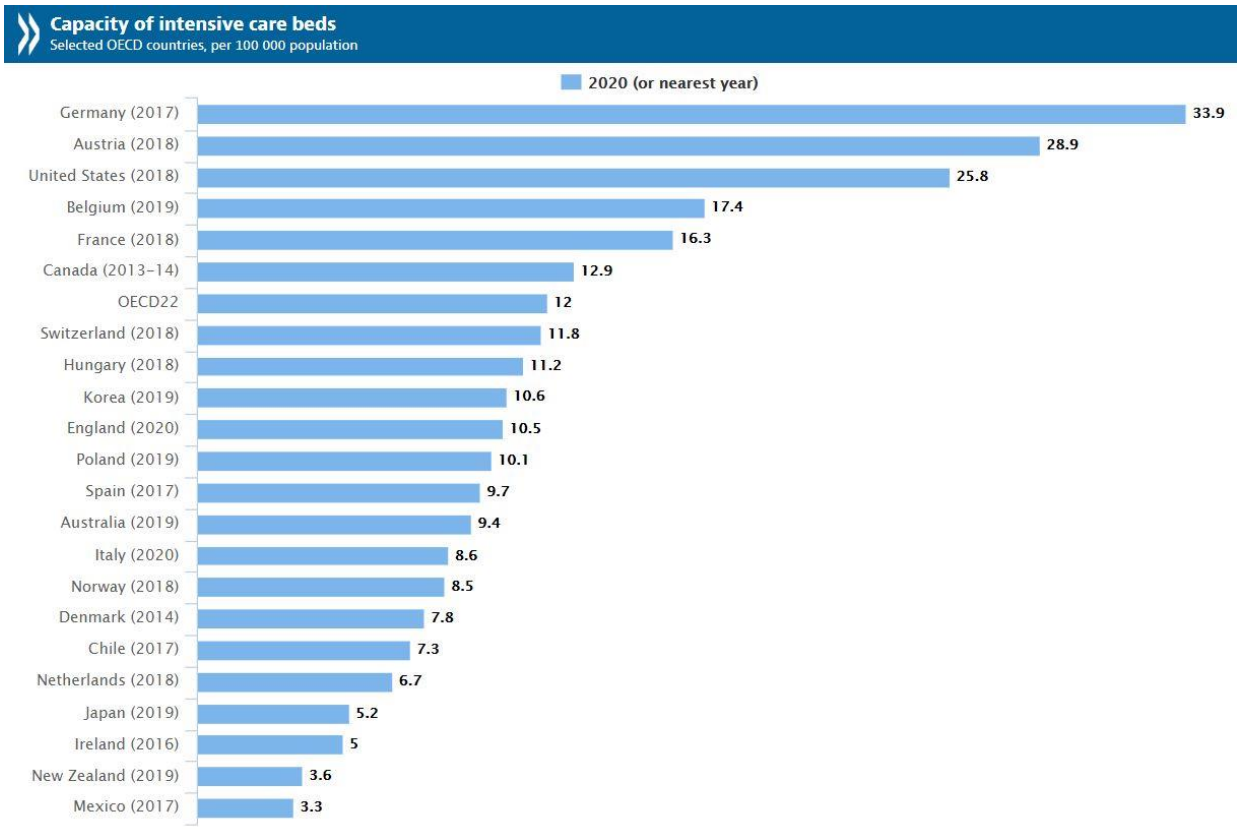
The critical care sector in Aotearoa supports a nationally agreed and integrated long-term plan. This document provides a framework to address gaps, develop services, and define regional links within a national framework. Together, these will improve access, increase service delivery and efficiency, and inform future investments in critical care infrastructure.

Bed capacity compared with other OECD countries

There is acknowledgement that Aotearoa has fewer critical care beds per 100,000 population compared with other OECD countries. Comparisons between OECD countries are subject to many factors, including the differences in health systems, health funding, bed type counted and models of care. Also, there is a lack of clear linkages between improved health outcomes and a higher bed count per 100,000 population. Some comparisons can, however, provide a reference point for discussion of access to care. Comparisons at a bed count per 100,000 population are likely to be relevant at a national level but should be used with caution at a local unit level.

In a recent OECD publication, it was reported that Aotearoa has 3.6 beds per 100,000 population (Figure 1). This is among the lowest and is considered too low. Direct comparison however, even with Australia, may not be appropriate. For example, Australia has 9.4 beds per 100,000. Some of this difference can be accounted for by the considerable resourced ICU capacity available in private hospitals which is integrated into their service delivery models. Although this accounts for some of the gap, it does not fully account for the difference between the two countries. On face value a significant increase in bed numbers would be required for Aotearoa to move up the OECD comparison table.

Figure 1. Capacity of intensive care beds in OECD countries



Source: OECD Data Insights: Policy Brief on the response to the COVID-19 crisis

Planning process and consultation

Development of the plan

This national service plan led by the Infrastructure and Investment Group is the result of strong collaboration and partnerships with the health sector. Qualitative research and quantitative analysis were undertaken to understand current state, identify opportunities for future service models, and develop a bed demand forecast. Extensive health sector engagement and consultation at a national level have supported this work.

This includes input from:

- the project steering group
- working groups focused on the service framework and analysis
- individual unit interviews to collect qualitative data
- individual and regional group workshops

- surveys and patient flow mapping
- formal and informal meetings with clinical and non-clinical staff
- literature and evidence reviews
- service utilisation assessments
- multiple data sources
- wider sector feedback sought through the review process.

Principles

Principles which have guided the service plan development include:

- people at the centre of services
- care provided as close to home as possible
- equitable access for Māori and other population groups
- innovative and future responsive models of service
- whole system approach
- culturally safe sustainable services
- high-quality care
- planning and delivery in collaboration with District Health Boards and the wider health sector
- evidence-based decision making.

Section 2: Understanding our system

Current state qualitative survey

We completed a qualitative survey of multiple critical care units across Aotearoa. Twenty-five hours of informal interviews were completed with front line clinical staff, unit managers, flight teams, transport groups, and medical/nursing college and education representatives.

We gained a rich understanding of the current service delivery that has underpinned the plan.

Significant variation of the unit operating model exists across Aotearoa, with variability in regional capacity, geographic location, service configuration, and ability to meet demand. This leads to different access criteria for admission and discharge, different processes, patient mix, lengths of stay, and patient flows. Patient transfers and retrievals also vary in frequency, cost and process.

Geographic and locality differences explain some of the variation, however, there is a need to identify and address all variation that should not be present. A shift in focus from local planning to national and regional data-informed planning, modelling and decision making will enable this.

An opportunity exists to address variation by establishing national leadership, operational and collaborative oversight, agreed principles and policies, and a collective focus on system enablers, especially workforce, transport, and technology. In line with this, five main improvement opportunities were identified.

- Establish a national leadership group to provide strategic oversight for long-term planning and improvement.
- Address access issues and all variation that should not be present through the national leadership group and appropriate local clinical leadership.
- Improve operational networks with formal regional links and oversight to support the connection of critical care services required for a system solution.
- Prioritise strategic workforce planning which is the most important and urgent enabler for critical care services.
- Address patient flow and exit block with a whole-of-system approach.

Service planning at the national level requires agreed definitions for benchmarking, unit comparisons and data collection. It also needs to accurately describe or discuss the desired future state of services. A barrier to comparing critical care units is the lack of agreed terminology. Colleges have clear definitions and standards, however no agreed terminology is universally used to describe a critical care unit in Aotearoa, nor internationally.

For the purposes of this plan, units have been defined according to an operational and patient-centred model. The definitions relate to physical design, flow, and an operational structure which most directly influences unit capacity and efficient bed use. The main resource which will allow this capacity to be fully utilised is workforce.

The definitions used in the plan are less detailed than many other available definitions such as college standards, accreditation, vocational training, work practice, caseload, equipment, and staffing definitions. These additional details can be applied at the later planning stages of business planning and specific unit design.

Definitions

The following definitions are used throughout this plan.

Three types of unit are described.

1. An intensive care unit contains ICU beds which can all ‘flex’ down to a high dependency unit (HDU).
2. A high dependency unit containing only HDU beds.
3. A combined unit contains either HDU and HAA (High acuity area) beds, or HAA only beds.

Critical care medicine[7]

Intensive (critical) care medicine is the body of specialist knowledge and practice concerned with the treatment of patients with, at risk of, or recovering from potentially life-threatening failure of one or more of the body’s organ systems. It includes the provision of organ system support, the investigation, diagnosis, and treatment of acute illness, systems management and patient safety, ethics, end-of-life care, and the support of families.

Intensive care unit (ICU)[8]

An intensive care unit is a unit with specially staffed and equipped, separate and self-contained area of a hospital dedicated to the management of patients with life-threatening illnesses, injuries and complications, and monitoring of potentially life-threatening conditions. It provides special expertise and facilities for support of vital functions and uses the skills of medical, nursing, and other personnel experienced in the management of these problems.

High dependency unit (HDU)

Within a high dependency unit our assumption is that the bed is unable to ‘flex’ up to ICU level care. HDU beds are not available to provide ICU level care.

[7] UK Faculty of Intensive Care Medicine 2021
[8] College of Intensive Care Medicine Australia and NZ minimum standards 2016

Some units provide HDU-only level care. Other units provide mixed levels of care and function as combined HDU/HAA unit which may include coronary care and elective post-operative patients. We have included HDU in the bed counting and forecast as part of the critical care system.

High acuity area (HAA)

In an HAA, patients receive a level of care between ICU/HDU care and ward level care. More intensive monitoring is required than a general ward can provide, however these patients can be managed by other clinical teams. HAA are not a substitute for critical care but are a complementary service that will support flow.

Many options exist for HAAs. These are variations of step up/down beds which provide transitional level care, and they may exist in multiple configurations including:

- separate units
- ward-based surgical and/or medical areas
- surgical specialty post-operative areas
- extended PACU (post anaesthesia care units)
- medical specialty areas
- cardiac and coronary care units.

We have considered HAA in the service delivery framework but excluded HAA from the base bed numbers and forecast.

Critical care bed

Accurately describing the functional use of a resourced critical care bed is essential for planning and operational purposes.

A variety of units exist. Some units have mainly ICU beds, and some have a combination of ICU and HDU beds. Others are HDU, or mixed HDU and HAA beds including cardiac care. From a national infrastructure perspective, planning for critical care beds enables flexible use of the fixed infrastructure through variable operating models.

For long-term infrastructure planning, we have focused on critical care beds, which include ICU, HDU and PICU beds.

In ICU/HDU units, a patient can occupy the same physical space but can be changed between HDU and ICU care by changing the staff ratio. Units with HDU only, in usual circumstances are not able to flex up to higher levels of care, so ICU level patients will be transferred to an ICU capable unit, usually the closest hospital with tertiary services.

Planning for critical care infrastructure and beds enables current services to be delivered and future service models to evolve.

Intensive care specialist

For the purposes of the current state description the plan defines intensive care specialists as: ‘any medical specialist with currency of practice in intensive care medicine’. For the current state, there is no assumption this implies a College of Intensive Care Medicine (CICM) fellow and the term ‘intensivist’ is not used. It is acknowledged that in the long term, all future ICU-teams will ideally include a trained, qualified, and vocationally registered Intensive Care Specialist.

Operating models

We describe two types of operating models: open and closed-collaborative. The unit type is important to understand because it influences capacity and equity of access.

Table 1. Operating model definitions

Closed-collaborative model	Open model
A unit with a dedicated specialist intensive care team available over 24 hours. In this unit, all patients are referred to the intensive care specialist (who is not on-call for any other service while on duty for the unit). Patient care is provided in collaboration with the primary medical and surgical teams, however final decision making is the responsibility of the specialist ICU team. This results in greater equity of access by consistency of decision making.	A unit where the responsibility for care remains under the clinical medical or surgical team. 24-hour cover by an intensive care specialist is not available. There are multiple independent decision-making teams. This results in variability of admission and discharge criteria, and less efficient flow. This directly affects unit capacity because delays in discharge occur, and no single clinical team has full oversight of the unit.

Closed-collaborative units

Across Aotearoa, there are eleven closed-collaborative units. Most of these are in hospitals with tertiary services, however, three other hospitals, namely Whangārei,

Hawke’s Bay and Palmerston North, also provide intensive care in a fully closed-collaborative model.

Among the hospitals with tertiary services, Waikato is an exception and has a mixed model with two stand-alone units, one closed-collaborative ICU and one open HDU/HAA. An opportunity exists at Waikato to increase ICU and HDU capacity and flexibility by resourcing this open unit to become a closed-collaborative ICU/HDU model and provide specialty HAA beds in other areas of the hospital.

Open units

All the remaining hospitals have open units which provide care for ICU, HDU and HAA (including coronary care) patients in the same unit.

Eight units have a part-time medical ICU specialist dedicated to the unit during the day but not afterhours. These include hospital-based units in Rotorua, Taranaki, Palmerston North, Hutt, Nelson, Timaru and Invercargill.

In an open unit, for example, if there are six beds, there may be up to six independent ward teams, each with responsibility for one patient and one bed. Every admission, discharge and transfer must be discussed with a different team by nursing staff in the unit. Moving to a model of care with a single decision-making team with stronger tertiary oversight and potentially some shared resources, is an opportunity to reduce clinical variability and length of stay in these units.

The after-hours doctor for an open unit is also on-call for the rest of the hospital. This doctor may be an anaesthetist and nursing staff find their availability for the ICU is dependent on their responsibility to provide support for the acute operating theatre. Open units may be an appropriate use of nursing resource for a smaller hospital with lower volumes, however, stronger regional collaboration with more formal tertiary support is likely to be beneficial.

Specialist staff cover

Understanding unit operating models on a region-by-region basis highlights opportunities to improve patient flow, regional collaboration, networking and resource sharing, and develop a well-resourced and sustainable national delivery framework.

Table 2. Operating models of unit type by units

Region	Unit	Unit type	Dedicated medical specialist(s)
Northern	Whangārei	Closed	Yes
	Auckland city DCCM Auckland city CV ICU Starship	Closed Closed Closed	Yes Yes Yes
	North Shore	Closed	Yes
	Middlemore	Closed	Yes
Te Manawa Taki	Waikato (two units)	Closed Open	Yes No
	Tauranga Whakatāne	Closed Open	Yes No
	Rotorua	Open	Yes (Daytime only)
	Gisborne	Open	No
	Taranaki	Open	Yes (Daytime only)
Central	Hawke's Bay	Closed	Yes
	Whanganui	Open	No
	Palmerston North	Closed	Yes
	Wairarapa	Open	No
	Hutt	Open	Yes (Daytime only)
	Wellington	Closed	Yes
Te Waipounamu	Nelson Wairau	Open Open	Yes (Daytime only) No
	Greymouth	Open	No
	Christchurch	Closed	Yes
	Timaru	Open	Yes (Daytime only)
	Dunedin Invercargill	Closed Open	Yes Yes (Daytime only)

Regional networks

Stronger regional oversight and coordination is an opportunity for improved access, consistency of admission criteria and decision making. Formal links with clinical support between a network of units supports appropriate patient flow. Regional operational oversight and planning would ensure that patients are consistently admitted to, and managed in, the most appropriate unit in the network. Coordinated support across regions

is an opportunity to strengthen clinical networks, recruitment, and retention, particularly for nursing staff in smaller centres.

Each region has some warranted variation due to factors including geographic location, population demographics, disease profiles, and the co-location of specialties which require critical care support. For example, Waikato is surrounded by a number of small rural hospitals, and due to its central location also has significant trauma admissions, and Auckland is the centre for several national services.

There is also likely to be some variation that should not be present. Planning has historically been local, without a strategic regional or national overview. To fully understand future service requirements and optimise capacity and equity of access, care units will need to be planned in a regional and national context.

Patient experience

Limited data currently exists on consumer perspectives and experiences in Aotearoa ICUs, and there is no formal collection of this information. The Australian and New Zealand Intensive Care Society (ANZICS) is setting up a process to begin collecting national data from 2022, and this will become a routine part of data collection.

There is a known, negative, impact on patients and whānau when surgery is delayed because of a lack of critical care capacity. This is highlighted in the following patient experience:

A 60-year-old Nelson patient was scheduled for heart surgery. Her immediate family had taken leave from work to travel with her to Christchurch, to be there during and after surgery. The day before her scheduled surgery, it was postponed because no ICU bed was available. The same thing occurred on another two occasions. It was only on the fourth scheduled date that surgery went ahead as planned.

Because whānau had already applied for (and taken) leave three times, none of the family were able to take further leave. This patient eventually went through heart surgery without her family in Christchurch to support her.

The patient herself also had to apply for and take leave from her own workplace each time surgery was rescheduled. Staff in the hospital observed high levels of stress in this patient leading up to surgery, and her post-op recovery was negatively impacted because whānau were unable to be there to provide support.

Postponement of surgery is distressing, and the psycho-emotional effects of late postponement of cardiac surgery are well documented.[9]

[9] Not another postponement of surgery! Anxiety and depression in pre-operative planned coronary artery bypass graft patients,
AJ scull et al, Heart, Lung and Circulation; Vol 17: 2, January 2008

Bed counts

There are several definitions used to describe and count critical care and intensive care beds.

An October 2021 ANZICS statement[10] described and quantified beds in Aotearoa as follows:

- fully staffed ICU beds (around 172 adult and 14 paediatric beds: 186 beds)
- fully funded ICU beds (around 190 adult and 16 paediatric beds: 206 beds)
- fully funded ICU, HDU and coronary care beds (around 266 beds)
- fully equipped 'ICU capable' beds (up to 500 beds), with crisis staffing models (using normal models we have staffing for 186 beds)
- fully funded HDU and ICU beds (around 226 adult and 22 paediatric beds: 248 beds).

For long-term infrastructure planning, we have focused on critical care beds. This includes ICU, HDU and PICU. From a national infrastructure perspective, planning for critical care beds enables for flexibility in the use of the fixed infrastructure within the context of evolving future service models.

The critical care bed numbers were sourced from ANZICS 2018/19 Critical Care Resources (CCR) surveys and our project's qualitative and quantitative work. The numbers have been verified with the sector. While the baseline bed numbers provide a base for comparison to future forecast, the actual modelling process was based on the hours of critical care used.

Table 3. Critical care physical bedspaces distribution in Aotearoa (as of October 2021)

Unit	Physical Bedspaces	Comments
Auckland City Hospital - CVICU	26	
Auckland City Hospital - DCCM	24	

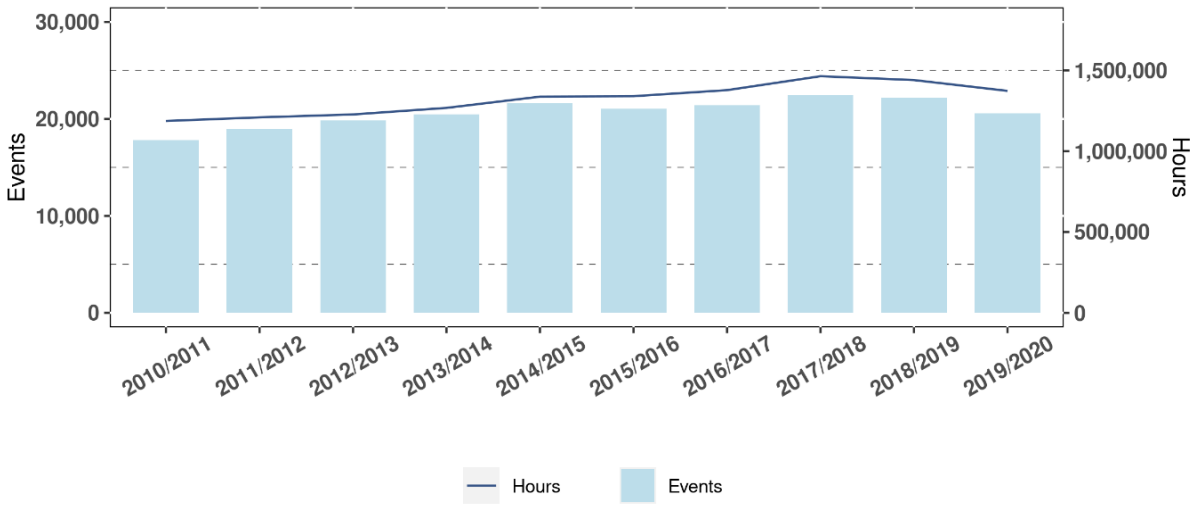
[10] Refer ANZICS statement: Responding to COVID in New Zealand. New Zealand, October 2021. **https://www.anzics.com.au/new-zealand-icus-covid-response-october-2021/**

Christchurch Hospital	24	Christchurch hospital has a non-commissioned but purpose-built ICU facility adjacent to their existing ICU; this includes 6 separate beds
Dunedin Hospital	12	Dunedin hospital has a non-commissioned but purpose-built ICU facility adjacent to their existing ICU; this includes 12 separate beds
Gisborne Hospital	3	
Greymouth Hospital	4	These beds provide services at an HDU/HAA level
Hawke's Bay Hospital	13	
Hutt Hospital	5	Hutt hospital has a non-commissioned but purpose-built ICU facility adjacent to their existing ICU; this includes 8 separate beds
Middlemore Hospital	25	
Nelson Hospital	9	
North Shore Hospital	14	
Palmerston North Hospital	6	
Rotorua Hospital	6	Rotorua hospital has 6 CCU beds within their ICU/HDU facility. These 6 CCU beds are not included in the critical care numbers in this table
Southland Hospital	6	
Starship PICU	22	
Taranaki Base Hospital	5	
Tauranga Hospital	10	Tauranga hospital has 10 CCU beds within their ICU/HDU facility. These 10 CCU beds are not included in the critical care numbers in this table
Timaru Hospital	4	
Waikato Hospital	16	Waikato hospital also has a separate HDU/HAA unit with 12 beds
Wairarapa Hospital	6	These beds provide services at an HDU/HAA level

Wairau Hospital	4	These beds provide services at an HDU/HAA level
Wellington Hospital	24	
Whakatāne Hospital	4	Whakatāne hospital has 2 CCU beds within their ICU/HDU facility. These 2 CCU beds are not included in the critical care numbers in this table.
Whanganui Hospital	3	
Whangārei Hospital	9	
Public Hospital Total	284	

Current state utilisation

Figure 2. Critical care utilisation in Aotearoa from 2010/11 to 2019/20



Critical care utilisation has increased over time, apart from 2019/20 due to the impact of COVID-19 (Figure 2). The number of critical care events has increased from 18,000 to 22,000 per annum and critical care hours from 1.2 million hours to 1.4 million.

While growth is observed, it is restricted by available resource. The current infrastructure and workforce are constraints that contribute to unmet demand. When there are limited beds available, clinicians are making decisions on which patients are prioritised for a critical care bed. Some patients may need to receive care in a different setting even if they would have benefited from being admitted to critical care service and some patients do not proceed with surgery that requires subsequent critical care support. While it is challenging

to quantify unmet need for critical care services we have aimed to adjust for this unmet need in the forecast.

Figure 3. Critical care events per 100,000 population by ethnicity in Aotearoa from 2010/11 to 2019/20

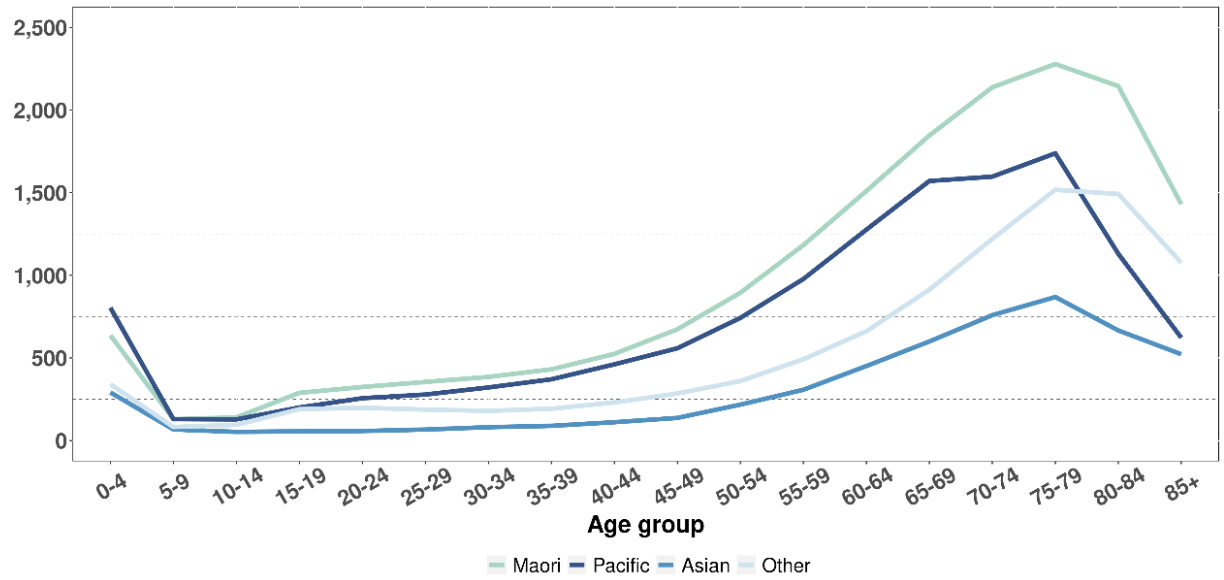
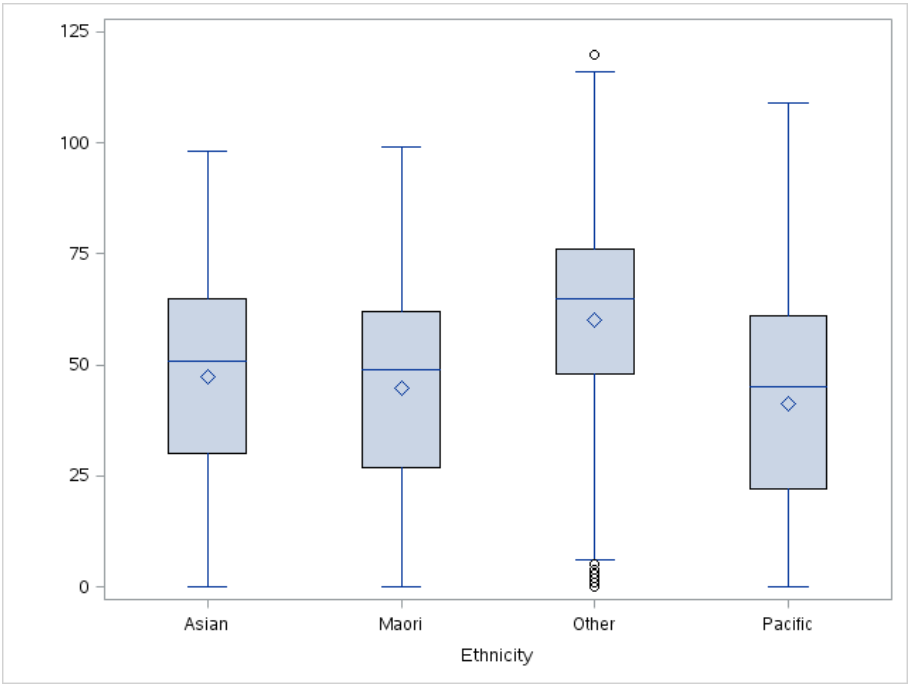


Figure 4. Age (years) at admission by ethnicity (2010/2011 to 2019/2020)



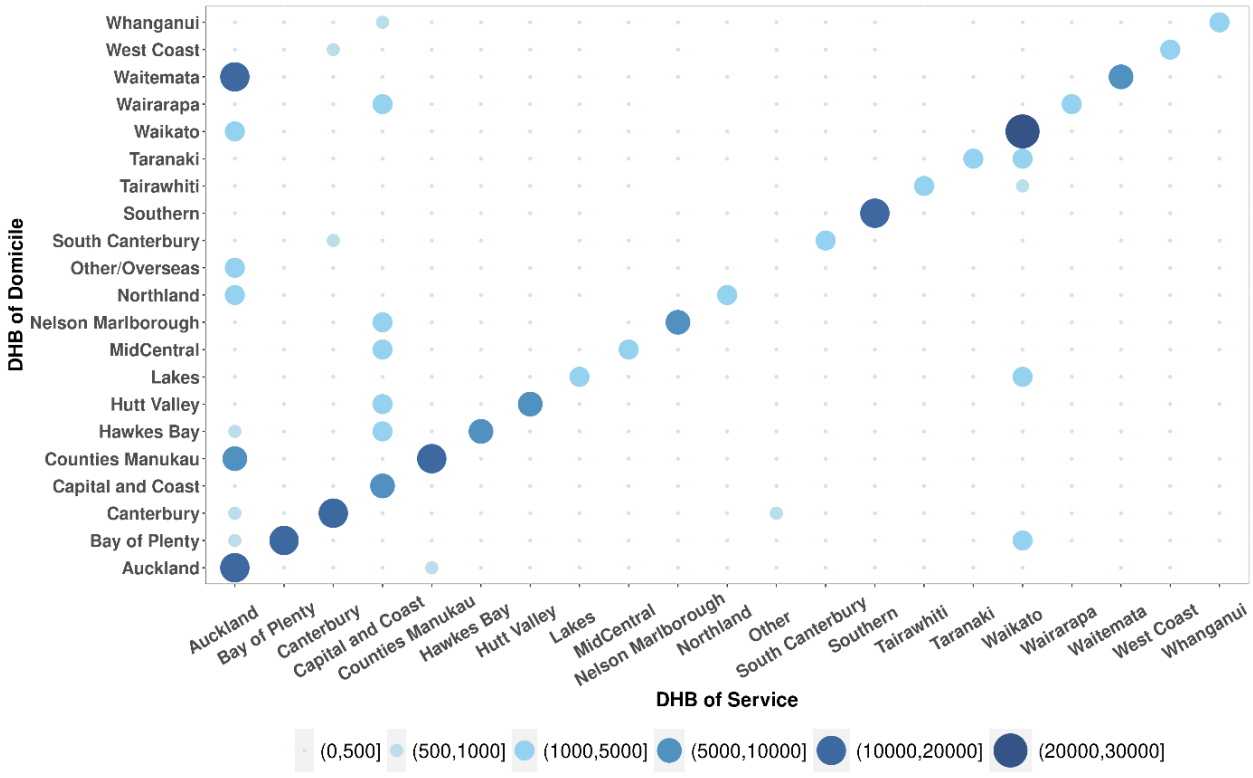
Critical care utilisation is strongly related to the patient's age and ethnicity (Figure 3). Across all ethnicities, the age group of 75–79-year-olds have the highest utilisation rates. Māori across all age bands, apart from children, have the highest rates of critical care

utilisation. Pacific also have higher rates of critical care utilisation that reduces only in older age groups. This is also reflected by the age at critical care events admission where Māori and Pacific were admitted at a younger age than Others (Figure 4).

As noted, Māori and Pacific patients have higher rates of critical care utilisation. Māori and Pacific patients also have higher rates of general admission to hospitals. Among hospitalised patients, critical care utilisation rates for Māori and Pacific patients are also higher than other ethnic groups. The higher rates appear to be associated with the higher health needs for Māori and Pacific patients. For instance, Māori and Pacific patients received critical care after cardiothoracic surgery had a higher clinical complexity level, as per patient clinical complexity levels (PCCL), than patients of other ethnicities.

It is difficult to determine whether the utilisation rates for Māori and Pacific are appropriate. There is a drive to support wellbeing and prevent people from needing complex services such as critical care, but there is also a drive to ensure these services are accessible when they are needed. An assessment of utilisation and outcomes for Māori and Pacific should be a priority for further national work.

Figure 5. Critical care patient flow and transfers in Aotearoa (events) from 2010/11 to 2019/20



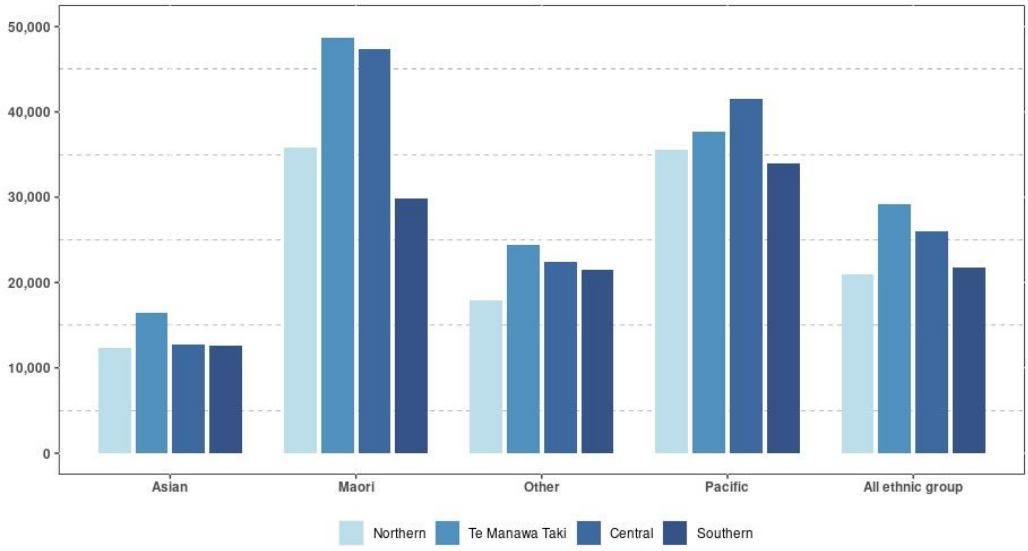
While most people receive their critical care within their local hospital, there are significant flows of patients between hospitals (Figure 5). Of note, 70% of critical care admissions to

Auckland City Hospital are from other District Health Boards (DHBs). Transfers to hospitals for services that are not available locally are depicted below.

The critical care units across Aotearoa are important parts of the whole networked system of critical care. At a national level, 59% of total critical care hours are provided by hospitals with tertiary services and 41% by other hospitals.

At a population level, critical care service utilisation differs across geographic regions by ethnicity (Figure 6).

Figure 6. Regional critical care utilisation (age-standardised rate, hours per 100,000 population) by ethnicity in Aotearoa from 2010/11 to 2019/20



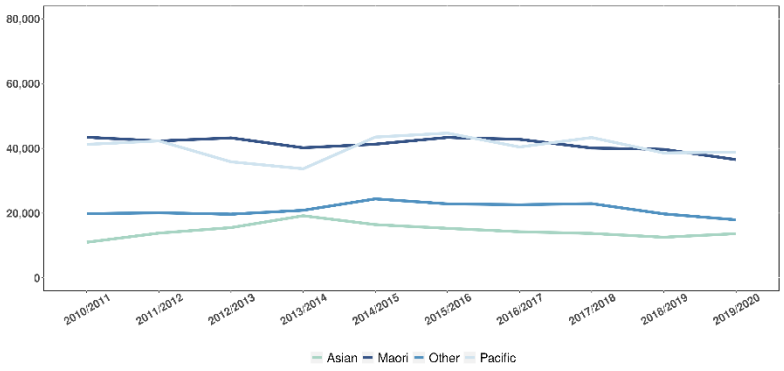
The differences in critical care utilisation rates were also observed in all DHB regions. Māori in the Te Manawa Taki region have the highest utilisation rates relative to all other groups. Māori and Pacific people across the regions have higher age-standardised rates of critical care hours per 100,000 population than other groups.

Critical care utilisation, flow and health specialties also differ between services and across regions. We have provided a summary of utilisation at a regional level using data from 2010/11 to 2019/20. Appendix 1 – Critical Care Technical Report provides further details on current critical care utilisation, flow, and health specialty across Aotearoa.

Northern Region

The Northern Region has a population of approximately 1.91 million in 2019/20. There are six units in the region. Whangārei and North Shore units are within secondary care level hospitals. The four other units support tertiary and quaternary services. Starship Children's Hospital provides critical care service for children. Auckland is the national and quaternary centre for many specialised services and includes a department of critical care (DCCM) and a cardiovascular ICU (CVICU). Middlemore Hospital includes the National Burns Centre that is supported by its ICU.

Figure 7. Age standardised critical care hours per 100,000 population in the Northern Region (2010/11 to 2019/20)



Critical care utilisation

The Northern Region had an average of 24,000 critical care hours per 100,000 population. After age standardisation, Māori and Pacific people had about 40,000 hours per 100,000 population which is nearly double when compared to Asian and Other ethnic group people.

56% of critical care hours are for the top 5 health specialties.

On average, 68% of critical care hours are for acute patients.

Figure 8. Top 5 health specialties in the Northern Region (2010/11 to 2019/20)

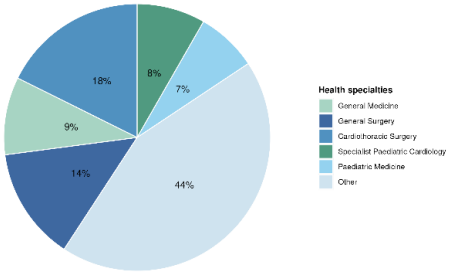
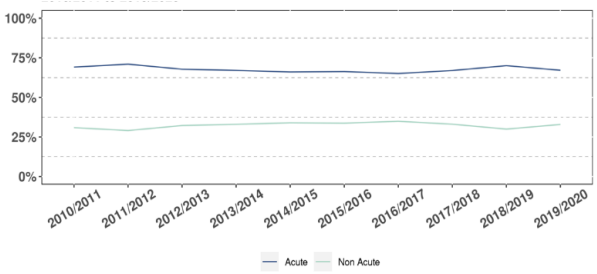


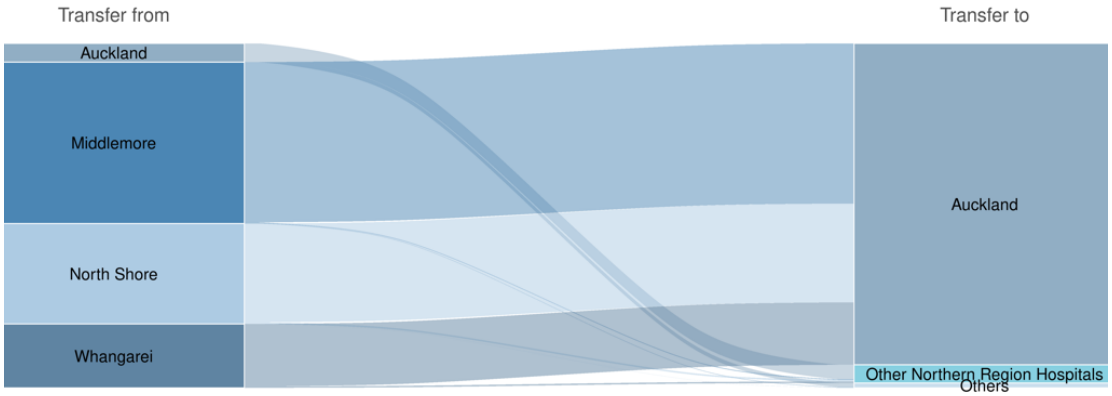
Figure 9. Critical care hours by admission type in the Northern Region (2010/11 to 2019/20)



Transfer patterns

Most of the transfers in the Northern Region were to Auckland City Hospital, with very few patients being transferred out of region for critical care. Of the small volume of patients transferred from Auckland City Hospital, most patients were transferred to Middlemore hospital.

Figure 10. Patients transferred from a Northern Region hospital (ICU or non-ICU patient) for ICU care in another hospital (2010/11 to 2019/20)

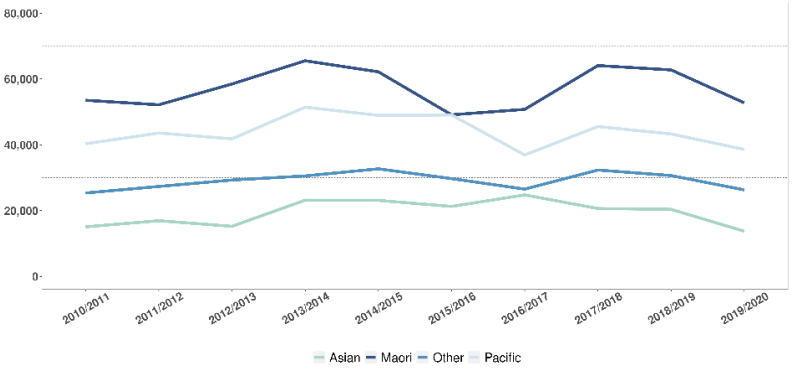


Te Manawa Taki Region

The Te Manawa Taki Region has a population of approximately 0.98 million in 2019/2020 people served by six units. The Waikato Hospital unit is the only unit in a hospital with tertiary services across the region.

The other five units are at Tauranga Hospital, Whakatāne Hospital, Rotorua Hospital, Gisborne Hospital, and Taranaki Hospital.

Figure 11. Age standardised critical care hours per 100,000 population in the Te Manawa Taki (2010/11 to 2019/20)

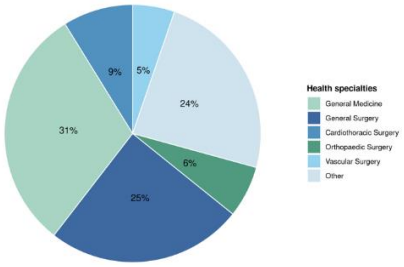


Critical care utilisation

Te Manawa Taki had an average of 34,000 critical care hours per 100,000 population. Māori had the highest age-standardised critical care hours of 60,000 hours per 100,000 population, followed by Pacific people, Other ethnic group, and Asian.

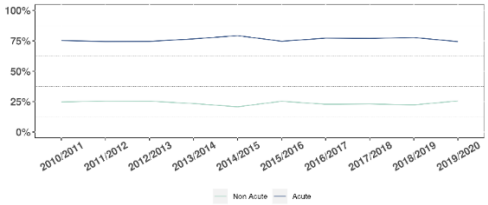
76% of critical care hours are for the top five health specialties.

Figure 12. Top five health specialities in Te Manawa Taki (2010/11 to 2019/20)



On average, 76% of critical care hours are for acute patients.

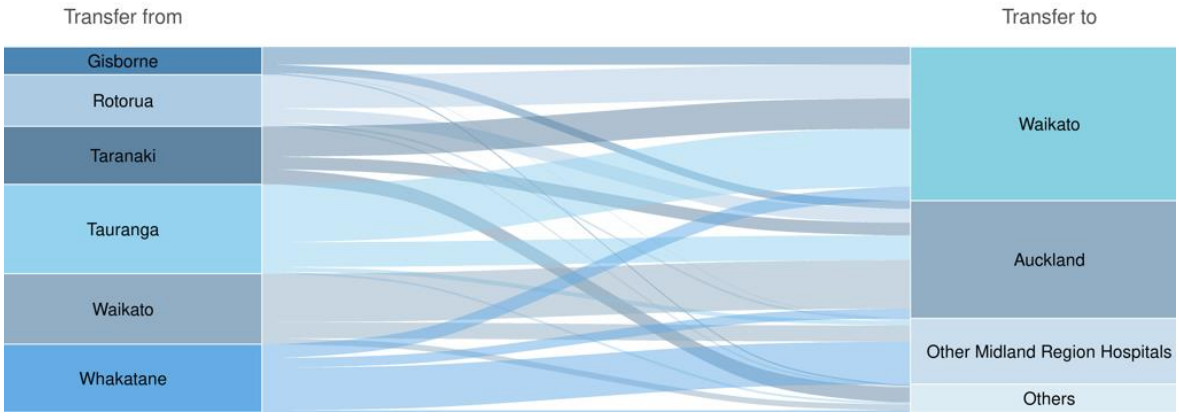
Figure 13. Critical care hours by admission type in Te Manawa Taki (2010/11 to 2019/20)



Transfer patterns

Most of the transfers for critical care were to Waikato hospital, except those from Whakatāne Hospital to Tauranga Hospital. The Taranaki Hospital unit also transferred a number of patients to Wellington Hospital to receive critical care.

Figure 14. Patients transferred from a Te Manawa Taki hospital (ICU or non-ICU patient) for ICU care in another hospital (2010/11 to 2019/20)



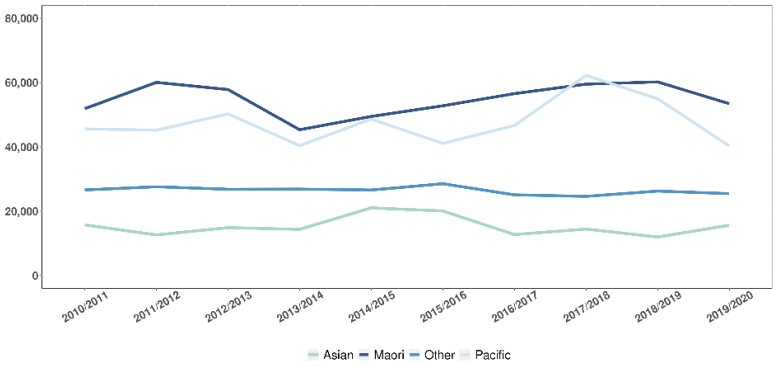
Central Region

The Central Region has a similar population to the Te Manawa Taki Region. In 2019/20 it had approximately 0.96 million population and is served by six units. The regional tertiary unit is located in Wellington Hospital, and the five other units are at Hawke's Bay Hospital, Whanganui Hospital, Palmerston North Hospital, Wairarapa Hospital and Hutt Hospital. Wellington Hospital also receives patients from Nelson Hospital and Wairau Hospital.

Critical care utilisation

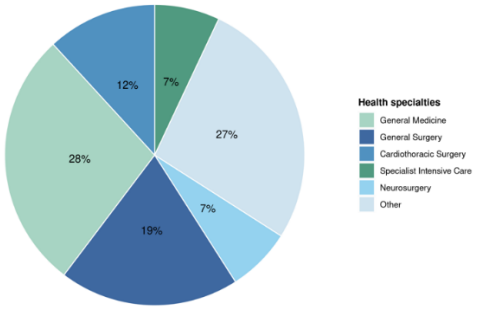
The Central Region had an average of 30,000 critical care hours per 100,000 population. Similar to the Northern Region and Te Manawa Taki Region, Māori had the highest critical care hours per 100,000 population. This rate is about 3.5 times compared to the lowest rate for Asian.

Figure 15. Age standardised critical care hours per 100,000 population in the Central Region (2010/11 to 2019/20)



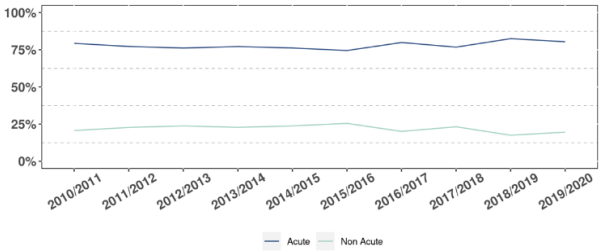
75% of critical care hours are for the top five health specialities.

Figure 16. Top 5 health specialities in the Central Region (2010/11 to 2019/20)



On average, 78% of critical care hours are for acute patients.

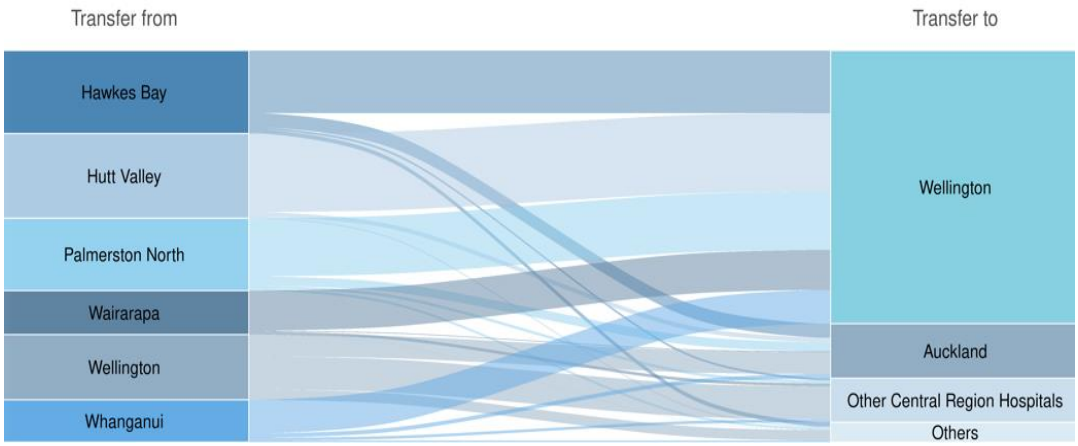
Figure 17. Critical care hours by admission type in the Central Region (2010/11 to 2019/20)



Transfer patterns

Most transfers for critical care were within the Central Region. Auckland City Hospital was the biggest patient transfer destination for critical care outside the Central Region.

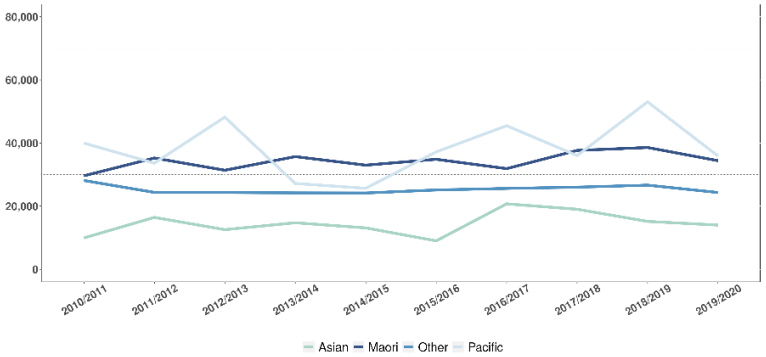
Figure 18. Patients transferred from a Central Region hospital (ICU or non-ICU patient) for ICU care in another hospital (2010/2011 to 2019/2020)



Te Waipounamu (Southern) Region

The Te Waipounamu Region has a population of around 1.2 million in 2019/20, and a total of seven units. It has the largest geographic spread. There are two units in hospitals with tertiary services for this region located at Christchurch Hospital and Dunedin Hospital. The other five units are Nelson Hospital, Wairau Hospital, Greymouth Hospital, Timaru Hospital, and Invercargill Hospital.

Figure 19. Age standardised critical care hours per 100,000 population in the Te Waipounamu Region (2010/11 to 2019/20)



Critical care utilisation

The Te Waipounamu Region had an average 26,000 critical care hours per 100,000 population. The Pacific people had the highest age-standardised hours per 100,000 population when compared to other ethnic groups.

72% of critical care hours are for the top 5 health specialities.

On average, 79% of critical care hours are for acute patients.

Figure 20. Top 5 health specialities in the Te Waipounamu Region (2010/11 to 2019/20)

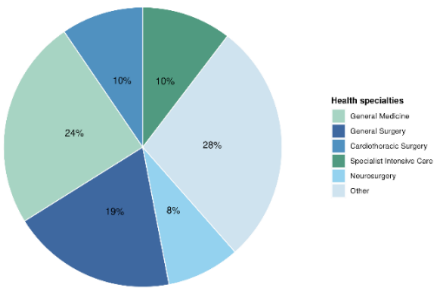
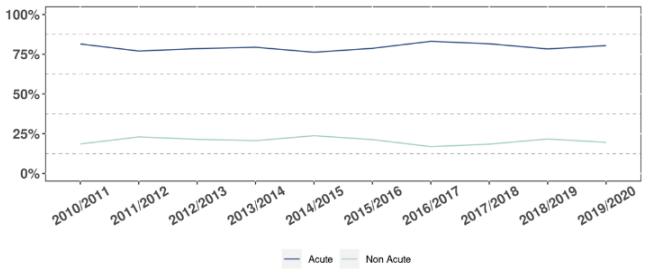


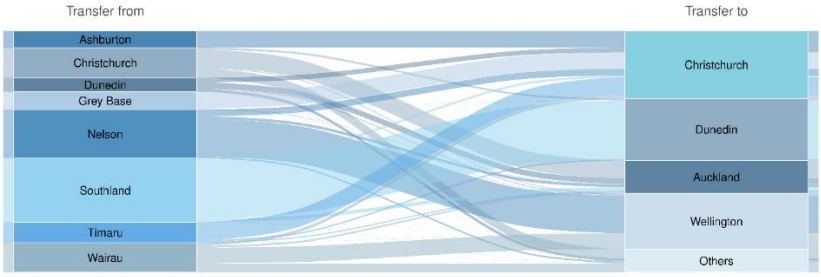
Figure 21. Critical care hours by admission type in the Te Waipounamu Region (2010/11 to 2019/20)



Transfer patterns

Most of the transfers were to Christchurch Hospital and Dunedin Hospital for critical care, although there are significant transfers from Nelson Hospital and Wairau Hospital to Wellington Hospital.

Figure 22. Patients transferred from a Te Waipounamu Region hospital (ICU or non-ICU patient) for ICU care in another hospital (2010/11 to 2019/20)



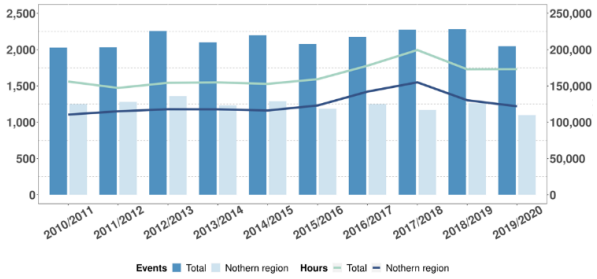
Critical care for paediatric patients

Critical care for children is provided across several sites in Aotearoa. Starship Children's Hospital in Auckland is the only site that provides quaternary level critical care and some specialised services for children. This has impacts on the pattern of critical care utilisation in Northern Region compared to other DHBs.

Critical care utilisation

From 2010/11 to 2019/20, there were, on average, 2,100 paediatric events and 165,000 hours per year. Of those, 58% of events and 76% of hours were for the paediatric patients from the Northern Region.

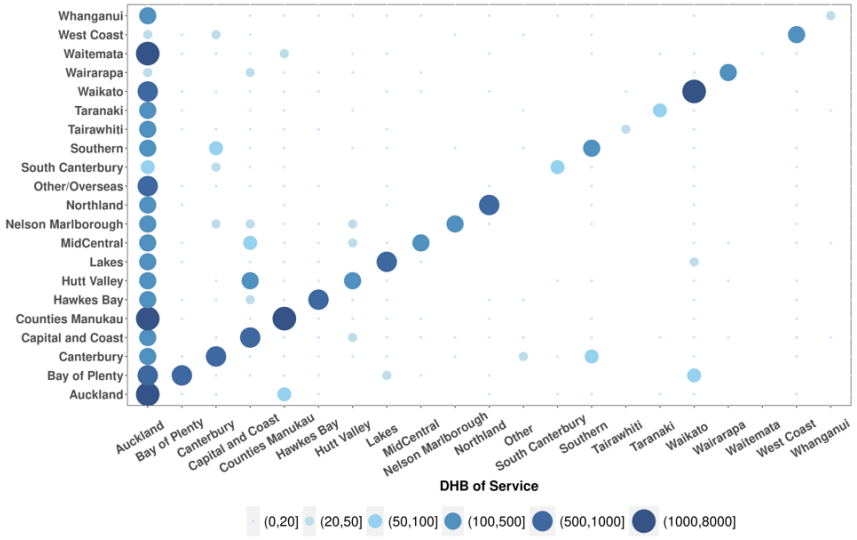
Figure 23. Paediatric critical care utilisation (2010/11 to 2019/20)



District of domicile and DHB of service

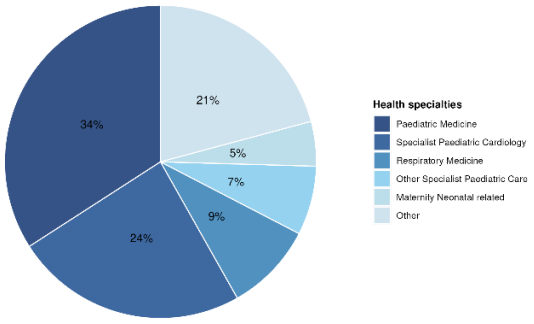
Most children received care within their DHBs, but some received specialised treatments in Auckland at Starship Children's Hospital. Starship contributed to, on average, 58% of total paediatric critical care events and 76% of total paediatric critical care hours from 2010/11 to 2019/20. The following figure shows paediatric care events by DHB of domicile and DHB of service.

Figure 24. DHB of domicile and DHB of service of paediatric critical care patients from 2010/11 to 2019/20



79% of critical care hours are for the top five health specialties. Some services are only provided at Starship Children's Hospital in Auckland, including specialist paediatric cardiology. It contributed to 24% of total critical care hours in the Northern Region.

Figure 25. Top 5 paediatric specialities (2010/11 to 2019/20)



Section 3: Describing our future service delivery framework

Current critical care delivery in Aotearoa is safe and good quality despite the challenges of a resource limited environment. A resilient and networked national framework is required to safeguard the system and ensure readiness for any pandemic and other large scale national emergency. Many existing facilities are at capacity and have unmet need evidenced by transfer of patients to other hospitals, and cancellations of planned surgery.

A sustainable future delivery framework requires significant investment over the next 5–15 years in physical infrastructure and across the system. In addition to the establishment of fit for purpose critical infrastructure within hospitals, wider system improvements are required.

Opportunities for improvement include establishing national leadership and oversight, strengthening regional flows, investing in workforce, centralising the patient transport system, and funding technology to support clinical care and workflows. A whole-of-system approach also means exploring options to design high acuity, transitional and step-down areas, and resourcing outreach services at every hospital to improve and support care of critical patients anywhere in the hospital. Applying a system focus outside of the unit itself prevents unnecessary admissions to critical care and therefore increases capacity in the unit.

A service delivery framework with system approach is summarised in this diagram:

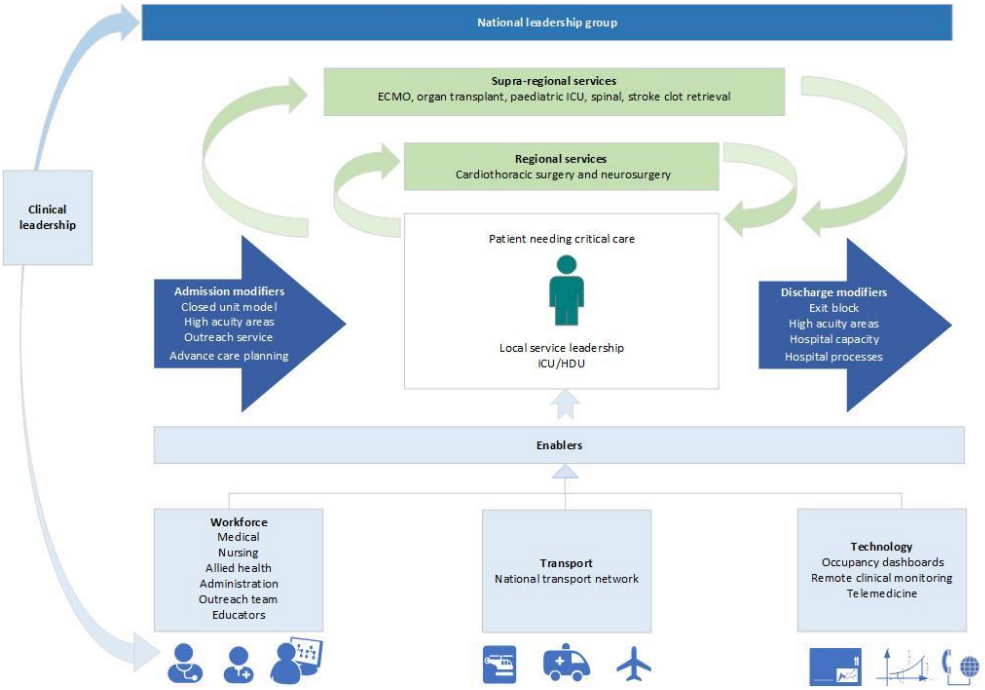


Figure 26. Critical care service delivery framework

National oversight of critical care planning

There is strong support across the sector for a formal national leadership group for critical care to be established. No national group currently has strategic oversight or a long-term system view for critical care. Services have evolved through local decision making. Drivers for these local decisions have included funding decisions around local capacity, workforce, decisions to fund sub-specialty services, and local infrastructure projects. National leadership can ensure a focus on long-term improvements that are Te Tiriti focused, equity based and person centred. National leadership will support nationally aligned change and improvement, while remaining conscious of local needs.

Supra-regional services

Highly specialised services that are low volume and high complexity are provided at national level with many located in the Auckland Region. Patients who present anywhere in the country who require care are transferred using agreed referral pathways to the

identified regional or supra-regional service. These transfers are important to consider as they are often key feeder services into critical care.

Units providing a regional or supra-regional service require additional capacity to be added to the baseline capacity for their local population. Service planning for these feeder services in the future, will have an impact on the distribution of critical care bed requirements. As these service plans are completed, there may be a need to reconfigure critical care bed distribution.[11]

Table 4. Supra-regional service examples

Service	Hospital	Note
Burns	Auckland Middlemore	National Burn Centre
	Waikato, Hutt, Christchurch	Regional Burn Units
ECMO	Auckland City	
Organ transplant	Auckland City	Heart/lung/liver
	Auckland City, Wellington, Christchurch	Renal
Spinal	Auckland Middlemore, Christchurch	
Stroke clot retrieval	Auckland City, Wellington, Christchurch	Supported by regional stroke centres
Paediatric ICU	Starship	Supported by regional locations at Auckland Middlemore, Waikato, Wellington, Christchurch

Table 5. Regional services

Service	Hospital	Note
Cardiothoracic surgery	Auckland City, Waikato, Wellington, Christchurch, Dunedin	Cardiothoracic also has some quaternary services provided by Auckland City
Neurosurgery	Auckland City, Waikato, Wellington, Christchurch	Full service
	Dunedin	Limited service

[11] Note: one reconfiguration scenario has been explored in Appendix 1.

Regional flows and networking

Regional patient flows

Opportunities exist to improve regional flows and manage capacity across regions. Patients are often transferred across regional boundaries, however there are no formally agreed and documented regional pathways or leadership.

Patients who could be managed in nearby smaller units may be sent to tertiary units due to capacity constraints. In these instances, tertiary units are providing secondary-level care to patients from outside their domicile. The flow-on effect is a lack of bed capacity for planned care and last-minute cancellation of planned surgeries.

Tertiary units provide advice to smaller units which smaller centres rely on. This advice is not consistently available across the country and units vary in the degree of support they receive. The process is informal and clinical teams often operate independently, referring and retrieving patients between units by negotiation. Formal pathways with clear roles and responsibilities would significantly improve access and flow.

Smaller or geographically isolated units, including those in rural hospitals, may only have resources to ventilate a patient for 12–24 hours. These units rely on larger units to accept and retrieve patients. If the nearest unit is at capacity, it often remains the responsibility of the smaller unit to source an alternative bed and arrange referral, rather than this being led through a regionally agreed process. Alternatively, with stronger regional support, some smaller units could retain patients for longer stays. This would advantage patients and families, reduce patient transfers, and relieve pressure on tertiary units. Creating a networking of services in each region will maximise the complementary roles between smaller and larger units.

A resourced and supported regional critical care operational team could be established to manage occupancy and efficient flow across their network of services. This would provide certainty and support for smaller centres, including those in rural centres. A regional network could ensure the sustainability of smaller units with a regional approach to capacity, capability and workforce development. It would also increase access, efficiency and capacity for each unit to deliver best practice critical care.

Many regional and national groups exist semi-independently, including the national trauma network, South Island emergency care co-ordination teams, the South Island ICU project group, other local groups including a Te Manawa Taki group. At times there is duplication and lack of information sharing between these groups.

The strengthening of regional and intra-regional collaboration will be an essential driver of success for the national network of critical care services. These new links will also be important supports for the national leadership.

Exit block

A lack of total bed capacity in many hospitals, with limited staffing and inefficient hospital processes, means that patients ready for discharge from critical care are often unable to leave the unit. This increases their length of stay and it reduces the capacity of the unit to provide care to additional patients. This is a major problem in every hospital and is exacerbated in annual seasonal winter surges. Whole-of-system changes are needed to address this.

High acuity areas

Establishing an HAA separate from ICU/HDU, is an opportunity to increase the total capacity within our system. Patients are often admitted to ICU/HDU, or stay longer once their acuity drops, because they are too unwell for general ward care. There is currently a lack of higher acuity clinical areas to care for these patients in other parts of the hospital.

During the COVID-19 outbreak, patients received high flow oxygen therapy in a ward setting. As we move towards endemic COVID-19, and there continues to be an increase in demand for higher levels of care, Aotearoa needs additional high acuity capacity to treat appropriately selected patients outside of ICU/HDU.

The lack of independent coronary care units (CCU) is also seen as a complicating factor. In some combined units the demand for CCU beds is high, and coronary patients reduce critical care capacity by occupying an ICU or HDU bed. In smaller units, a combination model allows for flexibility of staffing, however, reviewing the advantages of a separate coronary or medical high acuity unit would be appropriate in many hospitals and would increase critical care capacity.

Many patients could potentially be monitored and cared for in an HAA if this care was safely resourced with higher nurse-to-patient ratios, experienced nursing and allied health staff trained in advanced clinical competencies and resourced with appropriate processes and equipment.

Many larger hospitals with tertiary services have sufficient patient volumes to resource HAA. Different options for this exist, including step-down units, transitional care areas, observation units, progressive care units etc.

These may include:

- medical areas
- surgical areas
- perioperative areas
- emergency departments
- maternity units.

Establishing surgical HAA and/or extended PACU areas can decrease elective surgical cancellations. HAAs cost less and require fewer resources while providing flexibility for surge capacity along with increased opportunities to develop nursing expertise outside of a critical care unit.

Opportunities for the establishment of HAAs in each hospital should be explored.

Outreach services

For the past two decades it has been recognised that extending critical care services across the whole hospital prevents morbidity and mortality. Early recognition and management of deteriorating patients and supporting post-operative or other high acuity patients in a ward setting increases quality and safety of the whole system. Adverse events can be prevented, transfers to critical care units can be anticipated or avoided and advanced nursing expertise can be developed in ward staff.

Outreach services may include Medical Emergency Teams (METs), Deteriorating Patient Programmes, and Patient at Risk Teams (PARTs). Many hospitals in Aotearoa have no critical care outreach service. This is either because it is not seen as a priority and therefore not funded, or because the unit itself is already struggling with insufficient nursing resource.

Outreach services make the whole hospital safer. When ward care is supported by critical care staff who are available to come and review patients in any area of the hospital, this improves outcomes. These teams will contribute to the achievement of quality and safety clinical standards. There is also the added value of developing advanced ward nursing skills, critical care experience and improving the safety and wellbeing of all staff.

Outreach teams become even more necessary during surges like the COVID-19 pandemic. When an ICU/HDU reaches capacity, critically ill patients who would usually be admitted to a unit must be managed in the ward. This further reinforces the urgency to resource the critical care nursing workforce.

Where resource allows, outreach services also support retrievals and transfers. This needs to be recognised and resourced as part of our national critical care service. At times there are no clinical staff available to leave a unit to retrieve a patient and transfer delays can occur while a retrieval team is organised.

Outreach teams have different structures depending on hospital size. The introduction of outreach, as an integral part of delivering a critical care service, should be considered in each hospital.

Advance care planning

Advance care planning is a process where people make plans about their future health care and consider the preferred level of intervention should they become critically ill. If it is documented preoperatively that a patient declines ICU admission if there are life threatening complications, this is very helpful for patients and families, and it also prevents inappropriate admissions to ICU. Similarly, if advance care planning is completed in the community, the pathway for people who may require acute critical care can be directed in line with people's own preferences.

In a closed unit, all admissions are discussed with the unit specialist. This provides an opportunity to discuss the appropriateness of ICU intervention and, where appropriate, decide not to admit the patient. For open units, this discussion does not always take place. As a result, admission criteria are more variable.

An opportunity exists for all hospitals to implement advance care planning and for advanced directives to be in place prior to hospital admission and prior to surgery. This would have the greatest impact in open units by reducing inappropriate admissions to the unit and therefore increasing capacity.

Programmes to support this include the Shared Goals of Care Programme and the Choosing Wisely Campaign. These initiatives are supported by the Health Quality and Safety Commission and the College of Intensive Care Medicine.

Alignment with other planning

This service plan is focused on identifying long-term critical care needs, with a focus on infrastructure. The plan will provide direction for more immediate planning and investments, as well as system-wide planning as outlined below.

- The Health System Preparedness Programme (HSPP) was established to support the system to be more agile, better equipped and increasingly responsive to COVID-19. The Government recently allocated operational funding to support critical care capacity, and this service plan has been utilised to inform the funding allocation across regions.
- The Te Whatu Ora Infrastructure and Investment Group's Regional Hospital Re-Development Programme encompasses the major provincial hospital development projects across Aotearoa. The forecast of infrastructure requirements in this service plan has been utilised within these projects to ensure national alignment.
- The Northern Region DHBs and the Te Whatu Ora Infrastructure and Investment Group are working on the development of a Northern Region Capital Roadmap. Other regions are considering similar developments. This national service plan has been utilised within the regional planning to ensure national alignment. As regional clinical service planning identifies service configurations that may modify the distribution of critical care bed requirements, this can be updated in the national planning. While the distribution of infrastructure may be updated through the regional process, the overall critical care bed needs would be expected to in line with the national plan.
- The health reforms have a focus on establishing networks to support a Te Tiriti dynamic system and whole-of-system planning. This plan is the first step in identifying long-term critical care needs and can guide the work programme for a future critical care network.

Section 4: Forecast and modelling

Critical care modelling

The critical care modelling forecasts the future critical care infrastructure requirements based on a future focused service delivery model for Aotearoa.

All long-term forecasting is inherently limited based on the data available and assumptions required. While current utilisation trends are used as a base, this may not accurately reflect need. We have worked with our steering group to mitigate some of the limitations in the data available to develop a forecast on which we can progress long-term planning for infrastructure. While focused on infrastructure, we note the modelling can be used to guide other developments such as workforce.

The purpose of the forecast is to identify the critical care capacity to meet the population's needs. The modelling has aimed to account for the delivery of the usual critical care related to acute and planned care with the resilience to meet periodic peaks in demand. There may be some instances in which peaks in demand, that are particularly difficult to predict, may exceed the capacity that has been forecast. However, the resilience factor should mitigate this, and the system can, in these instances, adjust demand by adjusting patient in-flows, as has been demonstrated with COVID-19.

The 2014/15 to 2018/19 years were taken as the baseline for projection. Utilisation trends dropped in 2019/20 due to COVID-19 and are not considered an accurate reflection of baseline. Projections were made on a five-yearly basis for 15 years until the financial year of 2035/36.

We have used two methods for forecasting critical care needs. The epidemiological methodology has been completed by the Infrastructure and Investment Group and the data simulation methodology was commissioned through the University of Auckland. The results of both methods are similar and, along with the consultation process, provide assurance of the forecast results.

Critical care forecast model — Epidemiological methodology

The epidemiological model was developed in six key steps, starting from the development of a baseline dataset, followed by utilisation analysis and rates calculation to generate the base projection. Adjustments and scenarios based on the service delivery framework and design discussions with the sector were applied for the final forecast. Appendix 1 Critical Care Technical Report provides details of the methodology and related analysis that is summarised in this section.

The following is a summary of the methodology.

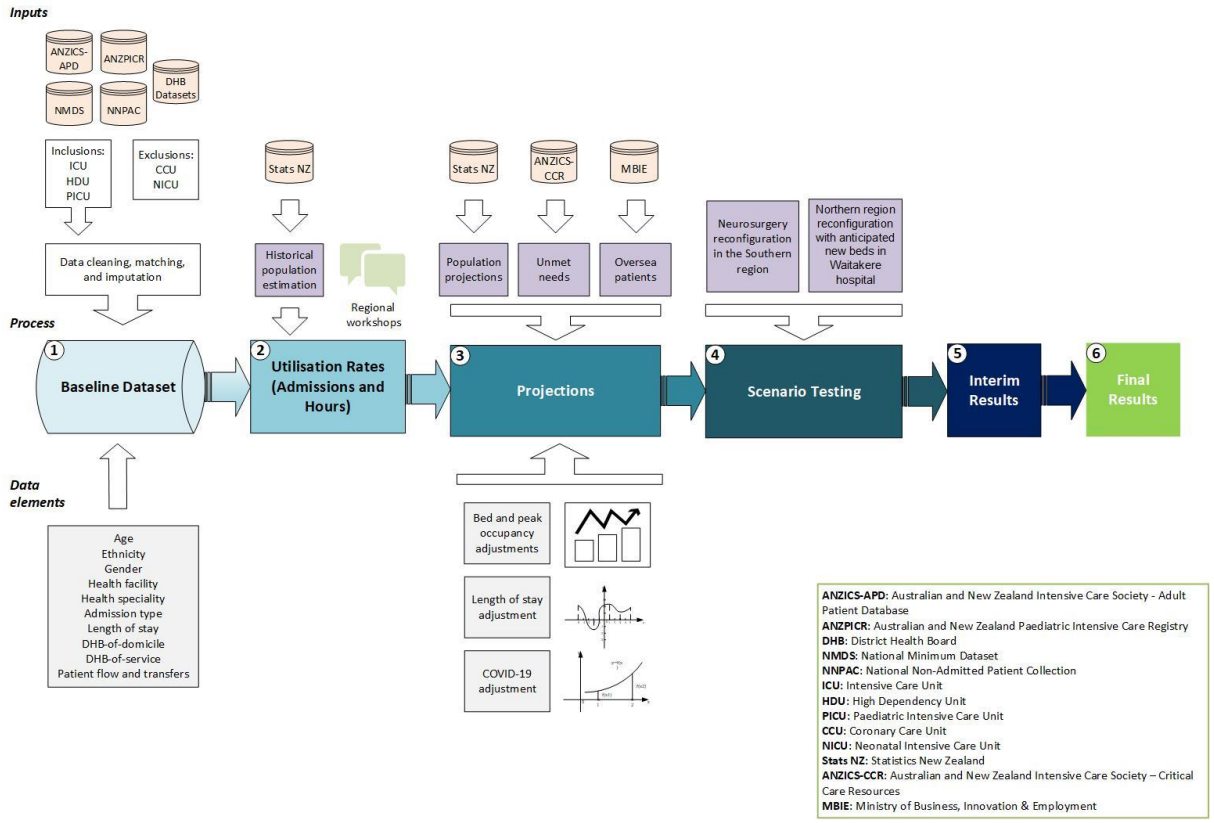


Figure 27. Processes of projection

Baseline dataset

The baseline dataset for the modelling was developed by matching data from four main data sources, because individually, the data sets did not provide a sufficiently accurate reflection of critical care activity.

- National data collections: National Minimum Dataset (NMDS) and National Non-Admitted Patient Collection (NNPAC)
- Australian and New Zealand Intensive Care Society databases: Adult Patient Database (APD) and Paediatric Intensive Care Registry (PICR)
- District Health Board (DHB) datasets (on request)
- Tatauranga Aotearoa – Stats NZ

We performed data cleaning, matching and sense checking with critical care teams and review by the steering group. Events related to ICU, HDU and PICU were included. CCU related events were excluded.

Utilisation analysis & rates

We analysed the data to gather insights into historical and current critical care service delivery across Aotearoa. We analysed the utilisation events and length of stay by age, ethnicity, gender, admission types, health specialty, patient flow and transfers. National-level analysis was shared with the steering group for review. Regional summaries of the analysis were developed and reviewed through four regional workshops. The workshops were an opportunity to verify data, provide insights for projections adjustments and discuss service development opportunities. Local data was tested with local teams as required.

Projections

Future critical care service projections were forecasted utilising population projection data from Stats NZ. Adjustments were made for:

- unmet needs (data source: ANZICS-CCR (Critical Care Resource Survey))
- overseas visitors' (data source: Ministry of Business, Innovation, and Employment; MBIE)
- length of stay changes over time
- bed occupancy and peak occupancy
- system resilience including COVID-19.

Unmet need

Critical care teams report that they manage the number of patients within the bed constraints that they have and that there is considerable unmet need in Aotearoa.

It is challenging to quantify unmet need for critical care services. There were several potential sources of data that we identified to estimate unmet need. We considered elective surgery cancellations and performance reported by DHBs, ANZICS afterhours discharge data and options for carrying out a snapshot audit. In discussion with the steering group, we have used data collected from two of the ANZICS quality markers to estimate unmet need.

- Elective surgery cases that are cancelled due to inadequate ICU resources.
- Refused unplanned admissions due to inadequate ICU resources.

We considered it the best source of data as it is reported directly by the intensive care services, it focuses on acute and elective services and captures a higher rate of unmet than other sources. While it appears to be the best national data source, we acknowledge that it has gaps and limitations.

- There is considerable variation in reporting of unmet need between hospital intensive care services. There is some reluctance from some intensive care services to record data on cancellations of elective services or refused acute admissions.
- As the data is not stratified by age, ethnicity or presenting condition we are unable to stratify the impact across the different population groups.
- The flow-on effect of people not being booked for surgery when there are known critical care capacity constraints is not captured in this data set.
- The transfer of people to a tertiary service due to a lack of capacity, rather than capability to deliver critical care, may not be captured in this data set.
- Some services are increasing their out of hours discharge to manage flow which is not considered best practice. This is not captured in this dataset.

We have reviewed the five years of data available for the two ANZICs quality markers and developed an average rate per site. The lowest average rate was 0% and the highest rate 11.7%. On discussion with the steering group and at the regional workshops, we have applied 11.7% unmet need across all critical care sites. This should account for under-reporting and factors in unmet need that may not be captured in this data set.

Estimate of overseas patients

We have adjusted for overseas patients as they are not captured in the base population. The historical rates of critical care events and hours for visitors were increased in line with the Stats NZ trends for visitors.

Average and peak occupancy

A bed cannot be used 100% of the time so average occupancy is an important factor. The occupancy is determined by the total number of critical care bed hours delivered by the service compared to the total number of critical care bed hours available. There are many variables that need to be considered for determining what an appropriate occupancy rate is for a service. These include the size of the service, the complexity of care delivered within the service, the ratio of planned and acute care by the service, and the proximity to other critical care services. This may be a warranted variation in occupancy.

In general, we have applied each service's current average occupancy rates to the forecast. However, we have adjusted the occupancy rate down to 75% in a few tertiary sites where their current occupancy is higher. We have also adjusted for peak to ensure that occupancy does not exceed 100% during seasonal variation.

Average length of stay

The average length of stay (ALOS) in intensive care was relatively stable at the national level over the years. ALOS appears to be increasing in a few units that are mostly in the hospitals with tertiary services. In contrast, ALOS appears to be decreasing in a few units in the hospitals with non-tertiary services. We have adjusted for trends in ALOS.

System resilience

The COVID-19 pandemic has heightened the focus for critical care capacity across Aotearoa. The forecast includes an adjustment for endemic COVID-19 requirements. While the adjustment has been quantified based on a COVID-19 scenario, the purpose is to include an adjustment that reflects critical care system resilience.

There are other peaks in critical care demand and these crises are difficult to predict. People who were in the Christchurch earthquakes, the White Island tragedy, and the mosque shooting were cared for in the critical care units. Critical care units also provided care for children during the Respiratory Syncytial Virus (RSV) outbreak. Our assumption is that the increase in beds that we have adjusted for with the resilience factor will enable the critical care system to have the capacity to manage periodic peaks in demand while maintaining other care, such as planned care that would otherwise be disrupted.

We distributed the additional beds across the hospitals based on the current critical care utilisation patterns in which patient flow and transfers were considered. We did not assign additional bed capacity to Whakatāne or Wairarapa as their regional partners are likely to provide the additional care.

While we generated the resilience factor based on the COVID-19 modelling conducted by Te Pūnaha Matatini, we acknowledge the limitations.

- The modelling was not designed to identify long-term infrastructure requirements or to account for other surge factors.
- The assumptions within the model are assumptions, and these may not be realised (eg, 85% to 90% vaccination rates for the population over 5 years old).
- The outputs were not separated by ethnicity or DHBs.
- COVID-19 modelling has continued to evolve. Other subsequent modelling cited appears to be more conservative in terms of critical care needs.
- This additional infrastructure capacity, while planned for, may not need to be operationalised continuously.

Scenario testing

Insights from the utilisation analysis and sector engagement has identified potential service forecast scenarios. We focused scenario development on those that are responsive to future patient needs and support sustainable investments.

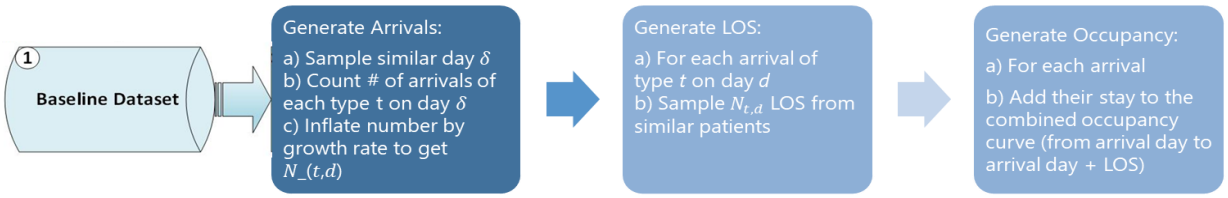
Two scenarios have been explored and are included in Appendix 1 – Technical Report.

1. Neurosurgery reconfiguration in Te Waipounamu
2. Northern Region reconfiguration of anticipated new bed capacity

Critical care forecast model — Data simulation methodology

The simulation model was developed in three key steps starting with the baseline dataset as described previously. The simulation first generated arrivals, then generated length of stay to finally produce total hours of occupancy to generate the simulation base projection. The results provided a quality check by yielding similar results to the epidemiological method.

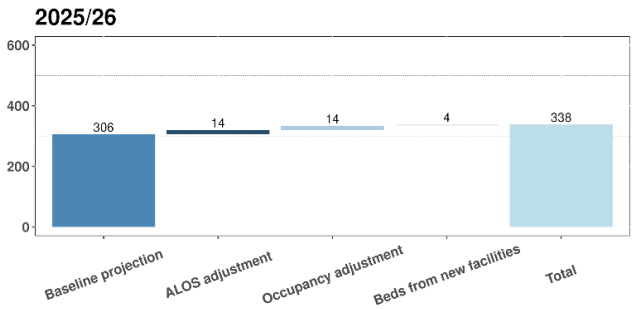
Figure 28. Critical care simulation model



Epidemiological methodology general forecast — without consideration of resilience capacity

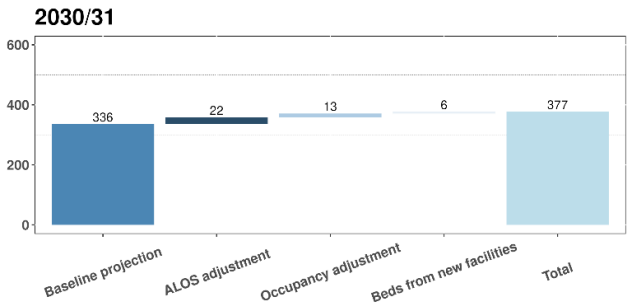
The forecast of beds required for Aotearoa in the future is outlined below (Figure 29). The service plan forecasts that by 2035/36, without consideration of additional resilience capacity, we will need 406 critical care beds across Aotearoa. These are beds that will need to be resourced and staffed to provide the care required across Aotearoa.

Figure 29. Sources of critical care beds estimation without the system resilience factor



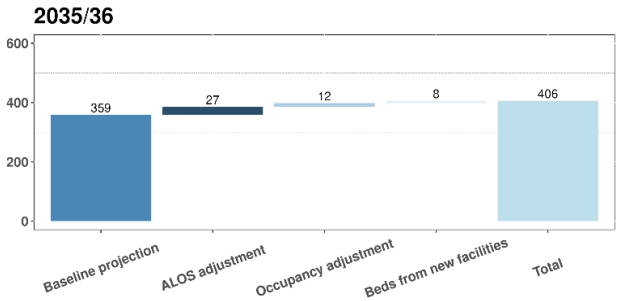
6.35

critical care beds per 100,000 population in 2025/26



6.81

critical care beds per 100,000 population in 2030/31



7.10

critical care beds per 100,000 population in 2035/36

The national forecast has distributed across the current critical care sites in line with current patient flow.

Table 6. Critical care beds estimated for the general forecast without the system resilience factor

Critical care unit	2025/26	2030/31	2035/36
Auckland City Hospital CVICU	31	35	38
Auckland City Hospital DCCM	27	29	31
Starship	28	30	33
Subtotal (Auckland City Hospital)	**86**	**94**	**102**
Christchurch Hospital	34	39	43
Dunedin Hospital	19	23	25
Gisborne Hospital	5	6	6
Grey Base Hospital	3	3	3
Hawke's Bay Hospital	14	16	17
Hutt Hospital	7	7	8
Middlemore Hospital	24	27	29
Nelson Hospital	8	8	9
North Shore Hospital	13	14	15
Palmerston North Hospital	7	7	8
Rotorua Hospital	8	9	9
Southland Hospital	8	9	10
Taranaki Base Hospital	6	6	6
Tauranga Hospital	15	17	18
Timaru Hospital	6	7	7
Waikato Hospital	20	22	24
Wairarapa Hospital	4	5	5
Wairau Hospital	1	1	1
Wellington Hospital	28	31	33
Whakatāne Hospital	6	7	7
Whanganui Hospital	4	4	4
Whangārei Hospital	8	9	9
Waitakere Hospital	4	6	8
Public Hospital Total beds	**338**	**377**	**406**
Population projected	**5,325,125**	**5,533,060**	**5,718,835**

Beds per 100,000 population (Public hospitals only)	**6.35**	**6.81**	**7.10**

With the Health and Disability System Review, and the recommendation of this service plan to strengthen regional partnerships, there is likely to be further consideration of bed re-distribution across critical care services within a region. Table 7 provides a regional view of the forecast that could support these developments.

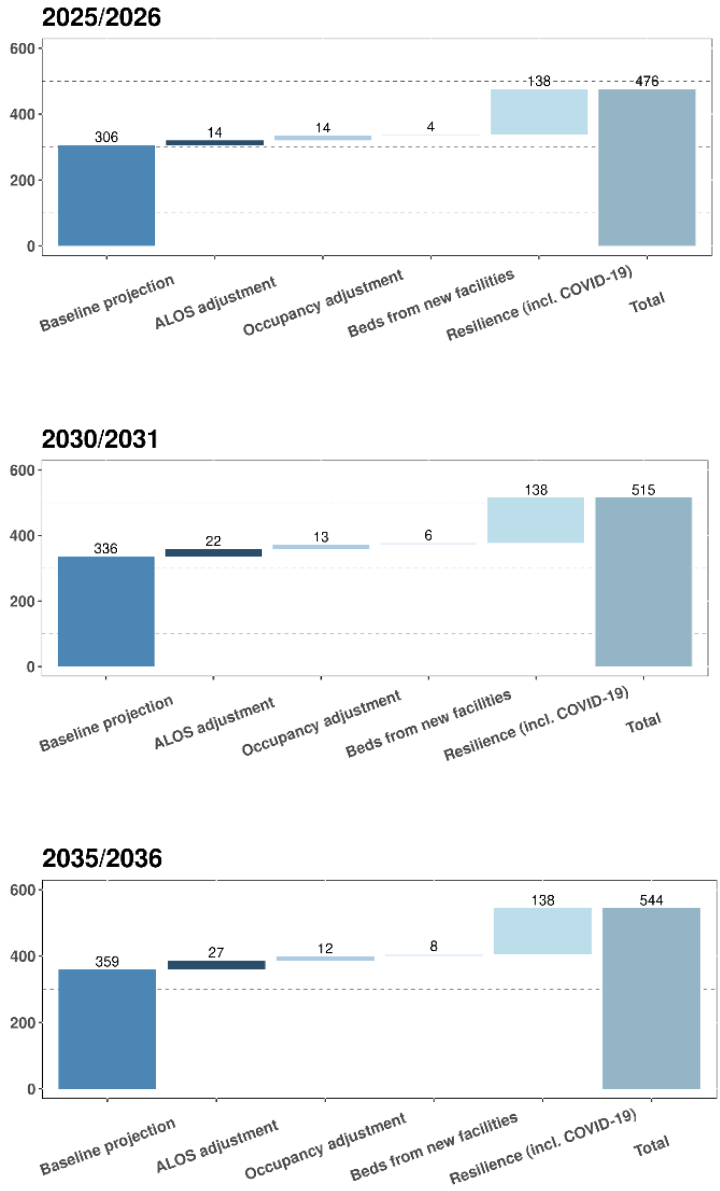
Table 7. Regional critical care beds estimated for general forecast without the system resilience factor

Region	2025/26	2030/31	2035/36
Northern	135	150	163
Te Manawa Taki	60	67	70
Central	64	70	75
Te Waipounamu	79	90	98
Public hospital total	338	377	406

Epidemiological methodology forecast that includes a resilience factor

The forecast of beds required for Aotearoa in the future is outlined below (Figure 30). The service plan forecasts that by 2035/36, including the consideration for resilience capacity, we will need 544 critical care beds across Aotearoa. These are beds that will need to be resourced and staffed to provide the care required across Aotearoa.

Figure 30. Sources of critical care beds estimation including the system resilience factor



8.94

critical care beds per 100,000 population in 2025/26

9.31

critical care beds per 100,000 population in 2030/31

9.51

critical care beds per 100,000 population in 2035/36

The national forecast has distributed across the current critical care sites in line with current patient flow.

Table 8. Critical care beds estimated for the forecast including the system resilience factor

Critical care unit	2025/26	2030/31	2035/36
Auckland City Hospital	*122*	*130*	*138*

Christchurch Hospital	*47*	*52*	*56*
Dunedin Hospital	*27*	*31*	*33*
Gisborne Hospital	*7*	*8*	*8*
Grey Base Hospital	*4*	*4*	*4*
Hawke's Bay Hospital	*20*	*22*	*23*
Hutt Hospital	*10*	*10*	*11*
Middlemore Hospital	*34*	*37*	*39*
Nelson Hospital	*11*	*11*	*12*
NorthShore Hospital	*19*	*20*	*21*
Palmerston North Hospital	*10*	*10*	*11*
Rotorua Hospital	*11*	*12*	*12*
Southland Hospital	*11*	*12*	*13*
Taranaki Base Hospital	*9*	*9*	*9*
Tauranga Hospital	*22*	*24*	*25*
Timaru Hospital	*9*	*10*	*10*
Waikato Hospital	*29*	*31*	*33*
Wairarapa Hospital	*4*	*5*	*5*
Wairau Hospital	*2*	*2*	*2*
Wellington Hospital	*41*	*44*	*46*
Whakatāne Hospital	*6*	*7*	*7*
Whanganui Hospital	*6*	*6*	*6*
Whangārei Hospital	*11*	*12*	*12*
Waitakere Hospital*	*4*	*6*	*8*
Public Hospital Total beds	**476**	**515**	**544**
Private Hospital beds	***29***	***29***	***29***
Total beds in NZ	**505**	**544**	**573**

Population projected	**5,325,125**	**5,533,060**	**5,718,835**
Beds per 100,000 population (Public hospitals only)	**8.94**	**9.31**	**9.51**
Beds per 100,000 population (All)	**9.48**	**9.83**	**10.02**

* Beds anticipated to be established in the near future.

With the Health and Disability System Review, and the recommendation of this service plan to strengthen regional partnerships, there is likely to be further consideration of bed re-distribution across critical care services within a region. Table 9. provides a regional view of the forecast that could support these developments.

Table 9. Regional critical care beds estimated for the forecast including the system resilience factor

Region	2025/26	2030/31	2035/36
Northern	190	205	218
Te Manawa Taki	84	91	94
Central	91	97	102
Te Waipounamu	111	122	130
Public hospital total	**476**	**515**	**544**

Section 5: System enablers

Workforce

Without workforce there is no service.

Establishing a national focus on strategic workforce planning to identify and address workforce issues is the most urgent issue facing the provision of critical care. Recruitment, retention, training, and professional development of critical care nursing, allied health staff, medical specialists, and other unit staff is the main challenge for all units across Aotearoa.

There is an opportunity to increase critical care capacity within the existing beds by resourcing and staffing them. Un-resourced beds exist in most centres. The existing critical care workforce is already under-resourced, and efforts are being made to fill vacancies in many units around Aotearoa.

Education and training take time and a significant investment in workforce is required to avoid burnout. Changing models of care are emerging as COVID-19 patients are treated in a variety of settings outside of critical care, and a resourced and upskilled workforce is needed to support and manage these new ways of working.

The development of a long-term workforce pipeline for critical care that has a focus on diversity is a priority for the system.

Data

To prepare this plan, multiple data sources were combined. Several different unlinked data sets currently exist, which provide a variety of non-standardised data. Detail is provided in the technical document which supports this plan.

The collection and reporting of more accurate data, and establishing transparent and standard reporting, with overview of critical care services is a national priority. Critical care units in Aotearoa need to be encouraged and supported to participate in the national data collection and quality benchmarking processes.

Improvements in ethnicity-based data collation and reporting are needed, particularly for unmet need. The development of data and intelligence that can support future developments that reduce unwarranted variation and improve equity of outcomes is

needed. Patient experience and outcomes also need to be a focus for future service delivery and planning.

Technology

A major enabler to advance critical care services is to upgrade technology and digital support for the critical care sector. Specific opportunities include dashboards, monitoring systems and telemedicine. Technology enablers will underpin regional and national collaboration across a future-focused national critical care service network.

Occupancy dashboard

National transparency of occupancy with a live status report dashboard for the whole of Aotearoa will transform the delivery of critical care. A dashboard, as an operational tool, will enable efficient transfers and best use of the critical care resources available across a network of critical care services. Even within individual hospitals, a hospital occupancy dashboard is not available for all units. Providing these digital support tools in every hospital in Aotearoa is an essential part of providing future care. The dashboards are also likely to become a rich source of real-time data collection for quality improvement processes and future service planning.

Clinical monitoring systems

The lack of digital bedside monitoring and electronic clinical records is currently a barrier to service provision. When advice is requested from a tertiary unit, or between units, the inability for most units to review patient status or clinical details remotely reduces efficiency and increases risk.

A national critical care service with equitable capacity means every patient will receive care in the most appropriate unit and bed for the level of care that they need. Networked digital monitoring systems are essential. When purchasing new systems, there is currently no requirement for a local hospital to consider regional or national planning, standardisation, interoperability, or ability to scale nationally. This is an opportunity.

Telemedicine

A safe operational regional network with the ability to provide remote advice will be enhanced by telemedicine. Some units have already started exploring this and future investments can be regionally coordinated.

Clinical networks

National emergencies and the COVID-19 pandemic have resulted in the formation of several multidisciplinary networks. These, along with strongly collaborative professional associations and vocational training networks provide clinical leadership. A more formal national clinical network structure for critical care will provide the necessary leadership to advance high quality critical care service delivery and developments for Aotearoa. Within clinical networks there will be expectations to include multidisciplinary clinical leadership, Māori leadership and consumer leadership. This will strengthen future service design opportunities that should be Te Tiriti led, equity based and person centred. These networks can be a driver of change as identified in this plan.

Transport

Retrievals and transfers are a major part of daily critical care. A consistent, sustainable, effective, centrally coordinated model supported by national policy and formally agreed pathways is a significant opportunity to improve critical care service provision.

Units in Aotearoa vary in size and location, and there are geographic challenges. Some transfers are weather dependent. A nationally coordinated model will need to be regionally designed and implemented to support local variations and needs.

The current system is fragmented and inefficient. Three transport groups (road, fixed wing, and rotary wing) operate independently with no central coordination for decision making or funding. For example, two independent retrieval teams may pass in transit, or follow one another, one returning after transferring a patient and the other on the way to the same centre to retrieve a new admission. This is expensive and inefficient especially as many retrieval teams take staff from the unit floor to cover retrievals. A flow-on effect of this is that the unit then becomes understaffed and unable to attend outreach calls or may have to call clinical staff to work additional shifts.

New South Wales operates a model where a single referral network is centrally coordinated and supports all critical care transport. There is strong support from the sector to replace the current fragmented transport system with a similar integrated system in Aotearoa. A national approach to tasking and coordination is critical to optimising the capacity of the system to ensure resources are prioritised based on their ability to deliver a patient benefit. The Aeromedical Commissioning Programme within the National Ambulance Sector Office will be working with sector colleagues and stakeholders on designing a future state.

Section 6: Future directions

Summary

Developing a sustainable critical care system is a priority for the health system. This national critical care service plan is focused on long-term infrastructure planning, describes current service utilisation and flows, outlines a future-focused service delivery framework, and provides a bed forecast. Ensuring there is adequate critical care infrastructure, as part of this system is essential.

The bed forecast accounts for delivering critical care in general situations, with the additional capacity required for system resilience. With the Health and Disability System Review underway, there will be new regional and national opportunities for further service development in critical care. There is an opportunity for the establishment of a network that can progress this plan and the outlined recommendations.

Recommendations

The purpose for undertaking this planning process was to analyse and understand the current state of critical care services in Aotearoa, and to set future directions for infrastructure planning for the next 5-15 years.

We have forecasted the need for 406 critical care beds across public hospitals in Aotearoa by 2035/36, when additional resilience capacity is not considered. With the addition of a resilience factor the forecasted need is for 544 critical care beds by 2035/36 across Aotearoa. This capacity is expected to support future health needs including uncertainties such as endemic COVID-19 and other national events requiring a surge in critical care availability.

New investment in critical care infrastructure needs national, regional, and local planning and whole-of-system support. Fit-for-purpose critical care infrastructure needs to be invested in. Additional opportunities include national leadership, regional operational networks, improvements in capacity and flow including high acuity areas, advanced care planning, and hospital outreach support services. There also needs to be a focus on system enablers including workforce, patient transport, data, and technology. Whole-of-system focused networks will be the vehicle to implement the recommendations.

A lack of ward beds across hospitals to receive discharges from critical care is a universal challenge. Most services are at capacity and barriers to patient flow across hospitals are long-standing. Integration and planning at all levels are needed.

As demand for services continues to increase, processes to prioritise investment and drive overall population health gains are needed. Increasing critical care beds and operational funding is a significant investment for Aotearoa. The service plan provides an evidence base for the need for critical care.

We acknowledge that investment in critical care must be balanced against investment choices for other areas of health gain. As the health reforms progress, service planning across several service areas is expected to be undertaken, and a whole-of-system service plan developed. A comprehensive national health plan that identifies the populations health needs and the systems response to meeting this need will also be developed. This whole-of-system plan will be used to commission service change and invest in appropriate enablers such as workforce, infrastructure, and transport. Investment in critical care infrastructure will need to be considered within this wider national process.

Thirteen focus areas have been identified to improve critical care service delivery, achieve equity of outcomes and access, and support future infrastructure investment:

1. **National leadership**
   Establish a national leadership to provide long-term strategic oversight.
2. **Critical care infrastructure roadmap**
   Prioritise regional and local infrastructure requirements within the national context.
3. **National clinical networks**
   Establish a national critical care network with a focus on long-term improvements that are Te Tiriti focused, equity-based and person centred.
4. **Regional operational networking**
   Formalise regional oversight and clinical support across regions, to reduce unwarranted variation, improve patient flow arrangements and focus on quality improvement.
5. **National workforce planning**
   Establish a national critical care strategic workforce planning programme.
6. **Accurate data collection to drive service improvements**
   Review and standardise national reporting with a focus on patient outcomes and experience, and equity to improve future service delivery.

7. **Technology to support provision of care**
   Establish national decision making and funding for technology investment to enable critical care.
8. **Exit block and hospital capacity**
   Include critical care clinical representatives in hospital capacity planning projects.
9. **Patient transport system**
   Review the critical care patient transport system and work towards a centrally coordinated national transport system with formally agreed destination policies.
10. **High acuity areas**
    Establish a project at each hospital to review existing high acuity areas and scope new models of care and new locations to care for HAAs.
11. **Outreach services**
    Establish and resource outreach services at every hospital.
12. **Advance care planning**
    Establish and resource advance care planning, especially at all hospitals where the critical care unit operates with an open model.
13. **Paediatric intensive care**
    Review the provision of national paediatric intensive care services to strengthen regional support and develop a national delivery framework for children.

Next steps

The service plan will continue to be used by the Te Whatu Ora Infrastructure and Investment Group to guide critical care investment in infrastructure projects and investments for critical care. This includes individual infrastructure projects put forward by DHBs, the major regional hospital projects, as well as further regional planning projects. The plan has already been used to support operational investments to increase critical care capacity.

The establishment of a national critical care clinical network should be a priority. The network can be the vehicle for implementing the service plan to create a resilient critical care system for Aotearoa. The plan can be applied to other enablers, including workforce development which is a priority. Health service planning is an ongoing process, and a network can ensure the change is realised and that the service plan remains current and is continually improved.

The critical service plan demonstrates the benefits of a sector-engaged and national planning process to inform infrastructure investments. National service planning in other health areas will generate similar benefits and will be a priority for Te Whatu Ora.

Appendix 1: Technical report

Estimate Critical Care Demand in Aotearoa New Zealand

Technical Report

June 2022

Introduction

Critical care is an essential service that saves lives.

The national critical care service plan lays the foundation for critical care infrastructure across Aotearoa New Zealand over the next 5-15 years. Prior to this work, each DHB had led its own critical care infrastructure planning.

Infrastructure planning for critical care requires long-term planning. We acknowledge that this forecast, while future focused, will evolve over time. As new service delivery models for critical care are developed and more robust data is available, the forecast and service plan will need to be reviewed. The potential of the Health and Disability System Review to increase regional and national service models will also impact on future capacity requirements for critical care. Hospital infrastructure takes time to plan and further time to build. A long-term capacity forecast, while open to evolution over time, is an essential starting point.

We have worked with the sector to develop the capacity modelling and forecast that underpins the service plan with the information and evidence available to us. Due to the limitations of data collected, emerging impact of COVID-19 and challenges to accurately quantify unmet need, there are opportunities to improve the modelling and forecast in the future.

We have used two parallel methods to forecast critical care bed requirements across Aotearoa. The epidemiological methodology was completed by the Infrastructure and Investment Group and the data simulation methodology was commissioned through the University of Auckland. The intention was to generate two forecasts as comparisons, which, along with the consultation process with the sector, would provide assurance of the results.

This document outlines:

- the epidemiological methodology for the forecast
- our analysis of the historical and current utilisation
- our forecasting assumptions based on key insights from the analysis
- the details of the scenarios we have tested
- and the forecast results.

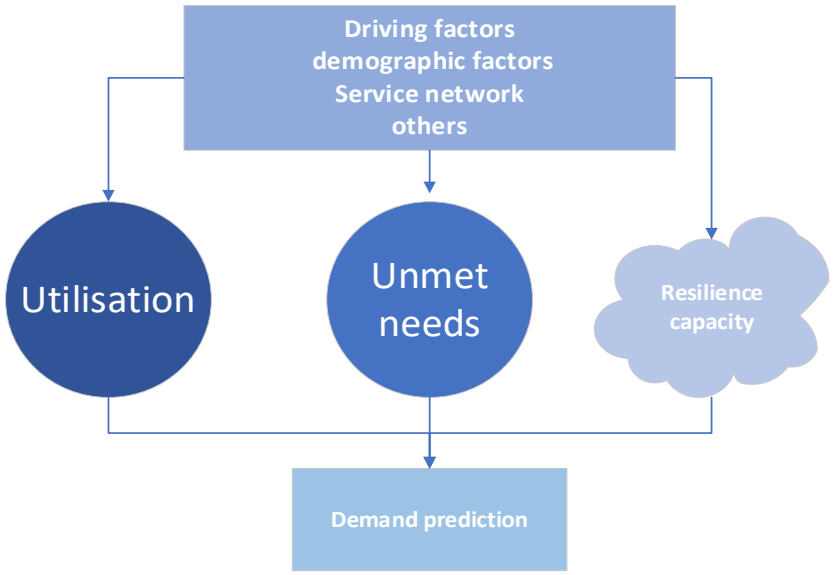
Methodology

Conceptual model and processes

The conceptual model of the projection of critical care demand includes the following key components (Figure 31):

- most current utilisation will continue into the future
- current unmet needs are to be addressed
- resilience capacity to cope with significant uncertainties (eg. major unexpected events or pandemic)
- the main driving factors including changes in population and critical care services are considered.

Figure 31. Conceptual model

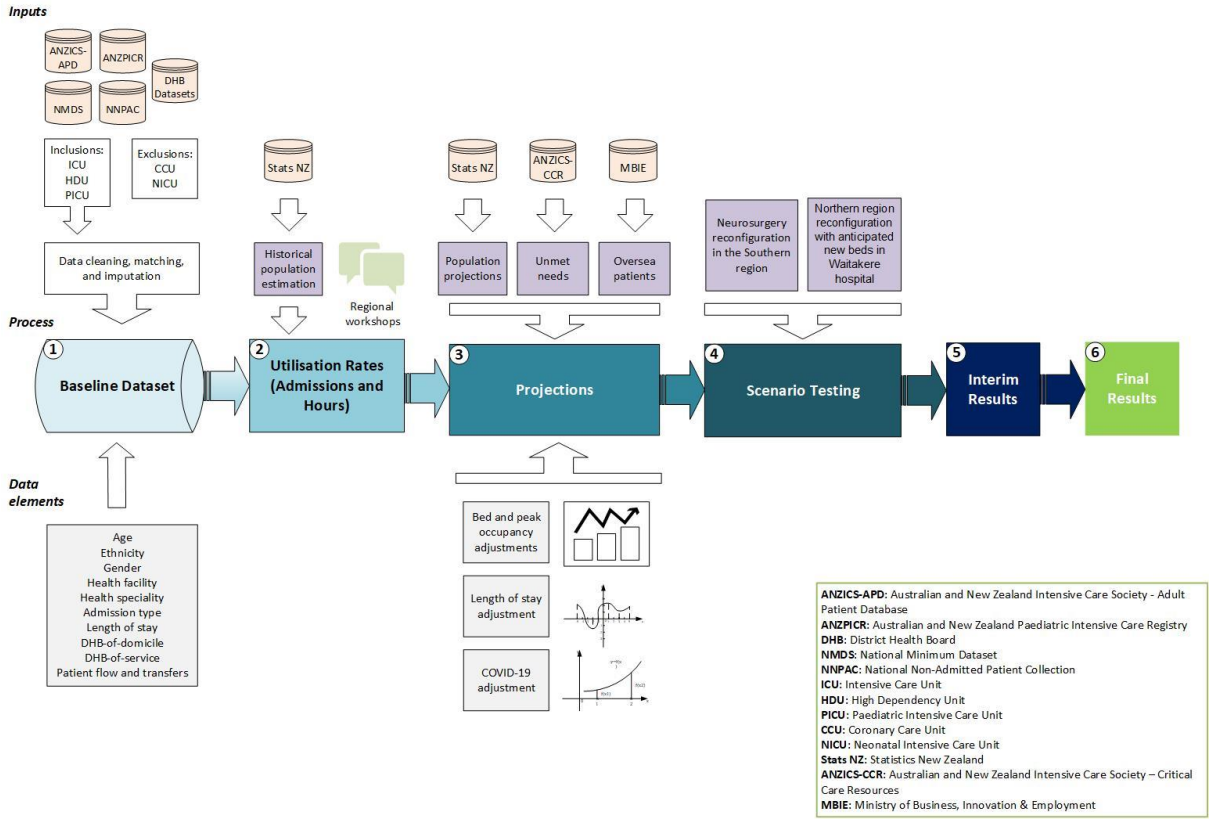


The conceptual model was further developed into several processes, including generating baseline dataset, utilisation analysis, projection, scenario testing and finalising projection results. Figure 32 summaries these processes and key inputs in each process.

Critical care events and critical care hours are key measurements in the analyses. ICU, HDU and PICU were included in this work. Neonatal events cared for in ICU, HDU and PICU were also included. CCU and NICU were excluded.

Critical care events in both public and private hospitals were included to gain a fuller picture of critical care utilisation by the Aotearoa population and overseas visitors.

Figure 32. Processes of projection



Data sources

There were four main data sources used to project the demand of critical care in the future, including:

- The National data collections
  - The National Minimum Dataset for hospital events (NMDS)
  - The National Non-Admitted Patient Collection (NNPAC).
- Australian and New Zealand Critical Care Society (ANZICS) databases
  - The Adult Patient Database (APD)
  - The Paediatric Critical Care Registry (ANZPICR)
  - The Critical Care Resource (CCR) Survey.
- Datasets submitted by DHBs on critical care records upon request
- Population projection from Stats NZ in December 2021.

Data linkages

Data linkage between NMDS and NNPAC

NMDS was the main source of critical care event data. However, the NMDS does not capture events where patients present to an emergency department (ED) in one hospital, then transfer to a critical care facility in another hospital within three hours.

To capture these events NMDS and ED presentations that were extracted from NNPAC were linked by matching NHI, timestamps and ED event end type. As a result, an additional 7,300 transfers from ED to a critical care unit between hospitals were identified between July 2010 and June 2020.

Data linkages between NMDS and ANZICS APD

Three steps were taken to link the NMDS and ANZICS APD.

- Data preparation includes creating a dummy statistical linkage key (dummy-SLK) from NHI database in the Ministry of Health, where a statistical linkage key (SLK-581) was created in ANZICS APD1. The dummy-SLK was then attached to NMDS by linking the NHI number.
- Around 25% of the ANZICS APD records during the period were identified with SLK-581. These records were linked with NMDS by matching dummy SLK with SLK-581. For those unable to be matched, further linking was performed by matching date of birth, name encrypted by the SLK method [1]gender, facility (hospital), hospital admission date and discharge date.
- The rest of ANZICS APD (without SLK-581, around 75% of all ANZICS APD records) were linked with NMDS by a fuzzy matching process, using variables of age, gender, facility, critical care starting date and ending date, hospital admission date and hospital discharge date.

In total, around 86% of all APD records were linked to the NMDS (98.6% for the records with SLK-581 and 81.3% for the records without SLK-581).

Data linkages between NMDS and ANZPICR

- Since NHI numbers are collected in the ANZPICR dataset, ANZPICR records were linked with NMDS by matching NHIs directly.
- For the records that could not be linked by NHI (about 0.3% of total ANZPICR records), further matching was conducted by using the variables of SLK-581, date of birth, gender, facility, critical care starting date and ending date, hospital admission date and hospital discharged date.

All ANZPICR records were linked to the NMDS.

Data linkages between NMDS and critical care data from DHBs

Some hospitals submitted their critical care records for time periods where those records had not been submitted to the National Data Collection. Critical care hours from these records were added to the NMDS by matching NHI, hospital admission date and hospital discharge date.

Data imputation

For two public hospitals, information related to HDU care was not able to be provided. Critical care admissions and hours for these two facilities was estimated using the following method:

- Calculating ratios of HDU admissions to inpatient admissions in the months when HDU information is available, stratified by health specialty and admission type.
- Calculating means of HDU hours in different strata of health specialty and admission type.
- The ratios and means were applied on inpatient admissions to estimate HDU admissions and hours over years in the different strata.

Levels of critical care facilities

Functional ICU levels for each critical care unit were classified according to guidelines from the College of Critical Care Medicine of Australia and New Zealand[2]. The level of each critical care unit was reported in ANZICS CCR (Critical Care Resources) surveys. The following table shows the level of critical care in 2018/19 or the latest year when the level was reported in the CCR survey.

Table 10. Levels of critical care unit

Critical care unit		
Level III	**Level II**	**Level I**
Auckland City Hospital CV ICU	Hawkes Bay Hospital ICU	Hutt Hospital ICU
Auckland City Hospital DCCM	Nelson Hospital ICU	Wairarapa Hospital HDU
Starship Children Hospital PICU	North Shore Hospital ICU	Wairau Hospital ICU
Christchurch Hospital ICU	Palmerston North Hospital ICU	Grey Base Hospital HDU (2016/2017)
Dunedin Hospital ICU	Rotorua Hospital ICU	Whakatane Hospital ICU (2015/2016)
Waikato Hospital ICU	Southland Hospital ICU	
Middlemore Hospital ICU	Taranaki Hospital ICU (2013/2014)	
Wellington Hospital ICU	Tauranga Hospital ICU	
	Timaru Hospital ICU	
	Whangarei Hospital ICU	
	Whanganui Hospital ICU (2016/2017)	

Paediatric critical care patients

In this work, paediatric critical care refers to the patients who received critical care and are:

- Aged under 15 years old, or
- Aged between 15 and 18 years old, and were cared for by specialist paediatric health specialties, including:
    - Specialist paediatric cardiology
    - Specialist paediatric neurology
    - Specialist paediatric surgery
    - Specialist paediatric haematology.

Patient flow and patient transfer

Patient flow and patient transfer were analysed as follows:

- Patient movement between where critical care patient lived (defined by DHB of domicile) and where the patient received critical care (roughly defined by DHB of service).
- Sources of patients (DHB of domicile) of each critical care facility or the collection of facilities in a DHB region, (eg, the number of critical care events admitted to Auckland City Hospital from patients living in Waitemata or Counties Manukau DHBs, or the number critical care events admitted to the hospitals in the Northern DHB Region from patients living in Te Manawa Taki Region).

- Transfers of critical care patients between hospitals, including:
    - transfers from ED presentations and general inpatient care to a critical care unit in a different hospital
    - transfers from a critical care unit to critical care unit in a different hospital.
- Transfers within the same hospital (eg. from general inpatient ward to ICU unit were not counted in this project)
- The transfers were determined by facility coded in NMDS and the results of data linkage between NMDS and NNPAC as described in the section of data linkage between NMDS and NNPAC.

Estimate of unmet need

The results of ANZICS CCR surveys between 2014/15 and 2018/19 were used to estimate unmet need of critical care. In the surveys, critical care units reported:

- elective surgery cases that were cancelled due to inadequate ICU resources
- acute patients referred to the ICU refused due to inadequate ICU resources.

The ANZICS surveys may not be reported appropriately by some critical care units in Aotearoa. Some critical care units have reported no cancellations of elective services or refused acute admissions over the period, which indicates that unmet need has been underreported. The ANZICS data shows considerable variations in reporting between hospital critical care units. In addition, the data is not stratified by age, ethnicity or presenting condition. While the ANZICS data has significant limitations, it may still be the best available data source that can be used to quantify the unmet need of critical care in Aotearoa at present.

For the purposes of the national service plan, we have calculated the percentage of elective surgery cancellations and refused admissions as the total critical care admissions by each unit in Aotearoa between 2014/15 and 2018/19. The lowest average percentage was at 0% and the highest percentage was at 11.7% in a level III critical care unit.

We have assumed that 11.7% is a reasonable figure as it may account for the underreporting issue and is relatively close to the true figure of unmet need which cannot be uncovered in a short-term timeframe. The highest percentage of 11.7% was used to estimate unmet need by applying this figure to all units for both elective and acute critical care admissions.

Estimate of overseas patients

Overseas patients were roughly identified by using patient's domicile code and purchaser code in NMDS.

Overseas visitor numbers to Aotearoa reported by Tatauranga Aotearoa – Stats NZ from 2010 to 2019[3,4] and calculated annual increase percentages were used to project overseas visitors in the years of 2025, 2030 and 2035.

Rates of critical care events and hours per 100,000 visitors over the years were calculated. The average rates of critical care events and hours for the 10 years were then used to project the events and hours in over 3 years, 2025/26, 2030/31 and 2035/36, by applying the average rates to the projected overseas visitors for the 3 years.

The projected events and hours were then proportionately distributed to each critical care unit according to the proportion of utilisation from overseas patients in each unit between 2010/11 and 2019/20.

Bed occupancy and critical care hours

To convert critical care hours to beds, an occupancy rate and critical care hours utilisation rate were assessed.

For the critical care units that participated in ANZICS data collection, daily bed occupancy at 7am and at 7pm were computed by using the datasets of ANZICS APD, ANZPICR and ANZICS CCR. Occupancy rates were calculated by bed occupancy dividing by available bed in the unit. Daily critical care hours were calculated by adding all care hours provided for all patients including patients who were admitted and discharged on the same day.

For example, a critical care unit had 10 resourced beds, with 10 patients at 7am and 9 patients at 7pm, provided 210 critical care hours for all patients in the unit in a given day. The occupancy rates were calculated as 100% (10/10) at 7am and 90% (9/10) at 7pm for the day. The care hour utilisation rate was calculated at 87.5% [210 hours / (10 beds x 24 hours)] for the day.

Relationship between the utilisation rate and the occupancy rates were quantified by regression analysis at different critical care levels (I, II and III). They are strongly associated with statistical significance ($P<0.0001$, $R^2>0.96$). The relationship was used to convert critical care hours to bed numbers in projection.

Some critical care level III units have an average daily occupancy rate higher than 75% which can have negative impact on the outcomes of the patients [5]. Critical care hours per bed in these units were adjusted to equivalent hours when the occupancy rate was 75%.

As a result, some extra beds were estimated for these units. For the units with average occupancy rate lower than 75%, no adjustment was made.

Peak occupancy adjustment

Average occupancy rates at 7am (which was usually higher than the rate at 7pm) were calculated for each day of the year (eg. day 1, day 2…day 365, day 366) for each unit, based on the historical data. The highest daily occupancy rate (eg. 100%) was compared with average daily occupancy rates (eg. 73%) using a factor that was calculated as (100%/73%) -1 = 37%.

This factor is then compared with the occupancy rate used in the estimated bed numbers for adjustment up to a maximum of 100%. For example, if an occupancy rate in calculating bed numbers of a unit is 60%, then no adjustment will be made since 37% + 60%= 97% which is smaller than 100%. If an occupancy rate in calculating bed numbers is 75%, then a 12% of adjustment on bed numbers will be added to the unit, since 37% + 75%=112% which is 12% higher than 100%.

Average length of stay (ALOS) adjustment

At a national level, the average length of stay (ALOS) in critical care was relatively stable over the years and no statistically significant trend was found. However, ALOS appears to be increasing in a few units that are mostly located in the tertiary hospitals. In contrast, ALOS appears to be decreasing in a few units in the non-tertiary hospitals.

Total critical care hours were adjusted to take the increasing trends of ALOS in the units into account. Adjustment was not performed for the units with decreasing ALOS since the related decrease in bed number (converted from the changes in critical care hours) is usually less than one in the small units.

Estimate beds for resilience capacity

The estimate on critical care beds for resilience capacity was based on the current COVID-19 pandemic. Results of a recent modelling conducted by Te Punaha Matatini (TPM) [6] and the critical care experience in Australia during the current outbreak were used for the estimation.

The TPM modelling produces results for a 12-month period following the start of an outbreak caused by Delta variant in Aotearoa, with scenarios that combine factors of:

- vaccine effectiveness
- vaccine coverage levels (over 5 or 12 years old in the population)

- baseline public health measures
- performance of the test-trace-isolate-quarantine (TTIQ) system.

Considering available information[7-12] in relation to these factors at this stage, we selected the results in the following scenarios:

- vaccine effectiveness between the 'central' and 'higher' in the modelling [6]
- 85% to 90% of vaccine coverage in the population over 5 years old
- baseline public health measures in place
- limited performance of TTIQ system (rather than full performance TTIQ) since a high infection number was predicted.

The average of the peak beds occupied from the modelling under the above selected scenarios were calculated and converted to peak critical care occupied using a percentage (19%) of hospitalised COVID-19 patients treated in ICU in Australia[13].

The estimated critical care bed numbers were then distributed to different regions and units.

Scenario tests

Some scenario tests were performed to estimate the change in bed numbers if the scenario occurred. These scenarios were selected according to the discussion with stakeholders during the consultation processes, including:

- Neurosurgery reconfiguration in the South Island.
- Northern Region reconfiguration with anticipated new beds in Waitākere hospital.

Results

Final dataset for utilisation analysis

The final baseline data contains 206,300 critical care events associated with 13.2 million critical care hours between July 2010 and June 2020. The process of linking data between NMDS and ANZICS datasets contributed an additional 35,000 critical care events that were associated with around 1.9 million critical care hours.

About 98.6% of the events and 99.5% of the hours were from critical care units in the public hospitals. Overseas patients counted for around 1.8% of the total events and 2.5% of the total hours during the 10-year period.

All 10-years of data were included for utilisation analysis.

Baseline dataset for projection

To capture the most up-to-date information (eg. patient flow and patient transfer patterns for projection), data from the latest financial years were used as the baseline for projection.

The first COVID-19 case was reported in Aotearoa on 28 Feb 2020. Similar to the decline in ED presentations and inpatient admissions in the following months [14], a 20% decline in both critical care events and hours was found in Aotearoa between March and June of 2020 when compared with the same period in 2019. Due to this finding the data from 2019/20 was excluded from the projection.

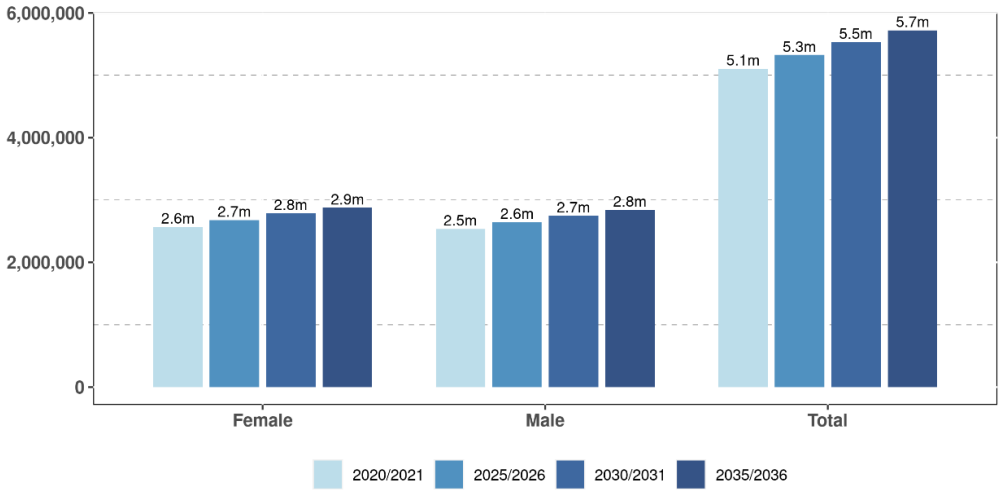
The baseline dataset for the projection includes data from 2014/15 to 2018/19.

General trends on population changes

National population projection

The national population is projected to exceed 5.7 million in 2035/36, an increase of 12% over the next 15 years or 0.2 million people every five years (Figure 33).

Figure 33. National population projection

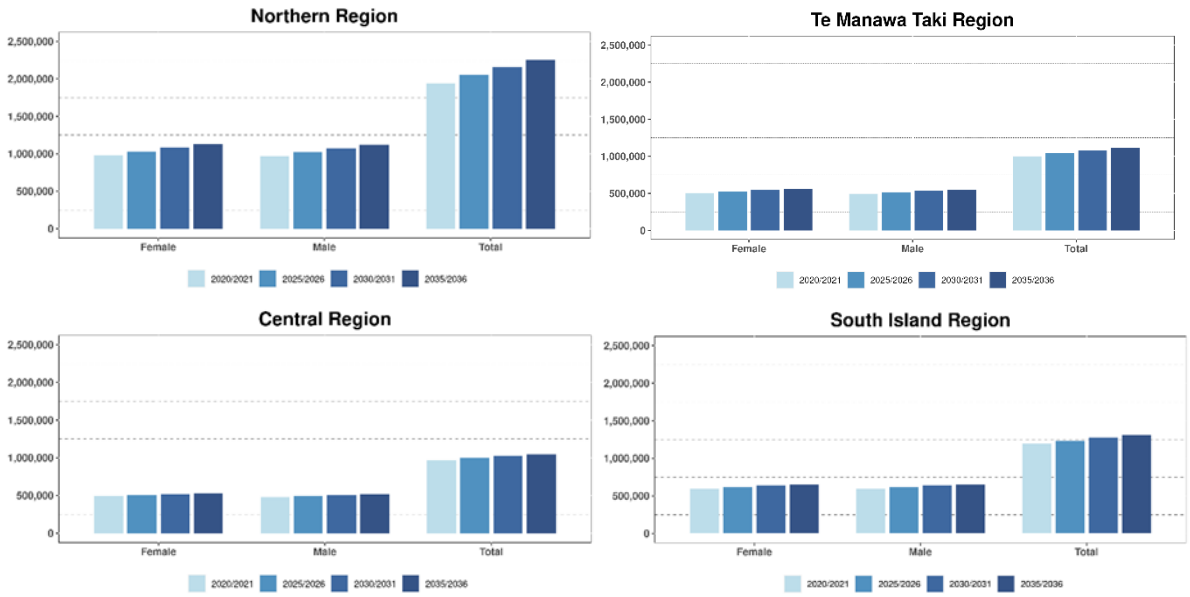


Population projection by regions

The population is expected to grow in all 4 regions (Northern, Te Manawa Taki, Central and Te Waipounamu). Compared with 2020/21, the Northern Region population is predicted to increase by 16% and exceed 2.25 million in 2035/36 — the fastest growing region. Te Manawa Taki, Central and Te Waipounamu regions are projected to have

respective populations of 1.11 million, 1.04 million and 1.3 million in 2035/36 representing an increment of 11.2%, 7.6% and 9.6%, respectively (Figure 34).

Figure 34. Population projection by region

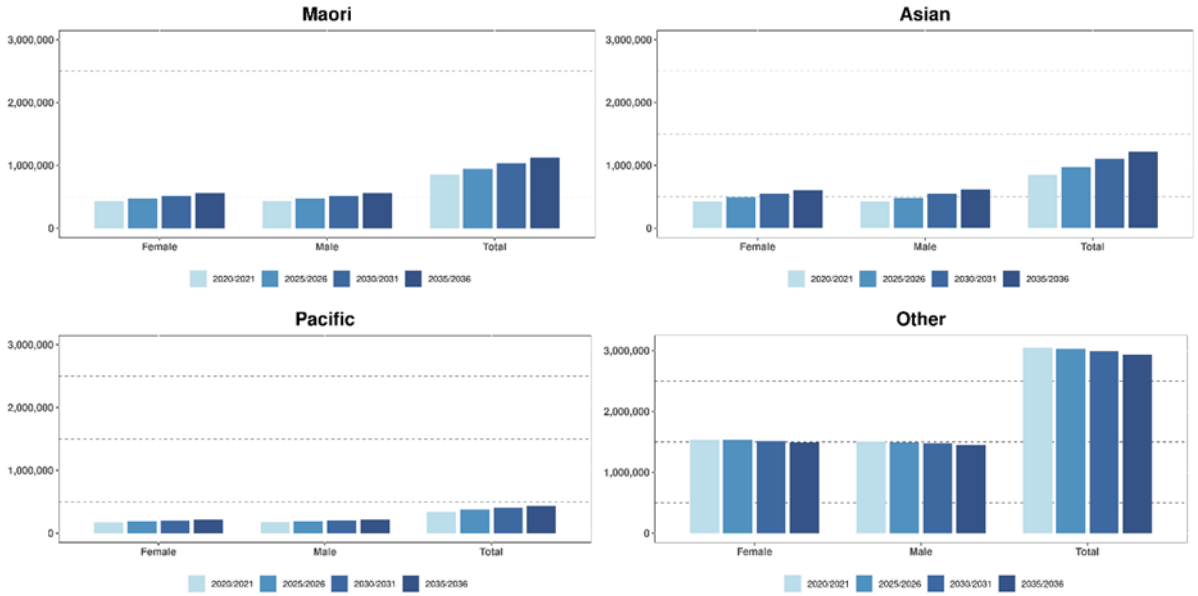


In the Te Waipounamu Region, the population in the West Coast is projected to increase in the next 5 years and then decrease in the following 10 years, eventually decreasing from 32,395 in 2020/21 to 31,935 in 2035/36.

Population projection by ethnicity

Compared with 2020/21, the population is projected to increase in Māori, Asian and Pacific people and decrease in other ethnic groups in the next 15 years. The Asian population is expected to increase by 43% to become the fastest growing population, and the population of Māori and Pacific will increase by 31% and 25% respectively. Other ethnic groups will drop from 3 million in 2020/21 to 2.9 million in 2035/36 — 4% decrease (Figure 35).

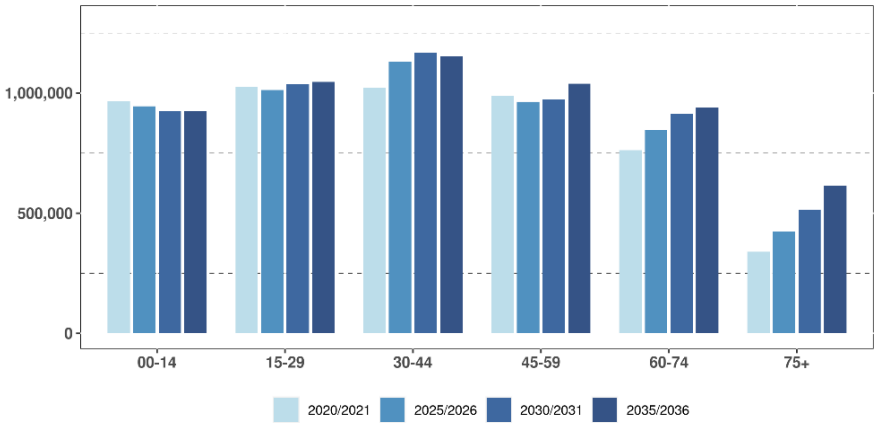
Figure 35. Population projection by ethnicity



Population projection by age group

It is projected that the population in the 0-14 age group will continue to decrease while the population in 60-75 and 75+ age groups will continue to rise in the next 15 years. In addition, the population of the 75+ age group is projected to exceed 0.5 million by 2030/31 with the fastest growing rate in Aotearoa (Figure 36).

Figure 36. Population projection by age group



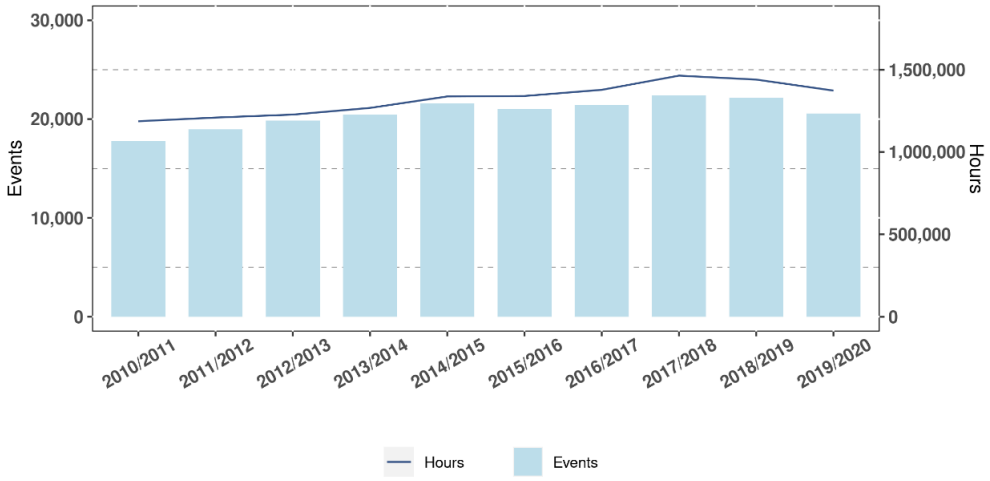
Critical care utilisation in Aotearoa

General trends and characteristics

There is an increase in critical care events and hours since 2010/11. The exception is 2019/20, which is lower due to the impact of COVID-19. Critical care events increased

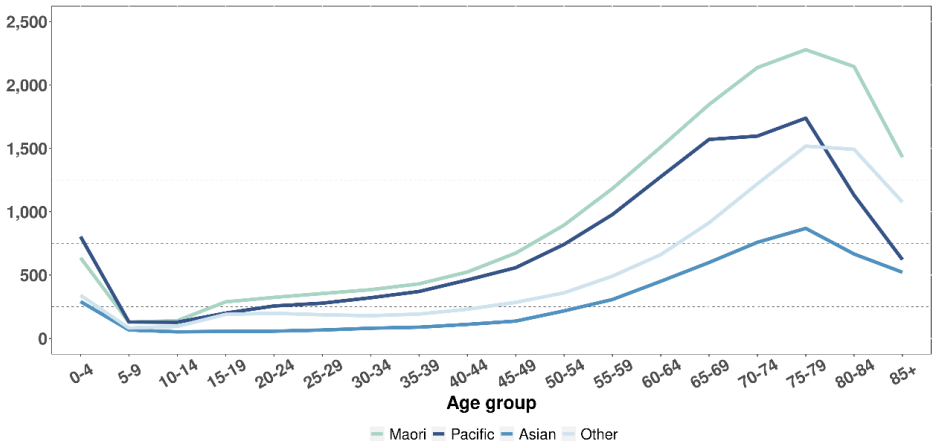
from 18,000 to 22,000 and critical care hours increased from 1.2 million hours to 1.4 million (Figure 37).

Figure 37. Critical care utilisation in Aotearoa, 2010/11 to 2019/20



Critical care utilisation is strongly related to the patient's age and ethnicity. The figure below (Figure 38) shows age-specific rates per 100,000 population in different ethnic groups. Māori and Pacific people tend to have higher rates than Asian and Other ethnic groups.

Figure 38. Critical care events per 100,000 population



At the national level, age-specific rates of critical care events and hours over the last 5 years ended June 30 are relatively stable (Figures 39 and 40).

Figure 39. Critical care events per 100,000 population, 2014/15 to 2018/19

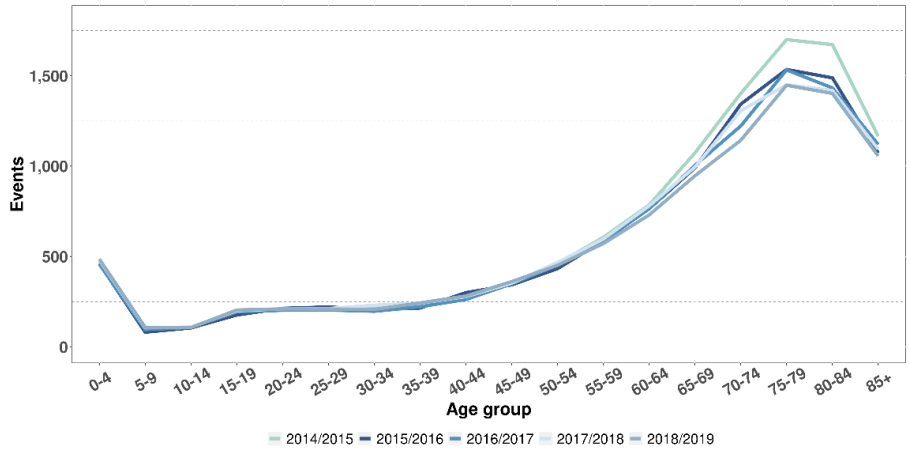
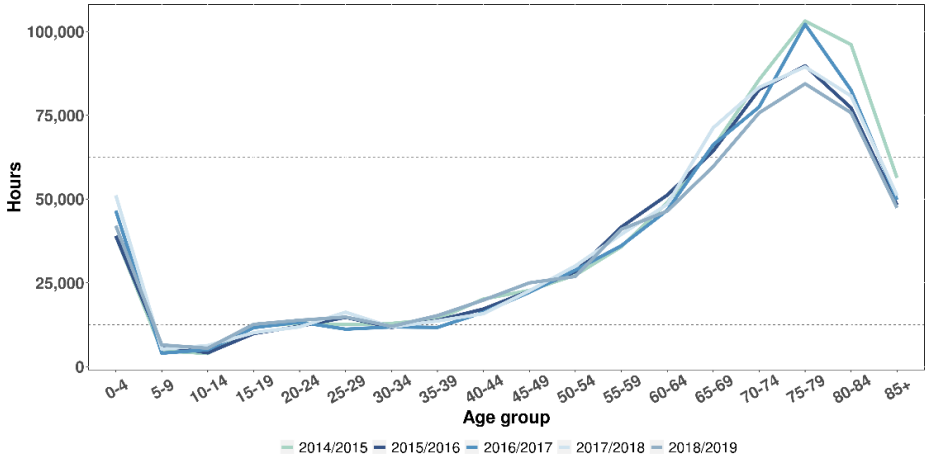


Figure 40. Critical care hours per 100,000 population, 2014/15 to 2018/19



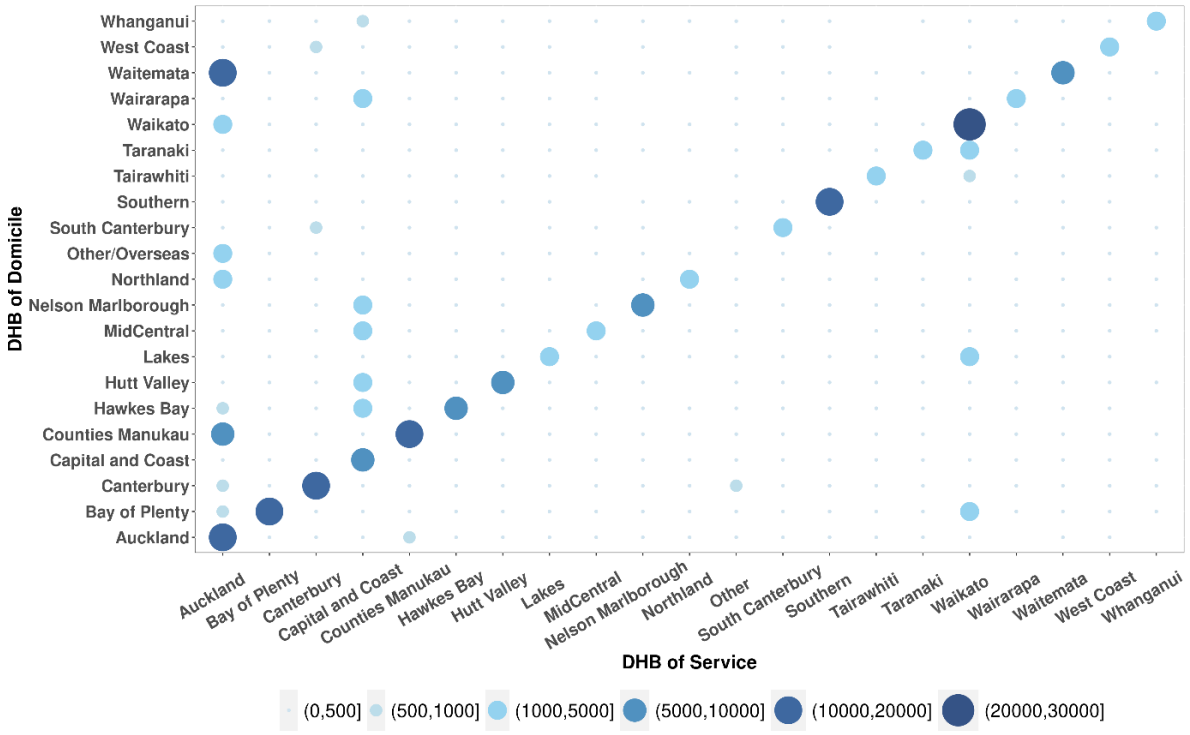
Utilisation by DHB of domicile and DHB of service

Many highly specialised services (eg. cardiothoracic surgery) are only provided at tertiary hospitals in Aotearoa. Patients with related conditions are transferred to, and treated in, the units of these hospitals. Such service provision has a large impact on critical care utilisation and the pattern of patient transfers at both regional and national levels.

Figure 41 shows the critical care events by DHB of domicile (where a patient lived) and DHB of services (generally where a patient received care). As can be seen, most critical care patients were treated in the hospitals within their local DHBs where the hospital has critical care units. However, due to some specialised services only available at tertiary hospitals, some patients were transferred to either the nearest tertiary hospitals or Auckland. For example, 49% of critical care patients from the Northland Region were treated in Whangārei Hospital, while 47% were treated in Auckland City Hospital; and 41%

of the patients in Whanganui were treated locally, while 35% were treated in Wellington. The events estimated for HDU units were included in the figure.

Figure 41. Critical care utilisation in Aotearoa (events)



Utilisation by principal diagnosis

For patients in all age groups, the most common principal diagnoses for all critical care events were:

- cardiovascular diseases (27%)
- injuries (16%)
- diseases of respiratory system (12%)
- diseases of digestive system (9%)
- neoplasms (8%).

For paediatric patients, the most common principal diagnoses were:

- diseases of respiratory system (36%)
- perinatal and congenital conditions (21%)
- injuries (12%)
- diseases of nervous system (7%)

- infectious diseases (5%).

Utilisation by health specialty

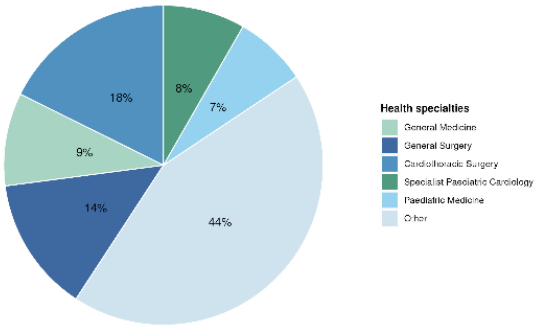
At the national level, critical care hours were mostly used to care for patients under the following health specialties:

- general medicine (21%)
- general surgery (18%)
- cardiothoracic surgery (13%)
- neurosurgery (6%)
- orthopaedic surgery (6%).

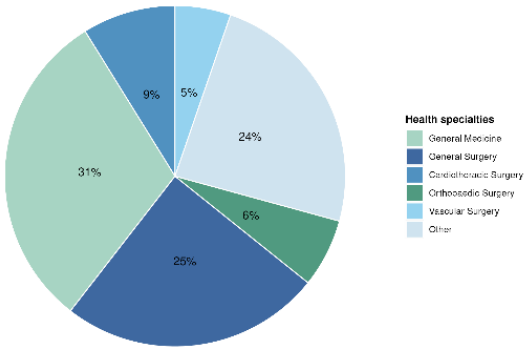
However, the utilisation of critical care hours was slightly different between DHB regions due to the range of services provided. The top five health specialties by critical care hours used in each DHB region are illustrated in Figure 42.

Figure 42. Critical care hours by top 5 health specialties (2010/11 to 2019/20)

Northern Region

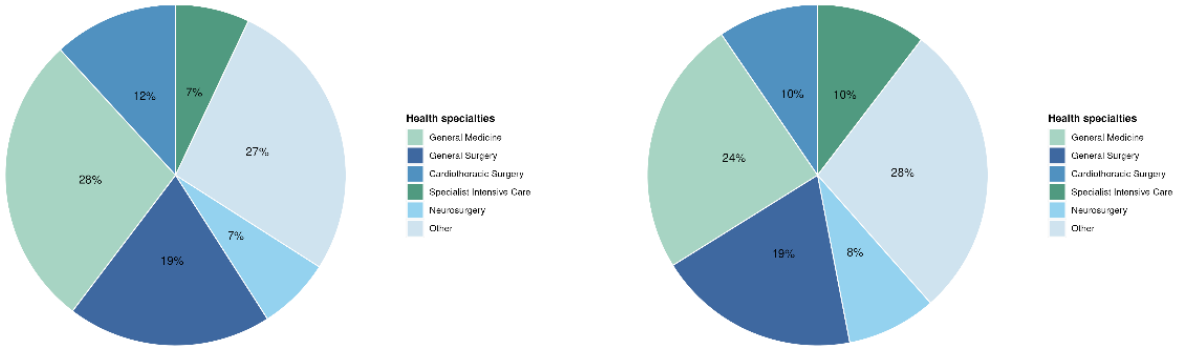


Te Manawa Taki Region



Central Region

Te Waipounamu Region



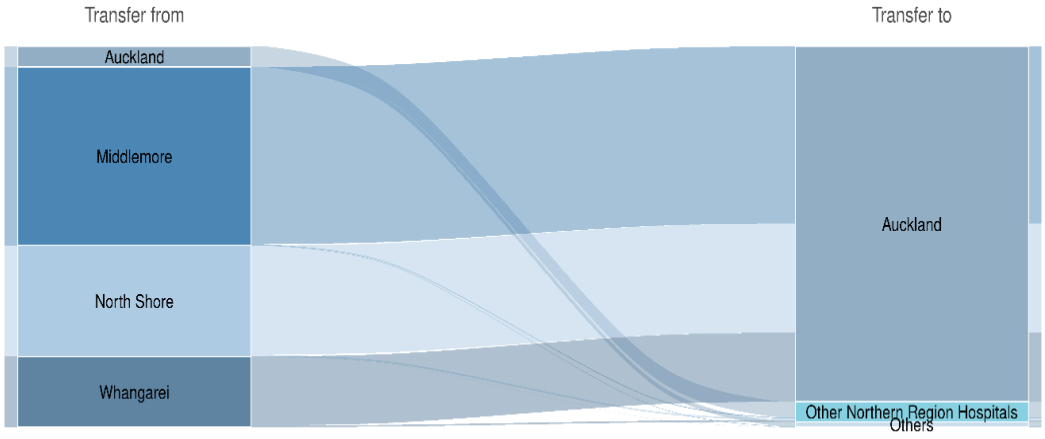
Utilisation and patient flow in different regions

Northern Region

Most patients from the Northern Region requiring intensive care were transferred to Auckland City Hospital. (Figure 43).

- Over 99% of transfers from Middlemore Hospital were to Auckland City Hospital
- 98%of transfers from North Shore Hospital and Whangārei Hospital were to Auckland City Hospital
- 77% from Auckland City Hospital were to other Northern Region hospitals.

Figure 43. Patients transferred from a Northern Region hospital (ICU or non-ICU patient) for ICU care in another hospital (2010/11 to 2019/20)

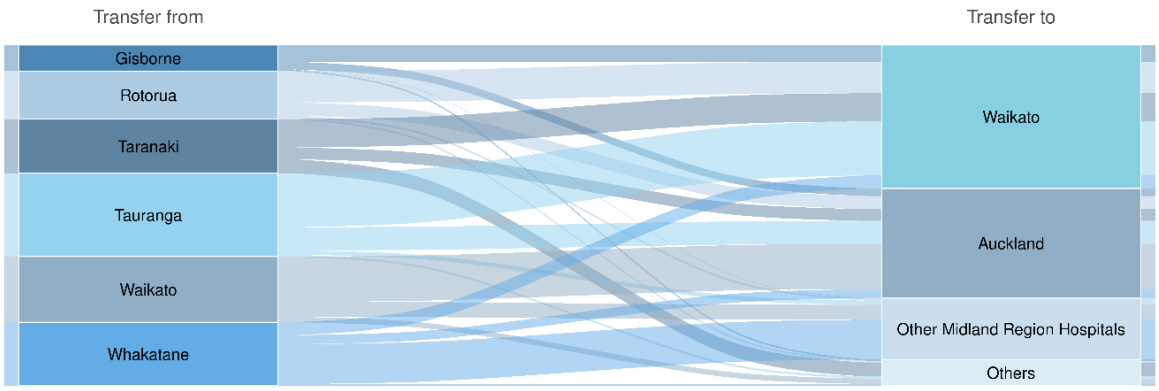


Te Manawa Taki Region

Within the Te Manawa Taki Region, most of the patients were transferred to the nearest tertiary hospitals to receive intensive care, except Whakatāne Hospital which transferred most of its patients to Tauranga Hospital for intensive care. (Figure 44).

- 69% of transfers from Waikato Hospital were to Auckland City Hospital
- 64% of transfers from Gisborne Hospital were to Waikato Hospital, 29% to Auckland City Hospital
- 65% of transfers from Rotorua Hospital were to Waikato Hospital, 27% to Auckland City Hospital
- 65% of transfers from Tauranga Hospital were to Waikato Hospital, 28% to Auckland City Hospital
- 52% of transfers from Taranaki Hospital were to Waikato Hospital, 23% to Wellington City Hospital
- 63% of transfers from Whakatane Hospital were to Tauranga Hospital, 20% to Waikato Hospital.

Figure 44. Patients transferred from a Te Manawa Taki Region hospital (ICU or non-ICU patient) for ICU care in another hospital (2010/11 to 2019/20)



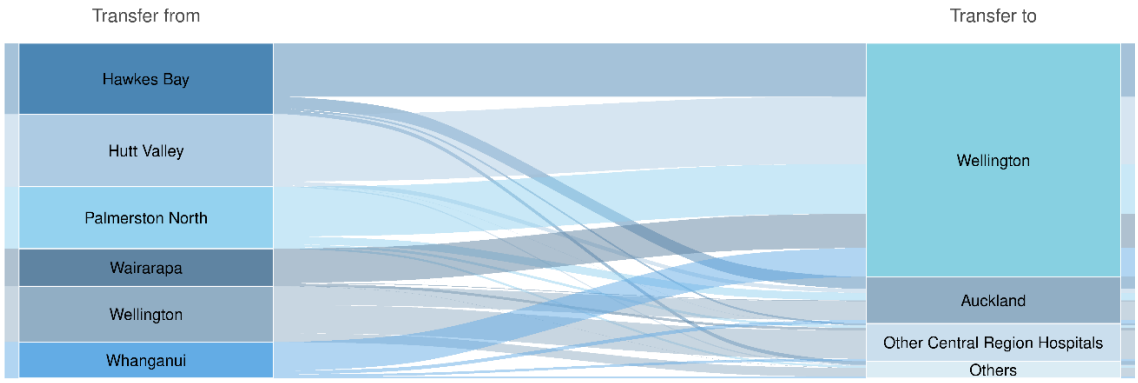
Central Region

In the Central Region, most of the patients who received intensive care were transferred within the region. (Figure 45).

- 93% of transfers from Hutt Hospital were to Wellington Hospital, 5% to Auckland,
- 91% of transfers from Wairarapa Hospital were to Wellington Hospital, 6% to Hutt

- 80% of transfers from Palmerston North Hospital and Whanganui Hospital were to Wellington Hospital
- 75% of transfers from Hawke's Bay Hospital were to Wellington Hospital, 17% to Auckland City Hospital
- 51% of transfers from Wellington Hospital were to other hospitals in the Central Region, 34% to Auckland City Hospital.

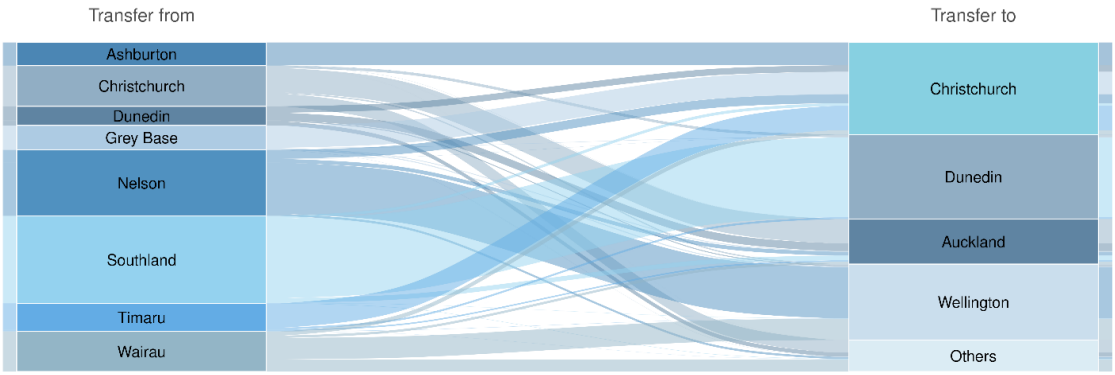
Figure 45. Patients transferred from a Central Region hospital (ICU or non-ICU patient) for ICU care in another hospital (2010/11 to 2019/20)



Te Waipounamu Region

- Most of the transfers in the Te Waipounamu Region were to the region's tertiary hospitals for intensive care (Figure 46), except some patients from Nelson and Wairau were transferred to Wellington Hospital to receive intensive care. Over 90% of transfers from Ashburton and Greymouth were to Christchurch.
- 87% of transfers from Timaru Hospital were to Christchurch Hospital, 7% to Dunedin Hospital
- 91% of transfers from Southland Hospital were to Dunedin Hospital
- 77% of transfers from Nelson Hospital were to Wellington Hospital, 13% to Christchurch
- 53% of transfers from Wairau Hospital were to Wellington Hospital, 29% to Nelson
- 60% of transfers from Christchurch Hospital and 40% from Dunedin Hospital were to Auckland City Hospital, and 20% from Christchurch Hospital were to St George's Hospital (private).

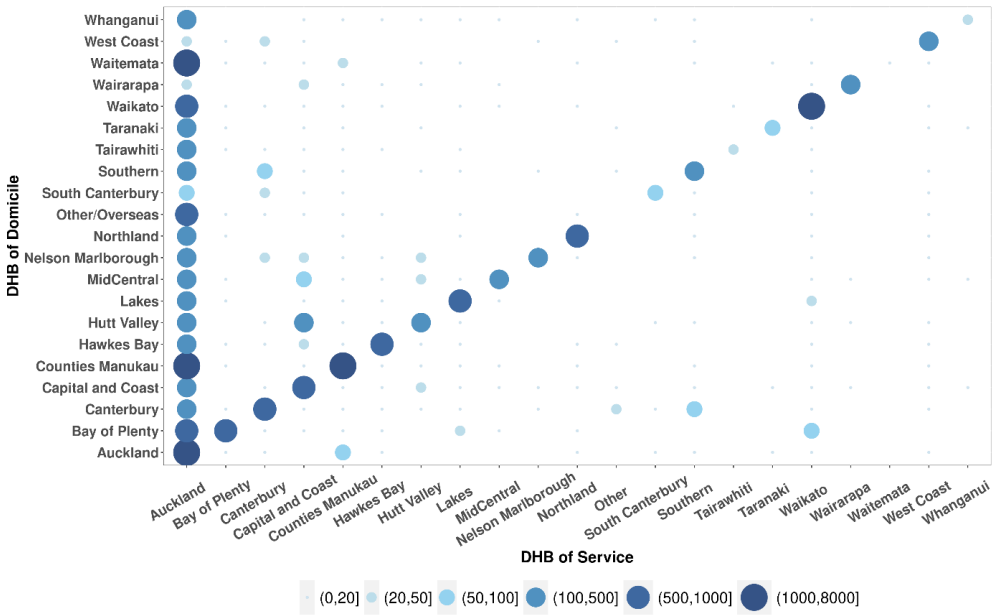
Figure 46. Patients transferred from a Southern Region hospital (ICU or non-ICU patient) for ICU care in another hospital (2010/11 to 2019/20)



Utilisation and paediatric patients

Figure 47 shows paediatric critical care events by patients' DHB of domicile and DHB of service. The Starship Children's Hospital has the only paediatric critical care unit (PICU) in the country and provides highly specialised services (eg. specialist paediatric cardiology, neurology, and haematology). As a result, we have seen a large proportion of paediatric patients treated in Auckland (as DHB of service) from different DHBs of domicile.

Figure 47. Paediatric critical care utilisation in Aotearoa (events)

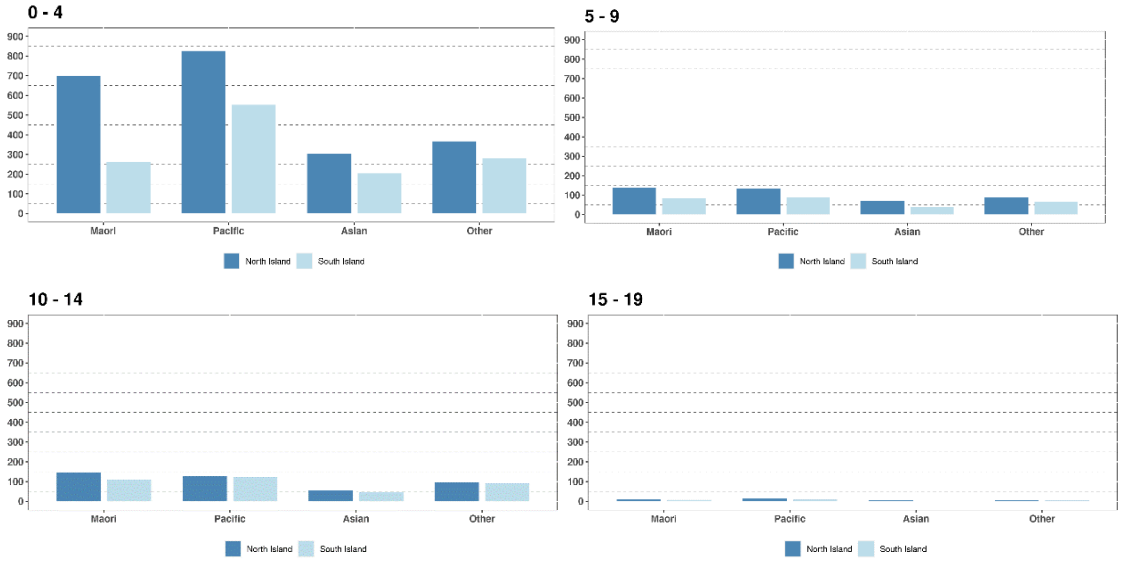


Over the 0-year included in this analysis total paediatric critical care hours totalled approximately 1.65 million hours. Around 72% of the total hours occurred in the Starship Children's Hospital.

The critical care utilisation rates in paediatric patients were significantly different between the North Island and South Island (Figure 48). In all ethnic groups, the utilisation rates under 15 years old in South Island were much lower than the rate in North Island (P<0.001). However, there is no statistically significant difference in the patients aged 15-19 years (P=0.59).

Among the three DHB regions in the North Island, Central DHB Region had a lower utilisation rate than the Northern and Te Manawa Taki regions especially in the paediatric patients aged under 5 years old.

Figure 48. Paediatric critical care utilisation between North Island and South Island, by ethnic group (events per 100,000 population)



Bed occupancy and critical care hours

Bed occupancy rate and utilisation rate

Table 11 shows average daily bed occupancy rates at 7am and 7pm, and utilisation rates of critical care hours for the units that participated in ANZICS data collection between 2010/11 and 2018/19.

Table 11. Occupancy and utilisation rates by critical care levels

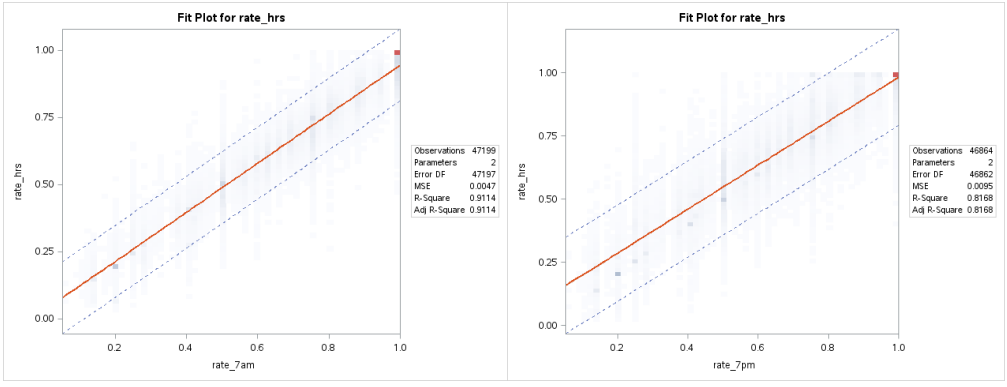
Critical care level		Mean (95% CI)	25% percentile	50% percentile	75% percentile
Level I	occupancy rate at 7am	60.0%(59.0% - 61.0%)	40.0%	57.1%	75.0%
	occupancy rate at 7pm	51.9%(51.0% - 52.8%)	28.6%	50.0%	75.0%
	utilisation rate (hours)	54.0% (53.1% - 54.9%)	32.4%	52.7%	75.0%
Level II	occupancy rate at 7am	63.8%(63.4% - 64.1%)	40.0%	63.6%	90.0%
	occupancy rate at 7pm	59.1%(58.7% - 59.5%)	40.0%	60.0%	80.0%
	utilisation rate (hours)	60.0%(59.6% - 60.4%)	39.1%	61.5%	83.2%
Level III non-PICU	occupancy rate at 7am	71.9%(71.6% - 72.1%)	58.8%	73.3%	87.5%
	occupancy rate at 7pm	65.6%(65.4% - 665.9%)	50.0%	66.7%	80.0%
	utilisation rate (hours)	68.6%(68.5% - 69.0%)	56.3%	69.1%	81.5%
Level III PICU	occupancy rate at 7am	83.4%(82.8% - 83.9%)	73.3%	86.7%	100.0%
	occupancy rate at 7pm	79.0%(78.4% - 79.5%)	66.7%	80.0%	93.3%
	utilisation rate (hours)	81.0%(80.5% - 81.5%)	70.5%	82.9%	94.4%
All	**occupancy rate at 7am**	**68.5% (68.3% - 68.7%)**	**50.0%**	**72.2%**	**88.2%**
	occupancy rate at 7pm	**63.0%(62.8% - 63.2%)**	**47.1%**	**63.2%**	**80.0%**
	utilisation rate (hours)	**64.9% (64.7% - 65.1%)**	**49.7%**	**67.2%**	**83.2%**

In general, occupancy and utilisation rates in level III units including PICU were higher than the rates of units in level I and level II.

Association between bed occupancy and critical care hours

Occupancy rates at both 7am and 7pm were strong predictors (Figure 49) of critical care hours utilisation (P<0.0001).

Figure 49. Association between occupancy rate and utilisation rate



The daily occupancy rates at 7pm were also significantly associated with occupancy rate at 7am of the day (regression model, F=66,771, P<0.001).

The following relationships were developed from the regression models. Daily occupancy rates at both 7am and 7pm were used to predict utilisation rate of critical care hours, specified by the levels of critical care:

- ***utilisation rate = 0.599 x occupancy rate at 7am + 0.415 x occupancy rate at 7pm – 0.0174 (PICU)***
- ***utilisation rate = 0.603 x occupancy rate at 7am + 0.387 x occupancy rate at 7pm + 0.0004[Level 3 critical care (apart from PICU)]***
- ***utilisation rate = 0.600 x occupancy rate at 7am + 0.401 x occupancy rate at 7pm - 0.0018 (Level 2 critical care)***
- ***utilisation rate = 0.606 x occupancy rate at 7am + 0.373 x occupancy rate at 7pm + 0.0049 (Level 1 critical care)***

These relationships are used to estimate annual hours of a critical care bed associated when an occupancy rate is given.

Table 12 lists the annual critical care hours that are associated per critical care bed at different critical care levels from the historical data.

Table 12. Annual critical care hours per bed by critical care levels

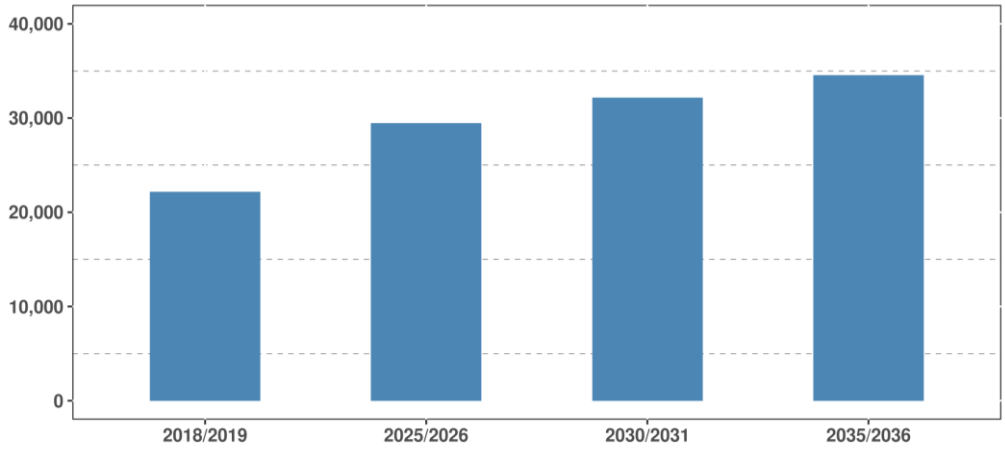
Critical care level	Occupancy rate at 7am	Annual hours per bed
Level III (PICU)	83%	7,065
Level III (non-PICU)	72%	6,035
Level II	64%	5,424
Level I	60%	4,917

Projections

Projection based on critical care events

Compared with critical care events in 2018/19, the events were estimated to increase by 33%, 45% and 56% in 2025/26, 2030/31, and 2035/36 respectively (Figure 50). These numbers did not consider resilience capacity which was reported in the projection based on beds for resilience capacity section.

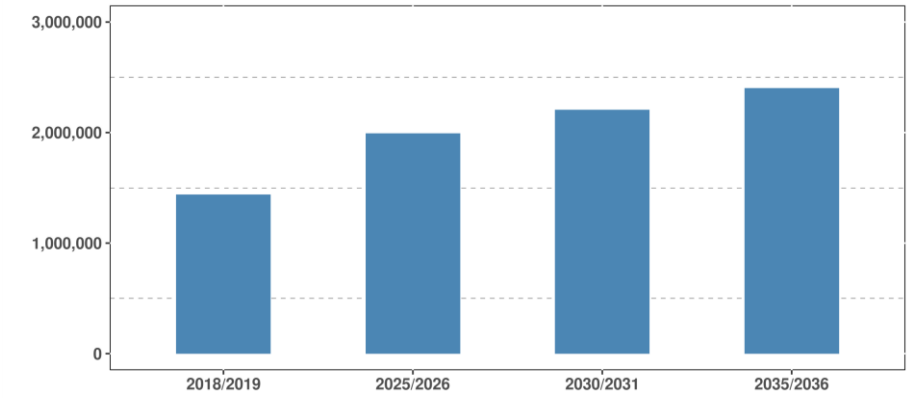
Figure 50. Projected increase in critical care events



Projection based on critical care hours

Compared with critical care hours in 2018/19, the hours were estimated to increase by 38%, 53% and 67% in 2025/26, 2030/31, and 2035/36, respectively (Figure 51). These figures included the adjustment based on the increase in average length of stay (ALOS) in some critical care units.

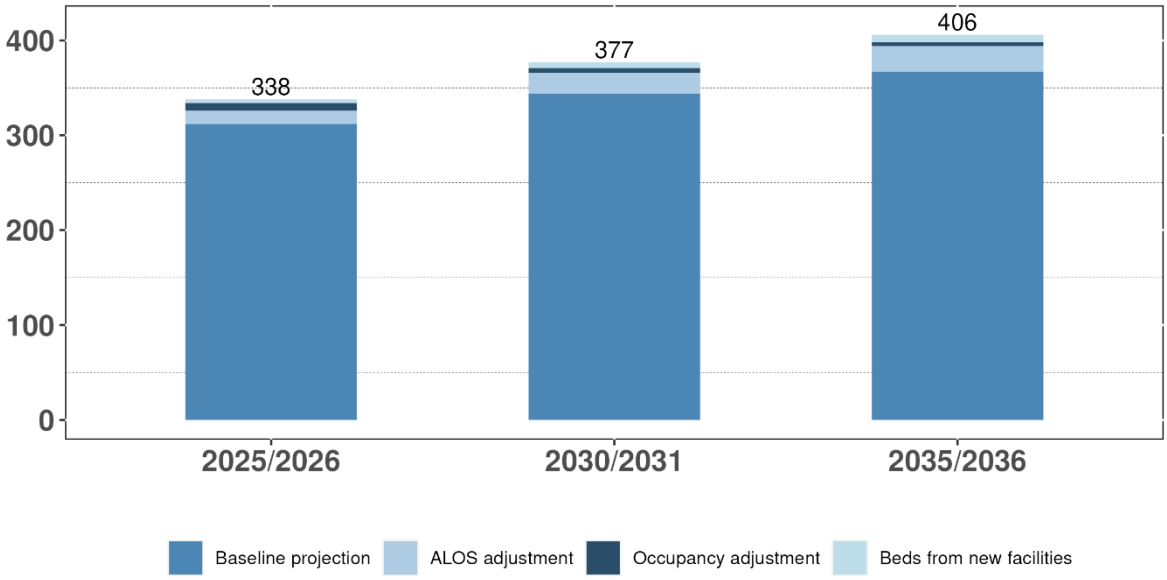
Figure 51. Projected increase in critical care hours



Projection based on beds without consideration of resilience capacity

The following chart (Figure 52) shows the general projection of critical care beds without the system resilience factor.

Figure 52. Projection of critical care beds



Projected bed numbers in each critical care units of the public hospitals are shown in Table 13. Bed numbers for the open HDU unit in Waikato hospital were not included in the projection due to data quality issues.

Table 13. Critical care beds estimated from the general projection without the system resilience factor

Critical care unit	2025/2026	2030/2031	2035/2036
Auckland City Hospital CVICU	31	35	38
Auckland City Hospital DCCM	27	29	31
Starship	28	30	33
Sub total (Auckland City Hospital)	**86**	**94**	**102**
Christchurch Hospital	34	39	43
Dunedin Hospital	19	23	25
Gisborne Hospital	5	6	6
Grey Base Hospital	3	3	3
Hawkes Bay Hospital	14	16	17
Hutt Hospital	7	7	8
Middlemore Hospital	24	27	29
Nelson Hospital	8	8	9
NorthShore Hospital	13	14	15
Palmerston North Hospital	7	7	8
Rotorua Hospital	8	9	9
Southland Hospital	8	9	10
Taranaki Base Hospital	6	6	6
Tauranga Hospital	15	17	18
Timaru Hospital	6	7	7
Waikato Hospital	20	22	24
Wairarapa Hospital	4	5	5
Wairau Hospital	1	1	1
Wellington Hospital	28	31	33
Whakatane Hospital	6	7	7
Whanganui Hospital	4	4	4
Whangarei Hospital	8	9	9
Waitakere Hospital*	4	6	8
Public Hospital Total beds	**338**	**377**	**406**
Population projected	**5,325,125**	**5,533,060**	**5,718,835**
Beds per 100,000 population (Public hospitals only)	**6.35**	**6.81**	**7.10**
*** Beds in new facilities**			

Projection based on beds for resilience capacity

In addition to the projection of the general situation, 138 additional critical care beds were estimated for the improvement of resilience capacity based on the peak beds occupied by COVID-19 patients in the scenarios selected. These beds were distributed to individual

hospitals based on the current critical care utilisation patterns in which patient flow and transfers were considered (Table 14).

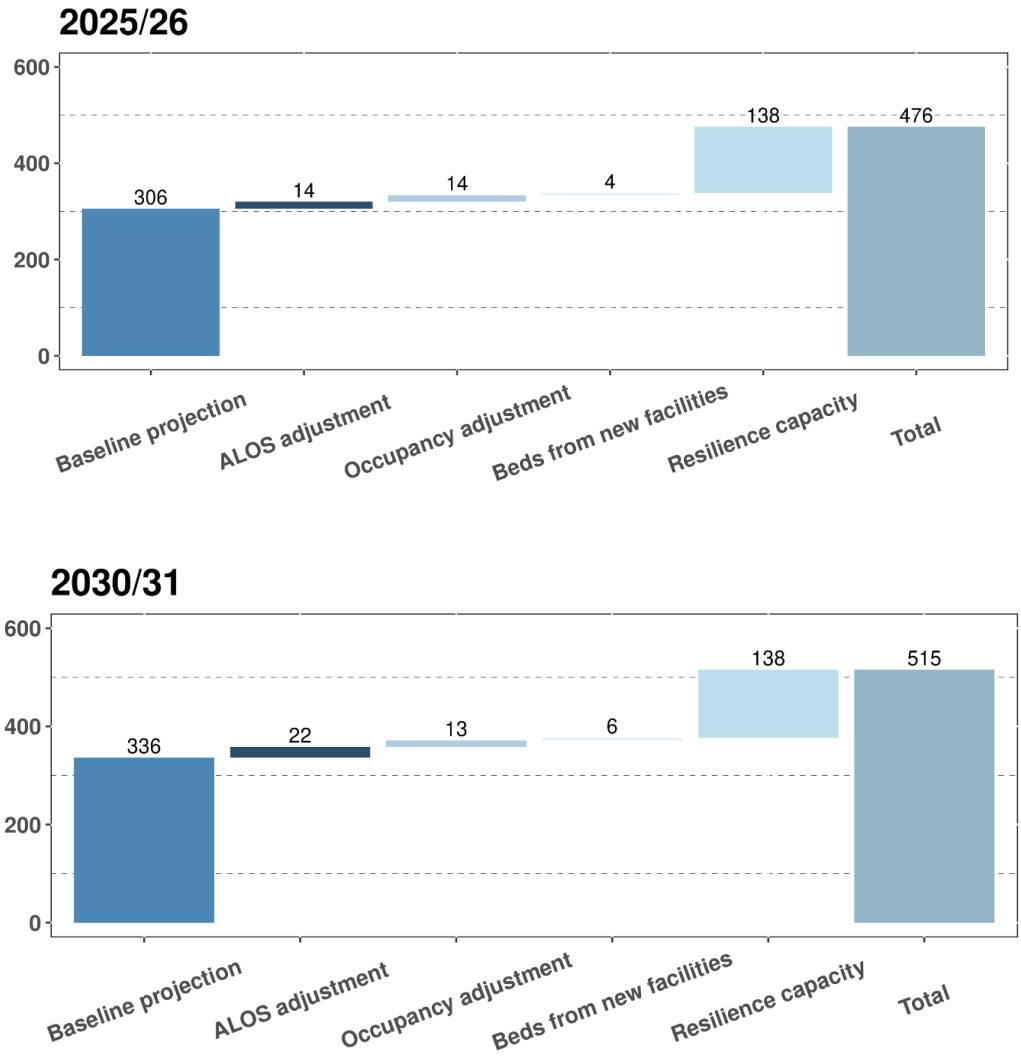
Table 14. Distribution of critical care beds estimated for resilience capacity

Hospital	Beds estimated for resilience capacity
Auckland City Hospital	**36**
Christchurch Hospital	**13**
Dunedin Hospital	**8**
Gisborne Hospital	**2**
Greymouth Base Hospital	**1**
Hawke's Bay Hospital	**6**
Hutt Hospital	**3**
Middlemore Hospital	**10**
Nelson Hospital	**3**
North Shore Hospital	**6**
Palmerston North Hospital	**3**
Rotorua Hospital	**3**
Southland Hospital	**3**
Taranaki Base Hospital	**3**
Tauranga Hospital	**7**
Timaru Hospital	**3**
Waikato Hospital	**9**
Wairau Hospital	**1**
Wellington Hospital	**13**
Whanganui Hospital	**2**
Whangārei Hospital	**3**

Total	**138**

Figure 53 shows the sources of total critical care beds estimated for selected years. The assumption is that the critical care beds estimated for resilience capacity can be added to those modelled using the baseline projection, occupancy adjustments and ALOS capacity adjustments.

Figure 53. Sources of critical care beds estimated



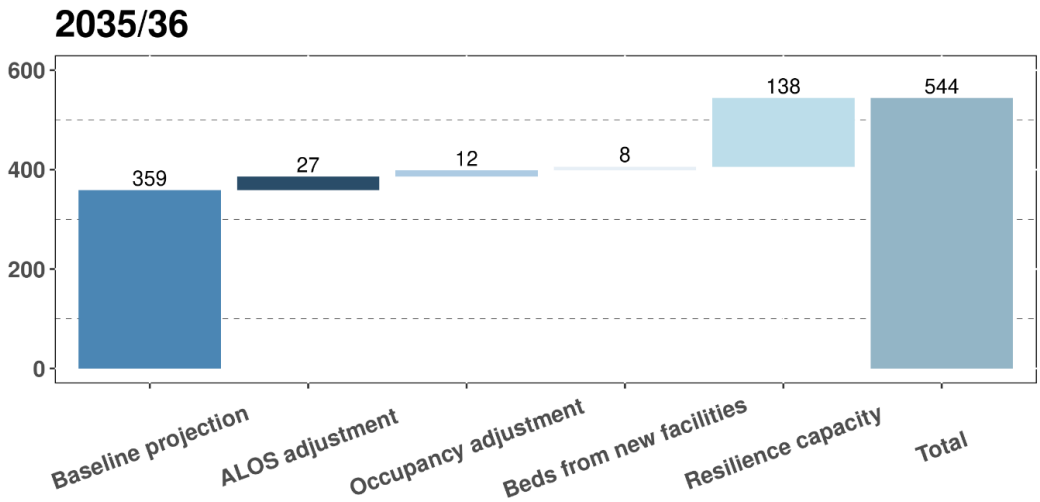


Table 15 shows the beds projected for each critical care unit including the resilience capacity. Critical care units, including Wairarapa, Wairau and Greymouth hospitals, have beds that are used for a mixture of purposes (eg. caring for CCU and other types of patients). The projected beds for ICU and HDU can be smaller than the total beds in the units at present.

Table 15. Total critical care beds estimated, including the projection for the system resilience factor

Critical care unit	2025/2026	2030/2031	2035/2036
Auckland City Hospital	*122*	*130*	*138*
Christchurch Hospital	*47*	*52*	*56*
Dunedin Hospital	*27*	*31*	*33*
Gisborne Hospital	*7*	*8*	*8*
Grey Base Hospital	*4*	*4*	*4*
Hawkes Bay Hospital	*20*	*22*	*23*
Hutt Hospital	*10*	*10*	*11*
Middlemore Hospital	*34*	*37*	*39*
Nelson Hospital	*11*	*11*	*12*
NorthShore Hospital	*19*	*20*	*21*
Palmerston North Hospital	*10*	*10*	*11*
Rotorua Hospital	*11*	*12*	*12*
Southland Hospital	*11*	*12*	*13*
Taranaki Base Hospital	*9*	*9*	*9*
Tauranga Hospital	*22*	*24*	*25*
Timaru Hospital	*9*	*10*	*10*
Waikato Hospital	*29*	*31*	*33*
Wairarapa Hospital	*4*	*5*	*5*
Wairau Hospital	*2*	*2*	*2*
Wellington Hospital	*41*	*44*	*46*
Whakatane Hospital	*6*	*7*	*7*
Whanganui Hospital	*6*	*6*	*6*
Whangarei Hospital	*11*	*12*	*12*
Waitakere Hospital*	*4*	*6*	*8*
Public Hospital Total beds	476	515	544
Private Hosptial beds	*29*	*29*	*29*
Total beds in NZ	505	544	573
Population projected	5,325,125	5,533,060	5,718,835
Beds per 100,000 population (Public hospitals only)	8.94	9.31	9.51
Beds per 100,000 population (All)	9.48	9.83	10.02
* Beds in new facilities			

Beds per 100,000 population were also calculated, with and without beds in the private hospitals. The 29 beds in the private hospitals were identified from ANZICS CCR surveys.

Projection based on beds in relation to different scenarios

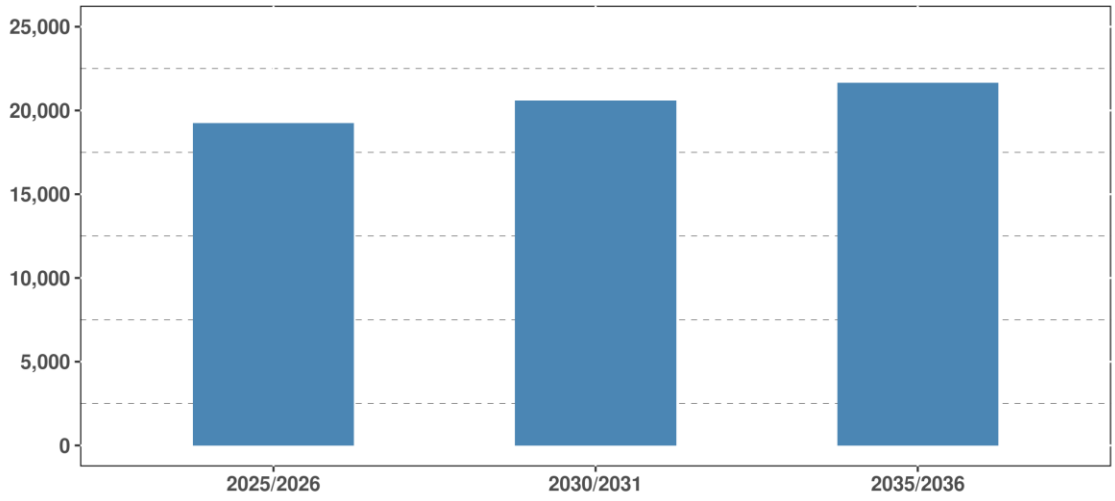
The following scenarios were developed in discussion with the sector. The scenarios are driven by changes to feeder services, rather than changes to the critical care service

framework, and have not been incorporated into the forecasting. They are presented as opportunities for critical care bed reconfiguration in the future.

Neurosurgery reconfiguration in South Island

Figure 54 shows the projection of critical care hours for neurosurgery patients cared for in Dunedin Hospital. The hours are equivalent to around four beds in 2025/26, 2030/31 and 2035/36.

Figure 54. Critical care hours projected for neurosurgery reconfiguration



Northern Region reconfiguration with anticipated new beds in Waitākere Hospital

There is current infrastructure project including the establishment of an 8-bed critical care unit in Waitākere hospital by 2035/36 for the patients cared for by the health specialties that the hospital is planning to provide. Historically, around 50% of these patients were cared for by Auckland City Hospital; the remaining 50% were cared for by North Shore Hospital. Other types of patients from the catchment areas for Waitākere Hospital (eg. cardiothoracic surgery, neurosurgery and specialist paediatric care patients) will still be cared for by other hospitals, predominantly Auckland City Hospital.

Discussion

Data sources and outcome measures

Using different datasets for the analytical work in this project has considerable advantages.

NMDS from the National Data Collection has sufficient variables in relation to patient demographics (eg. domicile, ethnicity, gender, and age), clinical (eg. diagnosis and surgical procedure) and service (eg. admission type, transfer between hospitals) information. These information elements make it possible to measure critical care utilisation as population-based rates at the national and local level, and at other sub-population groups, for example, the ethnicity-specific utilisation rate. Consequently, impacts of population changes on critical care in the future can be estimated.

However, the NMDS has considerable limitations in the lack of information on admission and discharge timestamps of critical care. This lack of the information makes it impossible to investigate bed occupancy at any level. In addition, the use of HDU is excluded from the National Data Collection in principle [15]. This exclusion would lead to incompleteness of critical care utilisation if only NMDS was used in the analysis.

In contrast, datasets from ANZICS have the advantages of including HDU patients and detailed timestamps of a patient admitted to, and discharged from, a critical care unit.

We used data linkage to gain a fuller picture of critical care utilisation and insight into patient flow, transfers, and the operation of critical care Aotearoa. The data linkage enables us to better use relevant information from different sources.

There are still some limitations in the final combined dataset. For example, some small critical care units have not participated in ANZICS data collection. Therefore, the quality of their critical care data reported in the NMDS cannot be assessed by comparing with ANZICS data. Particularly, the use of HDU and CCU beds are often mixed in some small units. We have managed the data issue by requesting individual district data and using data imputation and data cleansing. A focus on improving and maintaining data collections for critical care will improve future modelling.

In addition, around 14% of adult critical care events from ANZICS remain unlinked with NMDS due to the lack of SLK-581 in earlier years. We are unable to merge information about these events into NMDS.

Outcome measures are also a driver for bed capacity planning. ANZICS provides a suite of valuable quality outcome metrics for people who received care within a critical care unit. However, there are no quality metrics for Māori and there is limited data on the quality of care for people who do not make it into a critical care unit. Apart from the indirect adjustment made for the units with an occupancy rate higher than 75%, we have been unable to apply critical care quality measure in the projection. Improving the suite of quality metrics can help to shape scenarios to model in the future.

Utilisation of paediatric critical care

Many factors in relation to critical care utilisation in children need to be considered, including characteristics of paediatric hospitalisations (eg. condition and severity of illness), patient geographical location, availability of specialist paediatric services and patient outcomes.

Additional clinical analysis and consultation with the sector on these factors would inform the decision making on paediatric critical care in the future.

Estimate of unmet need

To estimate unmet need of critical care remains one of the most significant challenges of this work. To quantify the volume of unmet need, some approaches have been explored including text searching in the clinical notes on each hospital event, analysing critical care patients with a long ED stay, and cardiac surgery due to ICU cancellation in tertiary hospitals. However, the result derived appears to be under-estimated and incomplete.

The results from ANZICS CCR surveys appear to be a better approach compared with other methods explored. The results are based on data self-reported by almost all units in Aotearoa and theoretically cover both acute and elective critical care admissions. We are aware of the issue of under-reporting from some units especially on acute admissions which are most of admissions to critical care in Aotearoa.

The 11.7% of total critical admissions as unmet need was based on the highest percentage among all units between 2014/15 and 2018/19. It is just a best guess from the current available information. The figure can be reassessed in the future when data with better quality is available and the unmet need in critical care is well defined.

Estimate beds for resilience capacity

The estimate of beds required for resilience capacity was based on the peak beds occupied by COVID-19 patients in the hospitals. It was assumed that peak critical care beds occupied would be associated with the peak beds occupied estimated by Steyn [6]. A figure of 19% based on Australian experience was used to estimate the peak critical care beds. The equivalent percentage from the outbreak in Auckland at the time of the research was lower and not used since the total related hospitalisations in Aotearoa were small at that stage.

The modelling conducted by Steyn (6) was relatively comprehensive and took many scenarios into consideration. However, like other modelling conducted for COVID-19 pandemic [16,17] it may also contain considerable uncertainties. For input parameters, the modelling may be subject to uncertainties such as:

- uncertainties about vaccination effectiveness, especially the lack of information on the effectiveness for children aged between 5 and 11
- the differences in vaccination and contact rates between ethnic groups in the Aotearoa population have not been considered; comorbidities in relation to hospitalisation and critical care appears to be more prevalent in some ethnic groups than others
- uncertainties about the outbreak of other variants of COVID-19 and related clinical presentations.

Scenario uncertainty could also change during the COVID-19 pandemic, for example, changes in policy interventions and clinical management of COVID-19 patients [18-20].

An average of the results from some likely scenarios was used in our estimation. Such an approach may be able to reduce some but not all the impact of the uncertainties.

The 138 additional critical care beds estimated for resilience capacity are much higher than the historical records of critical care admissions from natural disasters occurring in Aotearoa, such as critical care admissions due to the Christchurch earthquake in 2011 and the White Island eruption in 2019. These projected beds are assumed to be sufficient to cover the need for critical care in a pandemic, epidemic or acute events in the near future.

As described in the conceptual model and processes section of this work, the estimation for resilience represents the amount of critical care capacity that would be required to deal with uncertainties in the future. It is a critical component of increasing the resilience of critical care in the health system.

Implications of the projection

There are two main parts of the projection in this work.

The first part is for critical care beds in the general forecast which has considered demographic changes, unmet needs and other factors in relation to clinical presentations and service management (eg. length of stay and occupancy). The beds projected for each time point (eg. 2025/26) represent the number of fully functioned beds that are needed to address the underlaying factors used in the modelling.

The second part is for critical care beds that would be needed for resilience capacity. The beds were estimated from the modelling on the COVID-19 pandemic and therefore can be

associated with the response to the current pandemic. However, the beds for resilience capacity can be different from the beds prepared for quick response to the pandemic. The rapid response required the critical care beds to be available within a short timeframe. Other potential resources need to be considered, including beds made available by reducing elective admissions. Such an approach appears to be practical in the short term but may not be suitable for developing resilience capacity in the long term.

Theoretically, adding these two parts together may lead to an over-estimation since related peak occupancies from both estimates may or may not occur at the same time. The modelling on COVID-19 does not produce an exact peak time. It is also difficult to predict a peak time for other major events in the future. Therefore, a liberal scenario was used by adding these two parts of the predictions together.

This combination of general scenario and resilience capacity bed requirements for public hospitals is equivalent to 8.9 per 100,000 population in 2025/26 and 9.5 beds per 100,000 population in 2035/36. Regardless of the potential differences of clinical practice and population between countries, the projected figures are close to the rates of Italy (8.6 beds per 100,000) in 2020 and Australia (9.4 beds per 100,000) in 2019. However, the projected figures are still lower than the average of selected OECD countries (12 beds per 100,000) in 2020[22]. Therefore, over-estimation may not be a concern.

The implementation of the Health and Disability Review will also impact on long-term capacity modelling. The critical care forecast provides an example of the long-term planning that is likely to be undertaken in the new health system. However, we acknowledge that we focused on the infrastructure forecasting. We expect that the new health system will take a system approach to health and service needs modelling and will identify service, infrastructure, workforce, and technology needs. We also expect that the new health system will identify health delivery networks and will affect demand for critical care across sites that were not in the scope of this project.

Critical care for Māori patients

Higher age-specific rates of critical care utilisation in Māori population were found in the utilisation analysis. The high rates were assumed to continue and were applied to the growing Māori population in the projection for the future. As a result, the critical care units that treated more Māori patients historically gained relatively more projected beds. This may improve access to critical care services for Māori. However, the lack of ethnicity-specific data on unmet need limits our ability to model the Māori access issue further.

Critical care beds in private hospitals

One of our reference figures is the 29 critical care beds in private hospitals in Aotearoa which were included in the calculation of the beds per 100,000 population. In contrast to other countries, the proportion of critical care beds in the private hospitals appears to be quite small. In addition, the critical care facilities in private hospitals are predominately used for certain type of patients and are not usually operated 24 hours per day.

Recommendations

Data collection and data quality

For better or more accurate projection or monitoring of critical care, the completeness and quality of the National Data Collection for critical care will need to be improved.

- HDU events should be included in the National Data Collection.
- Timestamps of critical care admission and discharge should be included in the NMDS, if possible, so that occupancy can be analysed and monitored.
- ICU, HDU, CCU and other type of patient events should be clearly differentiated and reported for the units with a mix of uses of critical beds.
- Critical care patients admitted to private hospitals should be reported.

In addition, all critical care units in Aotearoa need to be encouraged and supported to participate in the data collection processes and quality benchmarking processes managed by ANZICS.

Implementation strategy

Our projection results indicate that there is a significant increase in critical care beds needed in Aotearoa, especially over the next few years when the gaps of unmet need and resilience capacity need to be filled. The increase requires a significant investment in infrastructure and workforce. An implementation strategy may be needed to guide the management of main issues such as funding planning, prioritisation on urgent needs, workforce development and the balance of short-term and long-term considerations. For new building plans, the needs of critical care as projected for the future should be considered.

This work has not included CCU patients. If the current practice of admitting different types of patients (eg. ICU, HDU and CCU) continues in some critical care units, additional modelling for CCU may be needed for service planning in these units.

Resilience of critical care

The beds estimated for resilience capacity represent the need for dealing with uncertainties in the future. It can serve both short-term and long-term purposes and is an essential component for ongoing resilience planning for critical care.

References

1. Australian and New Zealand Intensive Care Society. 2020. *APD Data Dictionary*, ANZICS CORE - ADULT PATIENT DATABASE, Version 5.10.

2. College of Intensive Care Medicine of Australia and New Zealand. 2011. *Minimum Standards for Intensive Care Units*.

3. Statistics New Zealand. 2021. *Stats NZ Infoshare---Tourism*. URL: http://infoshare.stats.govt.nz/Default.aspx (accessed August 2021).

4. MBIE. 2019. *New Zealand Tourism Forecasts 2019-2025*. URL: https://www.mbie.govt.nz/immigration-and-tourism/tourism-research-and-data/international-tourism-forecasts/ (accessed August 2021).

5. Tierney LT, Conroy KM. 2014. *Optimal Occupancy in the ICU: A Literature Review. Aust Crit Care*. DOI: 10.1016/j.aucc.2013.11.003.

6. Steyn N, Plank M, Hendy S. 2021. *Modelling to support a future COVID-19 strategy for Aotearoa New Zealand*: Te Punaha Matatini.

7. Weldon R. 2021. *Pfizer, BioNTech formally ask FDA to authorize vaccine in kids aged 5 to 11 years*. URL: https://www.healio.com/news/primary-care/20211007/pfizer-and-biontech-formally-ask-fda-to-authorize-vaccine-in-kids-aged-5-to-11 (accessed October 2021).

8. Gallagher G. 2020. *COVID-19 vaccine more than 90% effective, Pfizer says: Healio*. URL: https://www.healio.com/news/infectious-disease/20201109/covid19-vaccine-more-than-90-effective-pfizer-says (accessed October 2021).

9. Pfizer. 2021. *Pfizer and BioNTech confirm high efficacy and no serious safety concerns through up to six months following second dose in updated topline analysis of landmark COVID-19 vaccine study*. Pfizer. URL: https://www.pfizer.com/news/press-release/press-release-detail/pfizer-and-biontech-confirm-high-efficacy-and-no-serious (accessed October 2021).

10. Miller J. 2021. *Pfizer Vaccine Effectiveness Diminishes against Infection, not Severe Disease: Healio*. URL: https://www.healio.com/news/primary-care/20211006/pfizer-vaccine-effectiveness-diminishes-against-infection-not-severe-disease?utm_source=selligentandutm_medium=emailandutm_campaign=newsandM_BT=52823063242 (Accessed October 2021).

11. Tartof S, Slezak J, Fischer H, et al. 2021. *Effectiveness of mRNA BNT162b2 COVID-19 Vaccine up to 6 Months in A Large Integrated Health System in the USA: A Retrospective Cohort Study*. Lancet. DOI : https://doi.org/10.1016/S0140-6736(21)02183-8.

12. Olson S, Newhams M, Halasa N ,et al.. 2021. *Effectiveness of Pfizer-BioNTech mRNA Vaccination against COVID-19 Hospitalization among Persons Aged 12–18 Years — United States, June-September 2021*.. Morbidity and Mortality Weekly Report (MMWR). DOI: http://dx.doi.org/10.15585/mmwr.mm7042e1 (accessed, 2021).

13. Department of Health. 2021. *Current COVID-19Cases in Hospitals and Intensive Care Units (ICUs)*. Australian Government. URL: https://www.health.gov.au/resources/current-covid-19-cases-in-hospitals-and-intensive-care-units-icus (accessed November 2021).

14. Zhang Z, Jones P. 2021. *Utilisation of Hospital Services during COVID-19 Pandemic in New Zealand*. International Epidemiological Association's World Congress of Epidemiology. Melborne, Australia.

15. Minstry of Health. 2021. *National Minimum Dataset (Hospital Events)---Data Dictionary*. Wellington:Ministry of Health New Zealand.

16. Leung K, Wu J. 2021.*Quantifying the Uncertainty of CovidSim*. Nature Computational **1**:98-99

17. Gugole F, Coffeng L, Edeling W, et al. 2021. *Uncertainty Quantification andSensitivity Analysis of COVID-19 Exit Strategies in An Individual-based Transmission Mode*l. PLOS Computational Biology. https://journals.plos.org/ploscompbiol/article?id=10.1371/journal.pcbi.1009355.

18. Mahase E. 2021. *Covid-19: Molnupiravir Reduces Risk of Hospital Admission or Death by 50% in Patients At Risk, MSD Reports*. British Medical Journal. https://www.bmj.com/content/375/bmj.n2422.

19. Pharmaceutical Management Agency. 2021. *NZ's Pharmac Negotiates Deal for Molnupiravir to Treat COVID-19*. PharmacoEcon Outcomes News. https://link.springer.com/article/10.1007/s40274-021-08122-0.

20. Deleted

21. Hidalgo-Tenorio C, Garcia-Vallecillos C, Sequera-Arquelladas S, et al. 2021. *Real-world Outcomes of COVID-19 Treatment with Remdesivir in a Spanish Hospital.* Medicine (Baltimore). DOI: 10.1097/MD.0000000000027228.

22. OECD. 2020. *Intensive care beds capacity: OECD.* URL: https://www.oecd.org/coronavirus/en/data-insights/intensive-care-beds-capacity (accessed October 2021).

Appendix 2: Glossary table

ACP	Advance care planning
ALOS	Average length of stay
ANZICS	Australian and New Zealand Intensive Care Society
CICM	College of Intensive Care Medicine of Australia and New Zealand
CPAP	Continuous positive airway pressure
CVICU	Cardiovascular intensive care unit
DCCM	Department of critical care medicine
ECMO	Extracorporeal membrane oxygenation
HAA	High acuity area
HDU	High dependency unit
ICU	Intensive care unit
MET	Medical emergency team
OECD	Organisation for Economic Co-operation and Development
PACU	Post-anaesthesia care unit
PART	Patient at risk team
PICU	Paediatric intensive care unit
Hospital with secondary services	A hospital which receives referrals from the community
Hospital with tertiary services	A hospital which provides a higher level of care and also receives referrals from other (secondary level) hospitals
Hospital with quaternary services	A hospital which provides an extension of tertiary care in reference to advanced levels of medicine which are highly specialised and not widely accessed, and usually only offered in a very limited number of national centres

Appendix 3: Acknowledgment

The development of the Critical Care Infrastructure National Service Plan has been collaborative.

This work, including service model design, statistical analysis and modelling, project management and report writing, was conducted by the Service Planning team, Infrastructure and Investment Group at Te Whatu Ora. The team was comprised of Astuti Balram (Manager), Zhi-ling (Jim) Zhang (Principal Analyst), Dr Dee Alexander (Principal Advisor), Albert Chin (Senior Analyst), David Chen (Analyst) and Jing Wu (Analyst).

A steering group, representing clinical leadership and sector engagement, has participated in the governance process and provided strong support to this work. The steering group included:

Alex Psirides	Co-Clinical Lead of ICU, Wellington Hospital
Seton Henderson	Clinical Director of Intensive Care, Christchurch Hospital
Andrew Stapleton	Director of Intensive Care, Hutt Hospital
	Chair (New Zealand) of the College of Intensive care Medicine National Committee
Andy Simpson	Ex Chief Medical Officer, Manatū Hauora – Ministry of Health
Craig Carr	Critical Care Director, Dunedin Hospital
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