Building a healthy future

The potential scale of investment in Crown-owned health infrastructure over the next 30 years

NZIER report to Te Waihanga, the New Zealand Infrastructure Commission

November 2023

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Key points

New Zealand faces significant infrastructure challenges

New Zealand's infrastructure lays a foundation for the people, places and businesses of Aotearoa New Zealand, to thrive. Health infrastructure is no different: It is a core building block of the system, supporting modern, effective health services and equitable, timely access to health care across the life course, enabling New Zealanders to live long, healthy lives.

The Infrastructure Strategy emphasises the importance of taking a system-wide approach to planning and delivering infrastructure, recognising the opportunities, challenges and interdependencies of infrastructure across all sectors, as well as the need for a longer planning horizon of 30 years, with careful consideration of the trade-offs that will inevitable. Across all sectors, infrastructure challenges, including climate change, population growth, population ageing, and cost pressures, are significant, pointing to much larger pressures than previous levels of funding and delivery have envisaged.

Health reforms offer an opportunity for better infrastructure planning and delivery

The Health System reforms support a system-wide view of the health sector expected to support improved health infrastructure planning and delivery. However, as highlighted by Te Waihanga's Health Infrastructure Review, the reformed health system inherits the deficits left behind after decades of under-investment. It faces the challenge of designing new systems and processes to assess, plan, fund and deliver infrastructure for a modern, fit-for-purpose health system. This is no small task, and infrastructure requirements continue to evolve as the reforms unfold.

For this report, we modelled the cost of continuing with 'business as usual'

This report describes our analysis of the health infrastructure implications of a 'business as usual' scenario for costs, asset management practices and service delivery methods. Rather than quantifying what the system should seek to spend, this report identifies the pressures that the system will face to highlight the importance of effective systems and processes for investment prioritisation.

For this report, we focus on the Crown hospital estate. Additional pressures are expected in other Crown-owned and privately-owned health infrastructure, but the Crown hospital estate represents the largest share and an area where sufficient data is available to inform the modelling of future pressures.

Our methodology makes the best use of the available data…

Our model aligns service demand and the physical space needed to deliver services based on the current dependence on physical infrastructure. We modelled the costs of building and maintaining those spaces over the next 30 years.

Our modelling brings together key datasets that describe the Crown hospital estate buildings in terms of age, condition, and gross floor area (Health Asset Register Tool

(HART)), the level of services supported by the estate, represented by the number of hospital beds (HealthCERT public hospital data), and the use of inpatient services (National Minimum Data Set (NMDS)). Future scenarios are informed by two sets of population projections: the Population Based Funding Formula (PBFF) population projections, which provide detailed ethnic breakdowns and the Stats NZ population projections, which provide a view of the likely population of New Zealand over the longest possible timeframe.

Our approach uses hospital beds and total gross floor area to create a unit of measure, allowing total space requirements in public hospitals to be estimated based on inpatient service use. A key advantage of our approach is that it reflects all possible infrastructure involved in the Crown hospital system – everything from operating theatres to carparks on the assumption that current proportions of gross floor area utilisation remain constant.

…but there are important limitations

Due to data constraints, our modelling is based on the current observable relationship between total hospital floor area, the number of hospital beds and the use of inpatient services, and implicitly assumes that the relationship between floor space and services and between different service types (e.g. inpatient and outpatient services) will remain constant. These relationships may, of course, change over time. However, existing data cannot identify past changes or potential future developments.

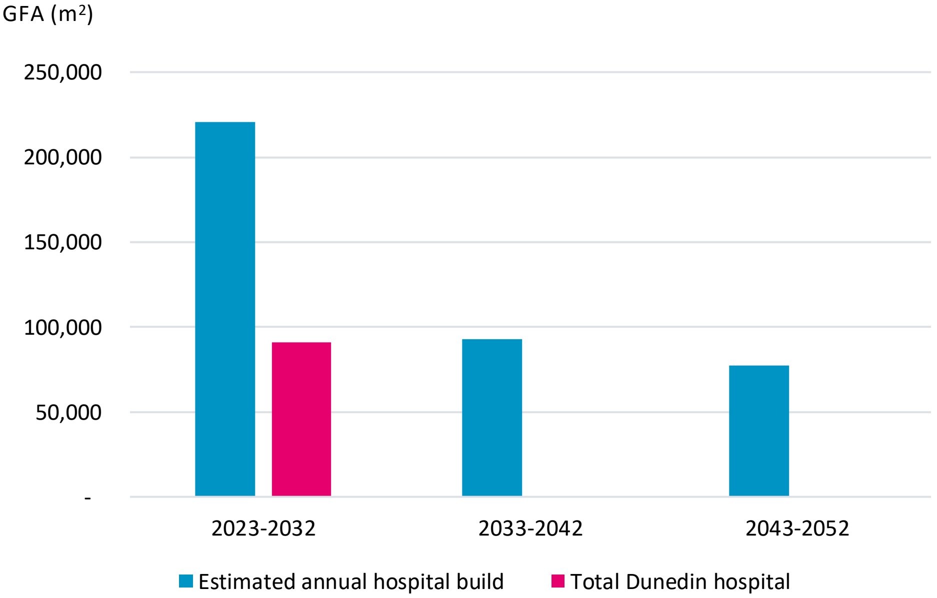
Our new build cost estimates are derived from recent hospital redevelopment business cases to reflect up-to-date, known cost pressure considerations. Without sufficient granularity in the data to support the use of a detailed set of specific costs for specific building types, we apply a representative cost from a whole hospital redevelopment project for an average-sized hospital to estimate the total cost of infrastructure pressures across the hospital system. Our refurbishment cost estimates were based on existing estimates collected during the assessment of hospital buildings for the HART. These are rough estimates which may require updating.

Health infrastructure faces a range of important challenges

The build and renewal task ahead is substantial

As shown in Figure 1 below, the average annual quantity of public hospital space projected by decade continues to grow and dwarfs even large-scale investments such as the new Dunedin Hospital project every year from 2023 to 2032. Even in subsequent decades, the estimated average annual requirement for new hospital buildings is almost equivalent to a new Dunedin Hospital built every year from 2033 to 2052.

Figure 1 Projected average annual hospital build by decade compared with the new Dunedin Hospital

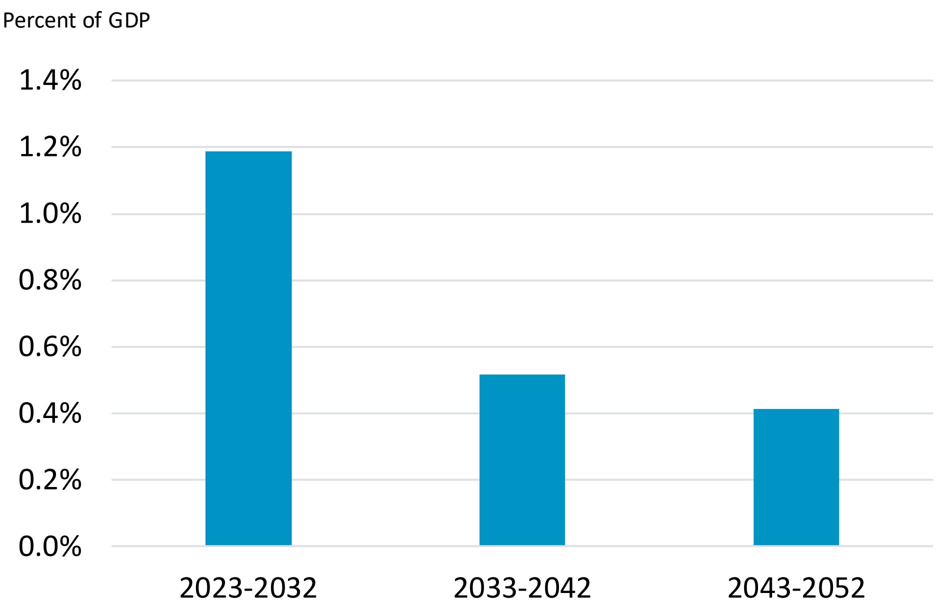


Source: NZIER

The required investment would represent between 0.7 percent and 1.5 percent of GDP annually

In the BAU scenario, we modelled, over the next 30 years, and based on smoothing within each decade, investment requirements for hospital infrastructure would represent between 0.4 percent and 1.2 percent of GDP annually, with the decade from 2023 to 2032 seeing the most significant level of investment required as a proportion of GDP.

Figure 2 Projected annual hospital investment by decade



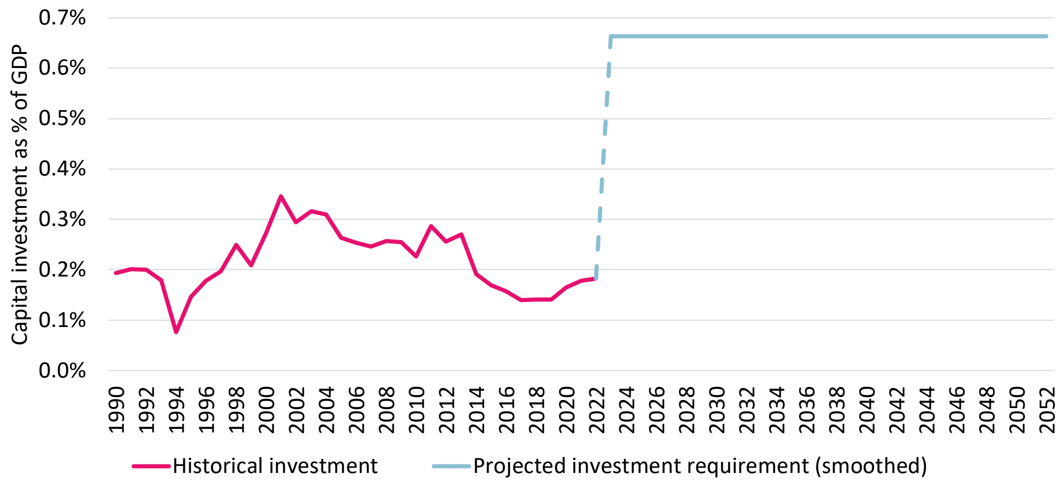
Source: NZIER, The Treasury (2021)

The projected investment under a BAU scenario is four times more than we have been spending

The projected level of infrastructure investment in the health sector under a BAU scenario exceeds previous investment. Based on estimated health capital expenditure since 1990 and smoothed projected investment requirements, the average annual investment would be expected to increase from 0.2 percent to 0.7 percent of GDP.

Figure 3 Public hospital infrastructure expenditure as a percentage of GDP

Historical versus projected



Source: NZIER, The Treasury (2021)

In total, 55 percent of the investment will be driven by the replacement and renewal of existing assets

Other drivers of future investment – population growth, population ageing and other demographic change – together account for 38 percent of expected investment need. Amongst these drivers, population ageing is by far the most important, accounting for two-thirds of the total demographically driven future investment need.

Figure 4 Contribution of major drivers of 30-year investment need

Percentage of total estimated investment need 2023–2052

Note: Percentages do not sum to 100% due to other (minor) drivers of 30-year investment need not included in this chart.

Source: NZIER

Envisaged improvements in the level of service contribute 8 percent of the estimated future investment need

A key insight from our analysis is that the investment needed to support expanded services in growing centres, ensure equitable access to planned surgeries, and provide spaces within hospitals to respond to the cultural needs of whānau amounts to comparatively little (a total of less than eight percent of the required investment over 30 years). This means the infrastructure investment needed to bridge the equity gap is achievable.

But efficiency improvements identified through BAU processes can only save 13 percent of the expected required investment

We modelled a range of system shifts and efficiency improvements suggested by Te Whatu Ora to test the potential impact of service redesign ideas to reduce health infrastructure requirements. Our analysis reveals that these solutions offer little opportunity for savings. Even a range of solutions implemented with a high degree of effectiveness will only reduce the infrastructure investment need by 12 percent.

Uncertainty about the condition of hospital assets drives uncertainty in future investment requirements

Our analysis was based on a 2022 version of the HART, which contained information in need of updating and further investigation, particularly regarding the condition of buildings. Due to the unreliable condition assessments available, the modelling was based on the age of buildings. After consultation with Te Whatu Ora, our analysis assumed an average 50-year useable life for hospital buildings. Many buildings last longer than this and careful attention to design may extend the useable life of physical assets and their ability to continue supporting modern models of care.

However, our sensitivity analysis indicates that extending the useable life of buildings by nearly 20 years makes little difference to costs unless there is also a reduction in the frequency, scale, or cost of refurbishments. Our model assumed a cycle of refurbishment that saw buildings undergo a moderate refurbishment at 16 years and a major refurbishment at 33 years. This cycle was a major area of uncertainty for which no evidence was found to either support or offer an alternative assumption. Table 1 below illustrates how the impacts of refurbishment cycles can be substantial. The same buildings with the same life expectancy but twice as many refurbishments can cost more than a third more over its lifetime. Similarly, extending the building's useable life offers little savings if this can only be achieved through continued refurbishments.

Table 1 Percentage reduction in infrastructure investment under alternative useable life of assets and refurbishment cycle assumptions

Relative to base case*

Alternative scenario summary	Percentage change in total investment requirement from base case*
More frequent refurbishment of buildings: Base case (50-year) useable life for all buildings with moderate refurbishment at 10 and 30 years and major refurbishment at 20 and 40 years.	34.4%
Longer useable life for all buildings: Base case refurbishment cycle (moderate refurbishment at 16 years major refurbishment at 33 years) extended to add an additional moderate refurbishment at 50 years to extend the useable life from 50 years to 67 years	-3.9%

*Results are calculated relative to the base case in which buildings were modelled with a 50-year useable life and with a moderate refurbishment at year 16 and a major refurbishment at year 33.

Source: NZIER

Health service infrastructure requirements are likely to evolve in unpredictable ways over 30 years

The current use of physical assets in the health sector is a function of health technologies – the range of services and treatments currently available and how these are delivered. Over a 30-year time period, new treatments will emerge, and new ways of delivering existing treatments and services will also be developed. The last 30 years have seen a significant shift to more ambulatory care and shorter inpatient stays.

There is also the potential for major advances in medical care to increase pressure on health infrastructure investment expectations as lifesaving, cutting-edge treatments may only be able to be delivered in specialised purpose-built facilities, as exemplified by the expansion of linear accelerators (LINACs) over the last 30 years.

Past advances in medical care and service design suggest that we can be certain that change will occur and that it will impact infrastructure requirements. When it will occur and what impact it will have is unknown.

The total investment estimated based on a BAU scenario is not affordable

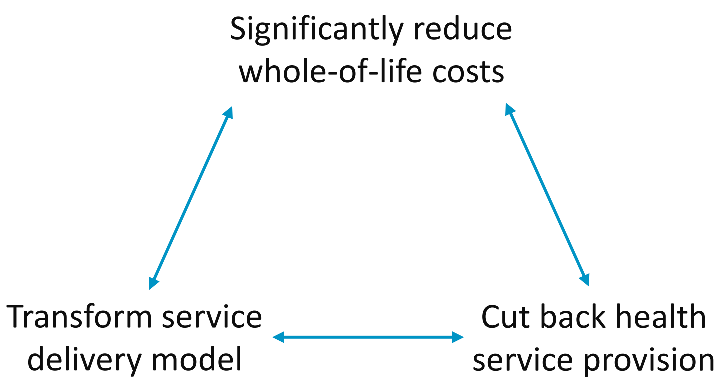
The model indicates the challenge that faces Te Whatu Ora. Health budgets over the next 30 years will not allow for the level of infrastructure investment estimated in this report. The service expansions and improvements that are wanted and needed to serve a growing, more ethnically diverse population in a health system focused on equity are achievable but only if considerable and sustained efforts are made to reduce infrastructure costs.

We have choices, but significant change is inevitable

Our modelling of BAU approaches to health infrastructure decision-making highlights that we cannot continue this way. The four-fold increase in average annual expenditure (as a percent of GDP) expected to be needed is largely a function of poor infrastructure decisions in the past but also indicates an urgent need to do things differently in the face of significant pressures.

The harsh choice facing the system is to choose amongst three options – a 'trilemma' for the health system: find ways of significantly reducing whole-of-life costs for health assets, fundamentally change the service delivery model, or reduce the amount of health services provided.

Figure 5 The future health system 'trilemma': Bringing means in line with requirements



Source: NZIER

While the health and disability system reforms indicate fundamental changes in the service delivery model might be expected, our modelling suggests that these would have to be extensive and profound. It is likely that to reduce future health infrastructure spending to achievable levels, every opportunity to reduce the cost and need for physical infrastructure must be maximised.

Recommendations for the sector

Information is a critical need for improved decision-making. Because our modelling is subject to uncertainty at this early stage of evidence gathering on health infrastructure and costs, we recommend that:

- Te Whatu Ora focuses on developing a deeper understanding of the space requirements of health facilities, their components and service areas, with outpatient spaces being a priority and investigates options for improving efficiency in the use of physical space.
- Te Whatu Ora works towards more detailed outpatient data that can support the modelling of future infrastructure requirements with the consistent recording of resource use based on spaces used, time dimensions of outpatient visits, and procedures undertaken.
- Te Waihanga undertakes further modelling of potential scenarios as new evidence emerges to refine the sector's understanding of trade-offs and opportunities.

Hospital asset management planning is critical to managing costs. Asset management planning should be informed by a clear set of options and trade-offs. We recommend that Te Whatu Ora works with Te Waihanga to develop:

- rigorous asset management systems and processes, including the management of hospital asset information
- a deeper understanding of options to reduce construction costs and the need for frequent refurbishment.

Additionally, because our analysis suggests improvements in services to address equity considerations have a relatively minimal impact on infrastructure investment requirements, we also recommend that health infrastructure decision-making continue to prioritise reducing health equity gaps.

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1 Background

Health infrastructure is a critical enabler of our system and requires substantial Crown investment

Underpinning the $22 billion annual government expenditure on health services, health infrastructure is a critical enabler of equitable, efficient, high-quality services, supporting patient and workforce experience and a major driver of overall system sustainability.

Forecast infrastructure requirements always exceed the available resources. The health sector is not 'self-sufficient'. It has relied on Crown capital injections over District Health Board (DHB) baseline funding (now consolidated as Te Whatu Ora baseline funding).

In 2018, based on DHB capital estimates, the National Asset Management Programme (NAMP) team at the Ministry of Health estimated that $14 billion of investment in buildings and infrastructure was required (Ministry of Health 2020). The final report of the Health and Disability system also referred to this "infrastructure deficit" in the health sector and added that this figure excluded repairs and maintenance, indicating a substantial flow of future infrastructure investment requirements.

According to Te Waihanga, the New Zealand Infrastructure Commission, over the past ten years, the average annual health sector capital expenditure has been around $500 million, but this is expected to grow to a multiple of three to four times that annual amount by 2030 (Te Waihanga 2021).

The expected investment requirements come in a context of uncertainty

But despite the critical importance of physical infrastructure in the health sector and the challenges it presents to the public health system, it remains an issue that is not well understood in terms of:

- the ongoing costs of maintaining buildings to a standard required to support health services over the building's lifetime
- the level of health infrastructure investment that would be required under a business-as-usual scenario (with no specific attempts to change the current degree of reliance on publicly-owned physical infrastructure to deliver health services)
- the respective contributions of key drivers (e.g. population growth, population ageing, building maintenance, etc.) towards the level of capital investment required under the business-as-usual scenario
- the implications of envisaged improvements in service quality and equity of access
- to what extent health system investments such as model of care changes and quality improvement could reduce the level of capital investment required to within financially sustainable levels.

The $14 billion estimated infrastructure deficit estimated by the Ministry of Health (Ministry of Health 2020) not only does not include overdue and expected repairs and maintenance (Health and Disability System Review 2020) but it is based on only 13 percent of the 1,269 hospital buildings in 2019 having been expertly assessed under NAMP's current state assessment (Ministry of Health 2020). This incomplete assessment was noted by the

New Zealand Infrastructure Commission, which noted, "*it is likely the actual cost to address existing issues and bring the estate up to a fit-for-purpose level is much greater than $14 billion*" (Te Waihanga 2021).

This is largely due to the challenging nature of the problem. Capital investment decisions in the health sector are complex. While buildings can have a life of 25 to 40 years (or longer) (Te Waihanga 2021), design needs may evolve more rapidly, in line with changes in health technologies and new clinical knowledge.

Health reforms present an opportunity to think differently about infrastructure

There is an emerging health sector narrative as part of the reform process, and infrastructure plays a central role in this narrative. But the reforms also present opportunities.

There are opportunities to reduce population need, to change models of care to favour ones with lighter infrastructure requirements without compromising safety and quality of care (even potentially allowing for improved access and outcomes), and to improve systems and processes to achieve efficiency gains in the building and use of health infrastructure.

Centralisation and a long-term, system-wide focus on infrastructure investment through Te Whatu Ora's Infrastructure and Investment Group has the potential to ensure better planning, monitoring and delivery of health infrastructure projects and better management of the asset stock. This opportunity was identified in the Health and Disability System Review's final report, which emphasised the importance of good asset management practice and the need for both future capacity planning and "*modelling of investment scenarios*" (Health and Disability System Review 2020).

2 Our approach

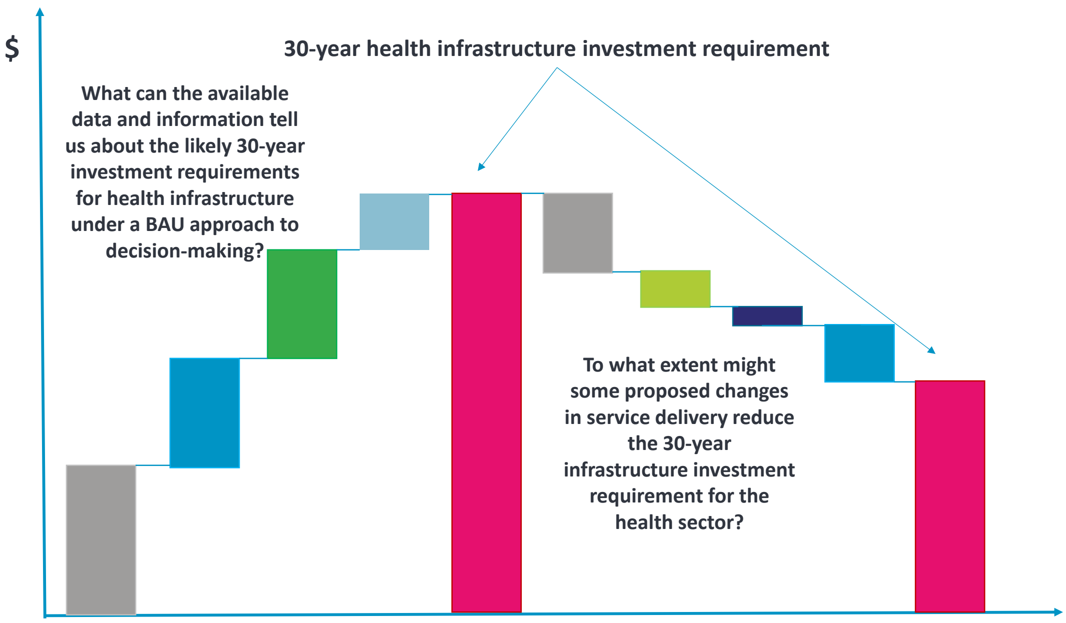
2.1 Our research questions

With the health sector taking a longer-term view of investment and likely supply constraints in the construction sector in the short to medium term, requiring important discussions about prioritisation, Te Waihanga commissioned NZIER to assess at a national level the total amount of capital investment required that may arise for Crown-owned health infrastructure over the next 30 years and the potential, under key assumptions, to reduce that requirement.

In a nutshell, this report seeks to answer two research questions:

1. What can the available data and information tell us about the likely 30-year investment requirements for health infrastructure under a business-as-usual approach to health infrastructure decision-making?
2. To what extent might some proposed changes in service delivery reduce the 30-year infrastructure investment requirement for the health sector?

Figure 6 Graphical representation of our research questions



Source: NZIER

The 'business as usual' scenario…

New Zealand has 83 public hospitals (Te Waihanga 2021). Te Whatu Ora's Infrastructure and Investment group is charged with assessing the projects for hospital development and setting priorities for a national pipeline of health infrastructure investment. A key challenge will be shepherding the many parts into a more coordinated system with a long-term focus.

Until now, District Health Boards (DHBs) have been responsible for developing the business cases for capital investment and have largely done so in isolation – without input from or consideration of neighbouring DHB plans (Te Waihanga 2021).

As much of the information that feeds into business cases will continue to come from the hospitals themselves, where there is limited awareness of national planning, one might expect to see continued high levels of capital requirements expressed. The total of such requirements – for investment without adequate consideration of broader long-term plans – will amount to an aspirational and unaffordable investment across the system.

We designed our base case to illustrate what the capital investment implications are of a system that:

- sets out to repair and replace all buildings that are in disrepair or are at end-of-life without asking the hard questions about the need and potential future use of those buildings
- builds new buildings and facilities without incorporating lessons learned about the performance of prior builds and their lifetime costs
- responds to a growing and ageing population as per current patterns, without consideration of the value of alternative ways of supporting quality and length of life.

Our objective is to demonstrate that without rigorous decision-making facing difficult trade-offs, the future envisaged for the health system may be aspirational, but it is also unrealistic.

Having established the level of capital investment required to meet all identified needs and wants across the system, we then consider how the system might do things differently – what opportunities may exist that will allow for improvements and service expansions to occur where needed while reducing the level of investment in other areas.

To identify potential opportunities, we sought insights from those working in the sector at Te Whatu Ora. The ideas we analysed included some that have been or are being actively considered and implemented and others that have not yet been explored to any degree. The total of these opportunities is relatively ambitious when considered against the pace of change and the tendency of the health sector to make adjustments at the margins rather than implement major transformational change. This approach seeks to address a key question: “Can we afford to be aspirational about improvement if we are also ambitious about re-design?”

This report represents a first attempt to cut through the complexity

This project is a modelling exercise. Modelling is, by definition, fraught with uncertainty. The health sector is complex, and despite good work already being done to better understand the need for health infrastructure investment, many unknowns remain about the current asset stock and what can be achieved with future investment. Modelling future health infrastructure requirements is also dependent on good health service utilisation data, but health service utilisation data has not been designed and collected for this particular purpose, so it is an imperfect input.

Modelling is also, by definition, a simplification of the complexity of detail and dynamics that drive reality. Some simplification is by design – a choice made by researchers to make the unmanageable manageable. Another simplification is by requirement – reflecting the gaps in information and data.

Despite these inherent shortcomings, modelling is critical to understanding how dimensions of a problem impact on overall results now and in the future and where the greatest opportunities to make significant change might be.

As new information emerges, we expect this analysis to be revisited, updated, and extended. Estimates may change substantially, and decision-makers must be ready to adjust accordingly.

2.2 Scope

For this report, health infrastructure investment is defined as investment in Crown-owned buildings and structures supporting health service delivery. Increasingly, the delivery of health services is also dependent on digital infrastructure, and there may even be a degree of substitutability with physical infrastructure or implications for different physical infrastructure. Digital infrastructure, however, was out of scope for this project, which focused on how services currently use physical infrastructure and potential implications for the physical infrastructure of model of care changes, setting aside the question of what digital infrastructure investment may be required to enable them.

Because our focus is on public investment, our analysis focuses on hospital buildings. Even though DHBs were able to access Crown capital for Tier 1 services, and this is expected to remain the case under Te Whatu Ora, Tier 1 investment has not typically been prioritised (Te Waihanga 2021, 233), resulting in a low level of capital investment in public health infrastructure outside of the hospital context.[1]

We define the 30-year investment requirements as the investment required to build, maintain, repair, demolish, and replace Crown-owned buildings to ensure the public health system can deliver on objectives and aspirations. That is, we sought to specifically identify the investment required to:

- update existing infrastructure by replacing end-of-life assets and refurbishing those in need of refurbishment, including addressing the existing deficit
- meet the needs of a growing population
- meet the needs of an ageing population
- meet the needs of a population with a changing ethnic composition
- support the expansion of services (including the addition of new services) that may be expected as some population centres grow and could sustain a tertiary hospital where a secondary hospital currently exists or where currently mid-sized secondary hospitals expand and increase their service offering
- meet established guidelines on the immediate space around hospital beds (AusHFG n.d.)

1 This may change significantly under Te Whatu Ora and Te Aka Whai Ora, with greater priority placed on empowering Māori providers in particular to deliver Tier 1 services.

- implement key improvements to support person and whānau-centred care with a focus on equity
- increase the level of service to improve equity of access to planned care with a focus on planned surgery.

Other forms of capital investment or infrastructure, such as roading, carparks, reticulated infrastructure (plumbing, electrical, etc.), ICT and major medical equipment, are out of scope.

In addition, we engaged with key decision-makers at Te Whatu Ora to identify potential interventions that could reduce the level of infrastructure investment. We sought to include interventions across a spectrum of intervention points and types, including:

- changes to models of care that result in services shifting into Tier 1 contexts without the need for Crown-owned infrastructure
- improvements in the way acute demand in managed in both Tier 1 and Tier 2 contexts
- interventions that reduce the need for hospital-based services by improving the health status of the population through more effective Tier 1 services for primary and secondary prevention
- interventions that improve quality and reduce unwarranted variation in lengths of stay.

2.3 Data and evidence

For this report, we gathered evidence from a range of sources to estimate the 30-year investment required to ensure the public health system's physical infrastructure (i.e. buildings) is adequate to meet the need. This included the information described in Table 2 below.

Table 2 Major sources of data used in the modelling

Data set	Data used
Health Asset Register Tool (HART)	Gross floor area (GFA) across all buildings by hospital campus Age of buildings Refurbishment costs GFA in specific service areas (Mental Health, Inpatient)
HealthCERT public hospital data	Specially supplied national count of hospital beds in 2021
National Minimum Data Set (NMDS)	Hospital admissions, primary diagnosis, discharge speciality, length of stay, patient demographics, admission type, diagnostic-related group (DRG) code
Population Based Funding Formula (PBFF) population projections	Population projections by prioritised ethnicity to 2043
Stats NZ population projections	Total population projections to 2053

Source: NZIER

The Health Asset Register Tool

The Health Asset Register Took (HART) is an Excel database of hospital buildings nationwide, along with key information about the gross floor area (GFA), age and condition of buildings. A description and descriptive analysis of the HART data is in Appendix A.

When the HART was shared with NZIER, the condition assessments were incomplete. While most buildings had a condition rating recorded in the HART, most were not based on a complete assessment of building condition and reflected the best available knowledge when the information was collected. Only mental health facilities had been subject to a recent complete condition assessment at that time. To base our modelling on complete, consistent, and transparent information, we used building age to determine the demolition and replacement of buildings.

While the HART data indicates that building age is not highly correlated with recorded building condition (see Appendix A), there can be many reasons why older buildings become unsuitable, including potentially higher maintenance costs and the incompatibility of their design with modern models of care. Additionally, as hospital campuses evolve in layout over time, older buildings may sometimes become barriers to adopting effective overall design principles.

We used the GFA of buildings to calculate demolition and refurbishment costs. The total GFA of all buildings on a hospital campus provided the numerator (referred to as "total facility GFA" for the calculation of total facility GFA per bed. We also used the GFA in inpatient units and inpatient mental health units and the shortfall in these relative to the Australasian Health Facility Guidelines (AusHFG) recommendation to model a service improvement.

The HART also includes some estimates of costs for building and refurbishing buildings, which we used to calculate building and refurbishment costs over the next 30 years (see Table 4).

HealthCERT

The Ministry of Health has collected data on the number of hospital beds by facility since at least 2009 as part of the HealthCERT certification process for public hospitals. The number of beds reported represents the best currently available measure of physical capacity for inpatient care in New Zealand's health facilities. The HealthCERT data is the same that has been reported to the OECD for international comparisons of the number of hospital beds per 1,000 population.

An estimate of the current number of beds in New Zealand's public hospitals was provided by Te Whatu Ora based on the 2021 total number of beds recorded as part of the HealthCert process. No detail as to the type of bed is available. In reality, some beds are resourced 24/7; others aren't. Some beds may be able to be occupied by any patient, whereas others (e.g. beds in maternity wards or children's hospitals) are more restricted. These issues would mean that in the short term, growth may not be able to be accommodated. However, our model is not concerned with current and short-term constraints and assumes that whatever beds are currently available across the hospital network and the spaces they occupy could be adjusted and staffed to provide 24/7 inpatient care to any patient over the medium to long term.

Population projections

The future health infrastructure requirements for the health sector are largely related to the expected population size and composition. Population composition is critical because older people, people from high-deprivation areas, and Māori and Pacific New Zealanders currently use hospital-based services at higher rates. While health service improvement may seek to alter these patterns, a base case assessment of future infrastructure requirements should be based on accommodating these needs to prevent increasing the level of unmet health need in the population.

Population projections are available from two sources:

- Stats NZ's (SNZ) population projections from the 2018 Census (SNZ population)
- the population-based funding formula (PBFF) population projections produced by Stats NZ to support the calculation of funding to the District Health Boards (PBFF population).

Both series are based on assumptions about future fertility, mortality, migration and inter-ethnic mobility (people changing their ethnic identification over their lifetime). Although the assumptions are carefully formulated to represent future trends, they are subject to uncertainty.

The two series are different in important ways for our modelling, with the key differences identified in Table 3 below.

Table 3 Key differences between the SNZ population and PBFF population projections

	SNZ population	PBFF population
Frequency	Yearly for 5 years from the Census, 5-yearly thereafter	Annual
End year	2073 total population 2043 ethnic populations	2042/43
Population composition	5-year age groups, multiple ethnicities possible for individuals	5-year age groups, prioritised ethnicity
Key challenges for modelling	Can result in double counting when stratified by ethnicity Requires interpolating for missing years to support annual estimates Requires a change of base year for modelling health service utilisation rates pre-2018	Requires projecting beyond 2042/2043
Key strengths for modelling	Covers the full time period for the model	Aligns to health service utilisation data with respect to prioritised ethnicity and district boundaries

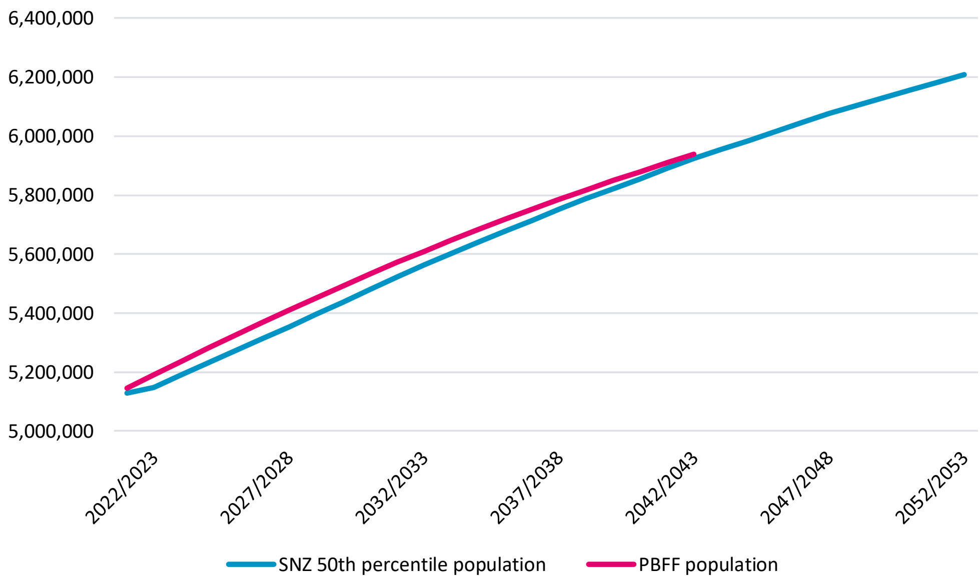
Source: NZIER

To overcome the respective challenges of each series and make the most of the respective strengths, we developed a hybrid series of population projections, which involved applying the age and ethnic composition from the PBFF population to the SNZ population 50th percentile projections.

As shown in Figure 7 Population projections for modelling there is little difference between the total populations projected by either the SNZ or PBFF series through to 2042/2043, the last year for which both series provide a projected population. In that year, the PBFF population projection exceeds the SNZ population projection by 13,870 individuals (0.2 percent of the SNZ population).

Our modelling is based on the Stats NZ 50th percentile population projections with the age and ethnicity breakdown applied based on the PBFF population.

Figure 7 Population projections for modelling



Source: NZIER, Stats NZ data

Cost estimates

When we wrote this report, limited information on the costs of building and refurbishing health facilities was available, and a high degree of uncertainty surrounded the available cost estimates. Costs were drawn from a range of sources, including business cases, the Health Asset Register Tool (HART) supplied by Te Whatu Ora, and personal communication from Te Whatu Ora. Some sensitivity analysis was conducted to understand the impact that cost variation may have on overall results.

Table 4 below summarises the cost estimates used in the model, the source of cost estimates, and values in 2022 dollars.

Table 4 Cost estimates used in the modelling

Cost	Value per m2 (2022 dollars)	Year of the original estimate	Source
New build (high – base case value)	$20,000	2022	Whangarei Detailed Business Case – rounded. As an average-sized hospital, Whangarei Hospital was considered to be a representative hospital. The redevelopment being proposed included a range of building types and a mix of clinical and non-clinical spaces such as acute services, ED, ICU, laboratory, radiology, support services, a ward tower, and medical-surgical wards, as well as a mix of new builds and re-builds, so the cost per m^2 was considered to be representative of the mix of building requirements at a national level.[2] Aligns with $30,000 per square metre for clinical spaces and $12,000 to $15,000 (midpoint $13,500) for non-clinical spaces as suggested by Te Whatu Ora Auckland[3], with an assumption of approx. 40% clinical and 60% non-clinical space.
New build (low – used for sensitivity analysis)	$15,136	2023	Weighted average building cost across the range of building types identified in the HART by highest building service (primary use of building) Replacement value (NAMP current state assessment, MoH)
Major refurbishment	$7,932	2019	Extensive refurbishment of a secondary or tertiary hospital, Health Asset Register Tool (HART) supplied by Te Whatu Ora, weighted average cost based on highest building use.
Moderate refurbishment	$5,549	2019	Moderate refurbishment of a secondary or tertiary hospital, Health Asset Register Tool (HART) supplied by Te Whatu Ora, weighted average cost based on highest building use.
Demolition	$1,000	2022	Whangarei Detailed Business Case
Whānau house	$3,632	2019	Based on Whangarei Detailed Business Case – Residential replacement cost, Health Asset Register Tool (HART) supplied by Te Whatu Ora
Whānau room	$6,659	2019	Based on Whangarei Detailed Business Case - Admin building replacement cost, Health Asset Register Tool (HART) supplied by Te Whatu Ora

* Inflated to 2022 using the Capital Goods Price Index

Source: NZIER

Additional information was sourced from a range of previously published reports and used in the model, including:

- the GFA per inpatient bed for service improvement is sourced from the AusHFG) Health Planning Unit for adult acute inpatient units and adult acute mental health inpatient units (AusHFG n.d.)

[2] Note: Other 2022 business cases supplied had similar costs per square metre for new builds. E.g. Nelson Hospital options had costs between $17,500 and $18,500 per square metre for phase 1 and between $21,000 and $22,000 for phase 2 building work.

[3] Personal communication.

- GFA implications of service improvements through adding whānau accommodation and whānau rooms in inpatient wards sourced from the Whangarei Detailed Business Case.

2.4 Methods

We used ratio methods common in the published literature (Ravaghi et al. 2020) to determine the infrastructure requirements within regions based on hospital beds as a unit of measure. Our application of these methods was somewhat more sophisticated than most, using a range of rates and ratios to finetune our estimate, including:

- the average total facility GFA per bed across all facilities (based on HART and HealthCert data) was used to estimate the space required to accommodate additional beds
- the demolition, building, and refurbishment costs per GFA (from the HART and from selected recent detailed business cases) were used to estimate costs
- the population-to-bed ratio in 2021 (based on data from the HealthCERT dataset specially compiled and provided by the Ministry of Health)
- the 2019 (pre-COVID) rates of inpatient events and planned surgeries of each 5-year age-ethnicity group were used to model future demand by applying these rates to population projections, along with adjustments for more equitable access to services.

2.4.1 Health infrastructure requirements are a function of health services demand

On the surface, modelling a population's future health infrastructure requirements appears to be a simple task. However, this exercise requires some link between a population and some monetisable measure of health infrastructure.

The only monetisable measure of health infrastructure available for this analysis was the gross floor area of hospital buildings available from the HART. It is monetisable using various estimates of refurbishment cost, demolition cost, and building cost, all of which can be obtained (within ranges) on a per square metre basis either from the HART itself or from current detailed business cases for hospital development projects. However, no direct link between the gross floor area of hospitals and population (e.g. what gross floor area per 1000 population is required to support a high-quality health system?) has been established in New Zealand, nor did our search of published literature identify any such link.

In any case, because our modelling also required being able to make adjustments to hospital service delivery to reflect the potential model of care changes, it was essential for our model to link hospital service utilisation to health infrastructure. This represented an opportunity as well as a requirement because, although a direct link between population and gross floor area of hospital buildings is not available, national health datasets allow for a direct link between population and hospital service utilisation (for hospital-based services) and one measure of hospital service utilisation can be linked to gross floor area: inpatient bed nights. Inpatient bed nights, calculated from the length of stay for inpatient admissions, translate directly into hospital beds with a broad assumption of bed availability (we have assumed 24/7, 365 days per year availability for overnight beds).

An estimate of the current number of beds in New Zealand's public hospitals was provided by the Ministry of Health. Inpatient beds can be directly linked to their immediate floor area through existing assessments of the shortfall in inpatient space relative to the Australasian standards or, for future building projects, to the Australasian standards themselves.

Challenges in separately modelling infrastructure requirements for outpatient and other activity

Unlike inpatient services, the volume of outpatient services is measured in attendance. Additionally, outpatient data provides no detail of what attendance to outpatient care involves beyond the health speciality under which services are delivered. Sometimes, patients who visit outpatient services are in and out within a short time for a 15-minute consultation. Sometimes, they have long waits in reception areas and see multiple health professionals. Sometimes, they have quick procedures. Sometimes, they stay for hours for lengthy procedures like kidney dialysis and infusions. Outpatient attendances vary greatly in terms of the resources they use, and the source of outpatient data – the National Non-Admitted Patient Collection – provides no information on the resources used.

Furthermore, the data available on hospital buildings collected by the Ministry of Health under the NAMP cannot provide a snapshot of the proportion of physical infrastructure currently used for outpatient services. While the building's use is recorded for most buildings, cases where a building has a single use are rare. For the most part, hospitals deliver outpatient care within buildings that support a range of services and functions, and no existing data allows proportions of the GFA of those buildings to be specifically attributed to their various functions. In other words, it is impossible to determine how much of the existing infrastructure supports outpatient versus inpatient care.

The challenge this creates from an infrastructure perspective is that infrastructure requirements for outpatient care cannot be separately modelled at a national level. This shortcoming in outpatient data is also a major hindrance to service planning across the full range of resources, not just infrastructure.

Other services and activities within hospitals present a similar problem to outpatient services. The use of operating theatres is collected with some (but varying) detail at a DHB level, and this data may, in the future, be collected into a national data set. Building cost estimates provided by Te Whatu Ora Auckland[4] suggest that the cost per square metre to build clinical spaces is at least twice that of non-clinical spaces. Unfortunately, the HART only confirms that many hospital campus buildings contain clinical and non-clinical spaces. We handle this by choosing a building cost for our base case that reflects a 60–40 percent balance between non-clinical and clinical spaces, respectively, in hospitals (the validity of this assumption requires further investigation).

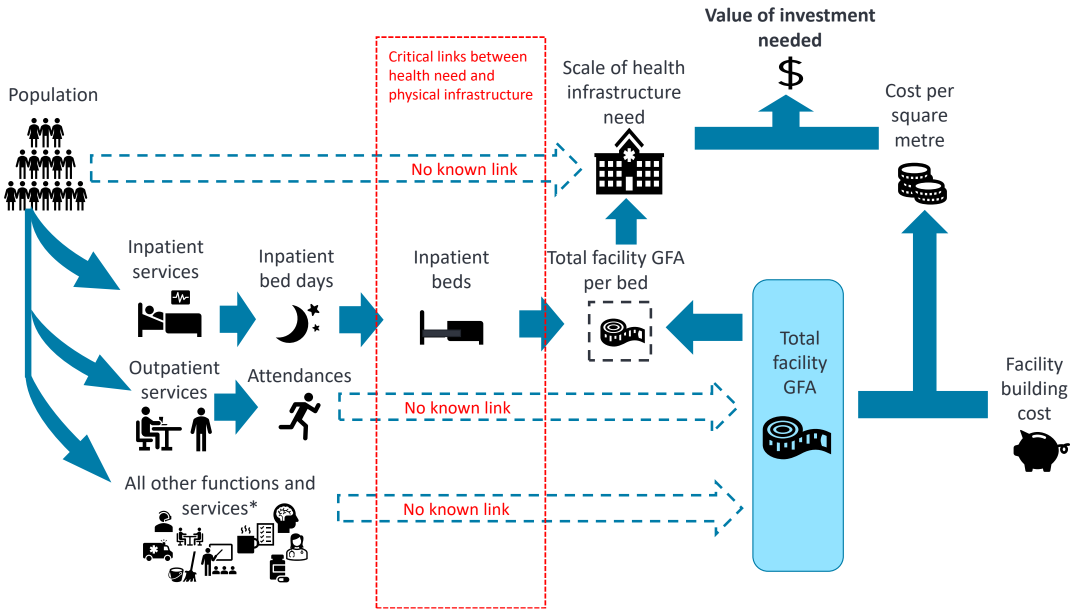
Overcoming data and information gaps linking services to physical infrastructure

Because the only available metric for linking population use of health services to infrastructure requirements is inpatient beds, and because the model mustn't ignore all other services provided within hospitals, we calculate the total facility GFA per bed of New Zealand's hospitals to reflect not just the immediate area around the inpatient bed (the way GFA is often used in the context of inpatient care), but also the floor area across the entire hospital, including outpatient services, support services, ancillary services, etc. and assume this relationship will continue to hold. That is, we assume that a 300-bed hospital will, in the future, require the same total gross floor area as it does today. The implicit

4 Personal communication.

assumption is that all other services, including outpatient services, will continue to use the same proportion of total facility GFA.

Figure 8 Critical links between population health need and physical infrastructure



*Other services and functions include clinical services that directly support inpatient and outpatient activity (e.g. operating theatres, diagnostic imaging, laboratories, pharmacies, physiotherapy units, etc.) as well as other services (e.g. reception areas, laundry services, food services, medical records, finance, human resources, security, etc.).

Source: NZIER

Our approach implies an overall 'business-as-usual' approach to service delivery

The assumption that the proportion of facility GFA that supports each type of service remains constant is critical to understand. The model *does* reflect all services and activity within New Zealand's hospitals and, therefore, reflects proportional floor area growth in all services. However, the model *does not* reflect any potential *changes* in proportional floor area requirements in specific services. For example, if outpatient services are reduced through greater delivery in Tier 1 contexts, the model currently has no way of reflecting the impact on infrastructure costs.[5]

In this sense, the model predicts a BAU scenario regarding how our hospitals operate and reflects the current knowledge gaps about the scale of impact that shifting services might have on the need for physical space.

Pre-COVID utilisation patterns by age group and ethnicity

Because COVID-19 disrupted hospital services considerably from 2020 to 2022, we use hospitalisation data from 2019 (the last complete year of data prior to COVID-19 disruption) to inform the demand side of the model.

Our demand modelling is based on 5-year age bands and three prioritised ethnicities: Māori, Pacific and Other, consistent with broad health system planning. However, at least

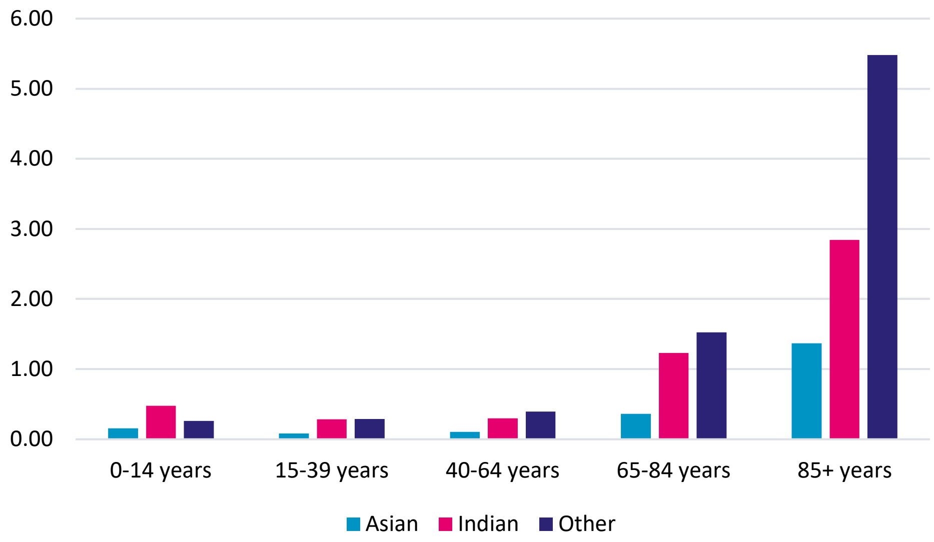
[5] A better understanding of the floor area requirements and usage of outpatient services would be needed to improve this aspect of the model.

one major and rapidly growing ethnic group has a relatively high prevalence of some major conditions: People of Indian ethnicity. If people of Indian ethnicity experience significantly more bed days than similarly aged people grouped within the Other ethnicity and the Indian population is growing rapidly, then our model could significantly underestimate future service utilisation by projecting 2019 utilisation rates onto the 2053 population of Other ethnicity.

To identify whether this issue required further analysis, we investigated the significance of concealing this group within the Other ethnicity in our model by analysing the 2021 bed days in this population compared with the other groups included in the Other ethnicity group – Asian and all other. We found that apart from the youngest age groups (combined as 0–14 in Figure 9 below), the rates of hospitalisation of people of Indian ethnicity are not significantly different from the rates of hospitalisation of others within the Other ethnicity group (see Figure 9 below). As a result, we considered the Māori/Pacific/Other ethnic groups to be sufficiently detailed for our model.

Figure 9 Bed days per person by age group and ethnicity

2021



Source: NZIER

2.4.2 Modelling the health infrastructure investment required to meet the demand for services

Our model assumes that the available infrastructure will meet the population's needs for services. Critical information factored in to estimate the cost of meeting this need through health infrastructure investment includes:

- the occupancy rate and the beds-to-population ratio
- the expected useable life of physical assets at the end of which we model demolition and rebuild, except where reduced need results from a model of care change
- the refurbishment cycle of physical assets
- the costs associated with demolition, building and refurbishment.

Occupancy rate and beds-to-population ratio

Hospitals currently run at 91.1 percent occupancy (calculated as a national annual average). An average occupancy rate this high can be unsafe due to the peaks at busy times when occupancy can rise significantly higher than the average. This can mean that patients wait longer than clinically optimal times for assessment or treatment, that patients are assessed, treated, or kept in unsuitable spaces, and that staff-to-patient ratios are below what is clinically optimal.

The National Centre for Health Care Excellence (NICE) recommendation for a safe occupancy rate in hospitals is 85 percent (NICE 2018). New Zealand health planners have largely adopted this, so our modelling uses this rate to determine how many beds are needed to meet demand. In other words, if the modelled demand is for 85 beds, our model calculates the cost of building infrastructure based on 100 beds.

Because our model calculates the number of hospital beds over time and under different assumptions, and because the population is also expected to grow and change over time, we also imposed a minimum constraint in the form of a bed-to-population ratio. Specifically, we imposed a minimum bed-to-population ratio equal to the 2021 ratio as calculated based on the number of hospital beds from the HealthCERT dataset and the PBFF population for the year 2020/2021. We added this constraint to the model because there is no evidence now that a lower ratio of beds to the population can or should be achieved (see section 3.3 for more detail on beds-to-population ratio trends and comparisons).

Demolition and rebuilding of end-of-life assets

The HART provides the approximate age of all buildings in the hospital network. While we do not suppose that these are all accurate, we assume the reported age of buildings provides a reasonable picture of the current stock's age at a national level. Each building identified in the HART also has a GFA identified, which allows the national total GFA due for demolition and replacement in any given year to be calculated based on a standardised life expectancy for buildings. When multiplied by the cost per square metre, we can then estimate the total cost of all expected demolitions and replacements of buildings in any given year.

We assume a 50-year life expectancy for buildings in the base case and test the impact of a 67-year life expectancy in the sensitivity analysis (67 years allows the base case refurbishment cycle to be maintained to test only the impact of extending the useable life of buildings without changing the refurbishment cycle). These scenarios are broadly consistent with the suggestion of a 50–75-year useable life from a Te Whatu Ora Auckland personal communication, but even our base case life expectancy for buildings exceeds the 25 to 40 years suggested by the Te Waihanga Health Infrastructure Review (2021).

Phasing

Because the starting point of our model is the year 2022/2023, and the model assumes any building over 50 years old is due for demolition and replacement, there is a substantial upfront deficit to address. This work cannot be done instantly, so we phase the deficit of demolitions and replacements over ten years.

Refurbishments of buildings

Hospital buildings are hard-working assets, many of which are used 365 days per year, 24 hours a day. Critical elements must be maintained in good working order for access and safety reasons, and patient and workforce experience demand that environments are attractive and well-functioning. Importantly, models of care and health technologies evolve rapidly and often require changes in the configuration of hospital spaces for safe and effective delivery.

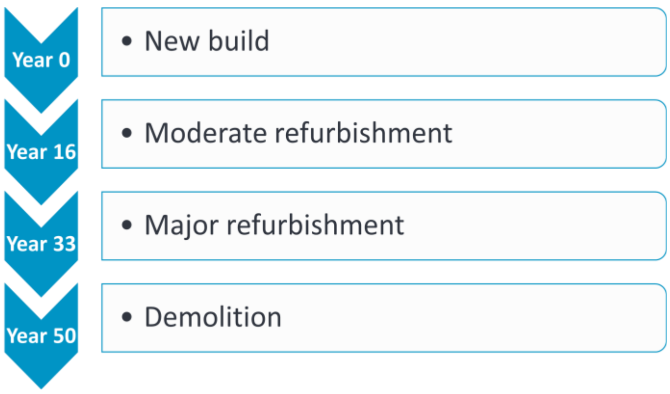
In New Zealand, hospitals have not been built to standard designs or with standard materials. They have also not been subject to standard or regular refurbishment cycles nor effective forecasting of these needs. With increased focus on asset management and centralised planning and the development of detailed data to support the forecasting of refurbishment needs, there may be increasing clarity about what refurbishments can be expected to be needed over the coming decades, enabling more effective investment planning.

A range of building life expectancies and refurbishment cycles were suggested by Te Whatu Ora in the early stages of this project, reflecting the high level of uncertainty regarding these two important determinants of investment requirements. Te Whatu Ora indicated that it expects that a system with central coordination, good cost control, and high-quality facility maintenance and planning functions may involve refurbishment only every 20 years or so (Te Whatu Ora Auckland personal communication), implicitly acknowledging that in the absence of such systems, a more frequent cycle of refurbishment may occur.

In our base case, we assume hospital buildings will require a moderate refurbishment by year 16, which may include cosmetic improvements to surfaces, replacement of interior finishes, plumbing and electrical work, but no major structural work, and a major refurbishment at year 33, which may include structural work to reconfigure internal spaces to accommodate unanticipated changes in needs.

In each year, we calculate the total GFA due for each type of refurbishment based on building age. The cost of refurbishment is then calculated by multiplying the total GFA for each type of refurbishment by the respective refurbishment cost estimate for each year.

Figure 10 Building-refurbishment-demolition cycle of health infrastructure



Source: NZIER

In addition to improved planning and cost control, well-designed, well-constructed buildings may also support less intensive refurbishment cycles without significantly compromising the quality and suitability of the physical environment. To better understand the impact of the refurbishment cycle on costs, we model alternative scenarios in our sensitivity analysis.

2.4.3 Modelling the potential to reduce the required investment

Having identified the 30-year infrastructure investment requirements of a BAU future health system, we then consider what improvements might be made to face the inevitable challenges and reach the aspirational goals affordably. We consider some major changes to models of care as well as other potential improvements that may allow the system to achieve more with less.

Model of care changes

The New Zealand Health Strategy indicates that the future direction of health services is towards investment in new technologies and models of care to enable more services to be delivered in outpatient and community settings rather than hospitals (Ministry of Health 2016).

Model of care changes can impact infrastructure requirements in three ways:

- by shifting care from hospitals to community contexts
- by creating new community-based services that reduce demand for hospital-based care
- by improving health status so that demand for hospital care is reduced.

We consulted with key decision-makers within Te Whatu Ora about options for modelling and developed the scenarios described in Table 5 below. In addition, we also included a scenario in which hospital quality improvement initiatives reduce unwarranted variation in the length of stay for General Medicine and General Surgery patients.

Table 5 Model of care changes and corresponding modelling scenarios

Model of care change	Modelling scenarios
Shifting care from hospitals to community contexts (to community models of mental health, psychogeriatric, stroke and surgical rehab)	Community models of care for mental health, psychogeriatric, stroke and surgical rehabilitation. Model assumptions: • Mental health inpatient units continue to be used but are not rebuilt/replaced at end of life. Community-based, non-Crown-owned facilities are used instead of re-building/building new hospital-based facilities. • 80% of psychogeriatric bed days are managed in non-Crown-owned community contexts. • 80% of stroke patient bed days are managed in non-Crown-owned community contexts. • 80% of surgical rehabilitation bed days are managed in non-Crown-owned community contexts.
New community-based services that reduce demand for hospital-based care	New community services are developed for paediatric acute care and acute ASH conditions, reducing the need for these patients to have acute visits and admissions to hospital. Model assumptions: • 80% reduction in bed days for acute, non-surgical, 1–2-day paediatric hospital stays due to acute care options in the community. • 25% reduction in bed days associated with ASH admissions due to ASH acute care options in the community.
Improved health status reducing the need for hospital care	Greater investment in Tier 1 services targeted to care for long-term conditions (LTCs) in communities with high concentrations of Māori and Pacific populations and high deprivation (NZDep Q5) communities result in better prevention and management of LTCs. Model assumptions: • 50% reduction in bed days for Māori, Pacific or NZDep Q5 patients with acute admissions for asthma, congestive heart failure, COPD or diabetes.
Quality improvement initiatives in hospitals that reduce unwarranted variation	Hospital process improvement reduces unexplained variation in length of stay in general medicine and general surgery. Model assumptions: • General medicine and general surgery events are reduced to the 25th percentile length of stay nationally (applied to events with a length of stay between 1 and 10 days).

Source: NZIER

2.5 Timeframe and discounting

Our results are presented as the total investment requirements for the next 30 years – through to 2052/2053 (undiscounted) in 2022 dollars and as a percentage of GDP based on the Treasury's long-term fiscal forecasts. Results in terms of total GFA and hospital bed numbers are presented in Appendix B.

3 Physical assets in the public health system

3.1 Economies of scale

The economic concept of economies of scale is fundamental to optimising investment in health infrastructure. Economies of scale refers to the ability to reduce the average cost of output as the scale of production increases. In theory, this concept is closely linked to the concept of efficiency – getting the greatest possible output from a given set of inputs. In practice, however, the health sector's inputs, outputs, and costs are difficult to measure.

The challenge of measurement and the criticality of how health systems can manage increasing demand in the face of fixed budgets has led to a wide range of methods being applied to this question.

Perhaps the most important study published on this subject is by Giancotti, Guglielmo, and Mauro (2017), who systematically identified 105 published and peer-reviewed reports over 45 years and analysed the evidence. They found that:

- hospital mergers are often successful due to economies of scale
- in general, results support policies of expanding larger hospitals and restructuring or closing smaller hospitals
- there is consistent evidence of economies of scale for hospitals with 200 to 300 beds
- diseconomies of scale are expected when hospitals have less than 200 beds or more than 600 beds.

What does this mean for New Zealand's hospitals? First, it is useful to note that economies of scale do not have clear implications for physical infrastructure. This is because the link between the scale of output and the physical scale of facilities has never been established. We found no study that addressed this question. In fact, across the published literature, the size of the facility is usually measured and reported as the number of beds.

3.2 Hospital beds as a unit of measurement

Much is made of the use of hospital beds as a measure of the size of health facilities and the capacity of health systems overall, despite it being a commonly used measure in published reports.

In the health sector, there is a great deal of reluctance to refer to hospital beds due to varying definitions of beds in use across the system for different purposes. Definitions of hospital beds can be quite broad, even including any space in a facility that is designed to be occupied by a single patient on a day or overnight basis (i.e. including treatment spaces that are often chairs rather than beds and cubicles in areas like emergency departments where overnight stays are not intended to occur, and even spaces intended for beds where no actual bed exists), or quite restrictive, including only fully-staffed beds designed for overnight stays.

The Ministry of Health has collected data on the number of hospital beds by facility since at least 2009 as part of the HealthCERT certification process for public hospitals. The number of reported beds is believed to represent the number of staffed or unstaffed overnight beds. It is, therefore, the best currently available measure of physical capacity for overnight patients in New Zealand's health facilities. This is also the same data reported to the OECD for international comparisons.

While not all public hospitals report bed numbers every year, the data collected by the Ministry of Health through the HealthCERT certification process allows for an estimation of the total number of beds across all public hospitals as of 2021. That number was 11,713.

Because of the varying definitions of beds in use across the system for different purposes and if the number reported to HealthCERT by public hospitals really does refer to only resourced overnight beds, bed capacity in the system could potentially be higher.

3.3 How many hospital beds do we need?

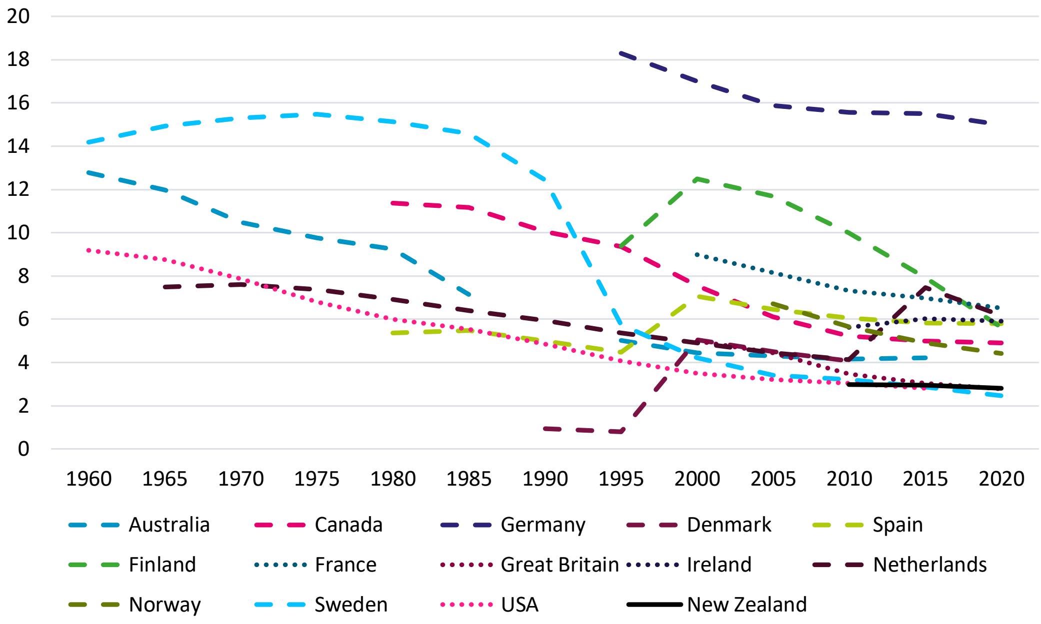
Hospital beds are a critical element of our modelling and the unit of measure in published studies that require a measure of facility size.

New Zealand's stock of hospital beds has been a subject of intense interest, and for good reason: To the extent that hospital care relies on overnight stays in particular, the number of beds directly impacts access to care. Planned care, in particular, is impacted by the degree to which the supply of beds at any point in time falls short of demand or need because acute care needs tend to be prioritised over care that can be delayed. A familiar symptom of bed shortages, therefore, might be increasing waits for planned care. But waitlists can be manipulated by changes in eligibility criteria, so falling intervention rates can be a more reliable indicator of this concern.

The OECD has collected data on hospital beds from member countries and others since the 1960s. While the data is patchy for many countries due to a lack of continuity in reporting and definition changes, taken as a whole, the data indicates a clear downward trend (see Figure 11 below). The downward trend in hospital beds reflects, to some extent, the decreasing length of stay associated with improvements in surgical techniques and quality of care and the general shift towards ambulatory care and recovery and rehabilitation at home or in the community. These trends have dramatically affected the overall demand for hospital beds despite population growth and ageing. These trends have been factors in the evolution of New Zealand's hospital bed ratio as well.

Figure 11 Hospital beds per 1000 population in OECD countries

1960–2020



Note: New Zealand has only submitted data on hospital beds per 1000 population to the OECD since 2010.

Source: NZIER, OECD data

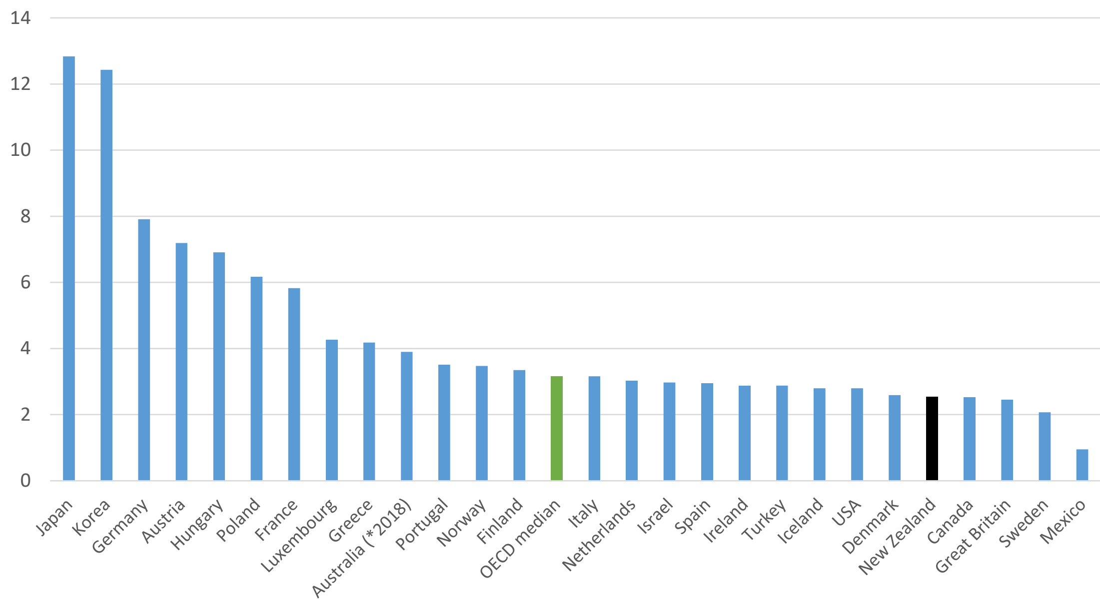
As of 2019 – the most recent year before the COVID-19 pandemic, which saw increases in the number of hospital beds in some countries (with some potentially temporary or specifically for pandemic response), the OECD report that New Zealand's number of hospital beds per 1000 population was 2.5 – a ratio similar to that of Denmark, Canada, Great Britain and Sweden.

While New Zealand's number of hospital beds per 1000 is sometimes criticised as being well below the OECD average of 4.4 beds per 1000 population, this average is heavily influenced by Japan and Korea, countries with a very different model of care characterised by long hospital stays – averaging over 16 days per patient compared to New Zealand's 7.1 days in 2017 (OECD 2019b) and also Mexico's very low bed-to-population ratio.

An OECD median removes the strong influence of outliers to produce a more appropriate comparator of 3.16 beds per 1000 population, still above New Zealand's 2.54 beds per 1000 (see Figure 12 below).

Figure 12 Hospital beds per 1000 population

OECD countries



Source: NZIER, OECD data

A report comparing the health system performance of 11 high-income countries (The Commonwealth Fund 2021) found that New Zealand's health system performance ranks sixth amongst the countries it analysed, in a group of three – along with the UK and Germany – that sit at about the average for the 11 countries. Norway, the Netherlands, and Australia were found to have the highest-performing health systems based on:

- Australia being first for health outcomes and for equity, and second for administrative efficiency
- Norway being first for administrative efficiency and second for health outcomes and access to care
- The Netherlands being first for access to care.

Figure 13 Overall performance of selected countries' health systems

Source: The Commonwealth Fund, 2021

Based on these three high-performing countries, if the ratio of beds to population is a key factor in health system performance, then New Zealand's bed-to-population ratio may be lower than ideal:

- Australia's most recent ratio was 3.9 beds per 1,000 population (Australian Institute of Health and Welfare 2019[6])
- Norway's ratio was 3.5 per 1,000 population (OECD 2019b)
- The Netherlands' ratio was 3.0 beds per 1,000 population (OECD 2019b).

On the other hand, Germany's bed-to-population ratio of 7.9 (OECD 2019b) has apparently not assured better performance than New Zealand or the UK's health systems, both of which had ratios of 2.5 beds per 1000 population, according to the OECD data that year, the unsurprising takeaway being that hospital beds alone do not lead to better outcomes.

However, affordability is also a key concern for health systems. Based on 2019 OECD data, New Zealand spent 9 percent of its GDP on the health system (OECD 2019a), while Germany, Norway, the Netherlands and Australia all spent in excess of 10 percent on their health systems.

Countries with a similar hospital bed-to-population ratio to New Zealand's (USA, Denmark, Canada and the UK) all spent more as a percentage of GDP on their health systems in 2019.

In summary, there is no indication from the data that there is an ideal ratio of hospital beds to population. But New Zealand is below the OECD median, and a further reduction in our bed-to-population ratio may be neither achievable nor desirable.

3.4 Gross floor area

Gross floor area is a measurement concept used in buildings. It refers to the total area of a space, including exterior and interior walls. It is larger than the actual useable space in a

6 This data is closer to the 2019 reference year than the 2016 data that Australia last reported to the OECD.

building but is more closely related to the construction cost of the building since it encompasses the walls.

In practice, and most commonly in the health sector, GFA can also refer to the space immediately surrounding an inpatient bed or within an inpatient ward.

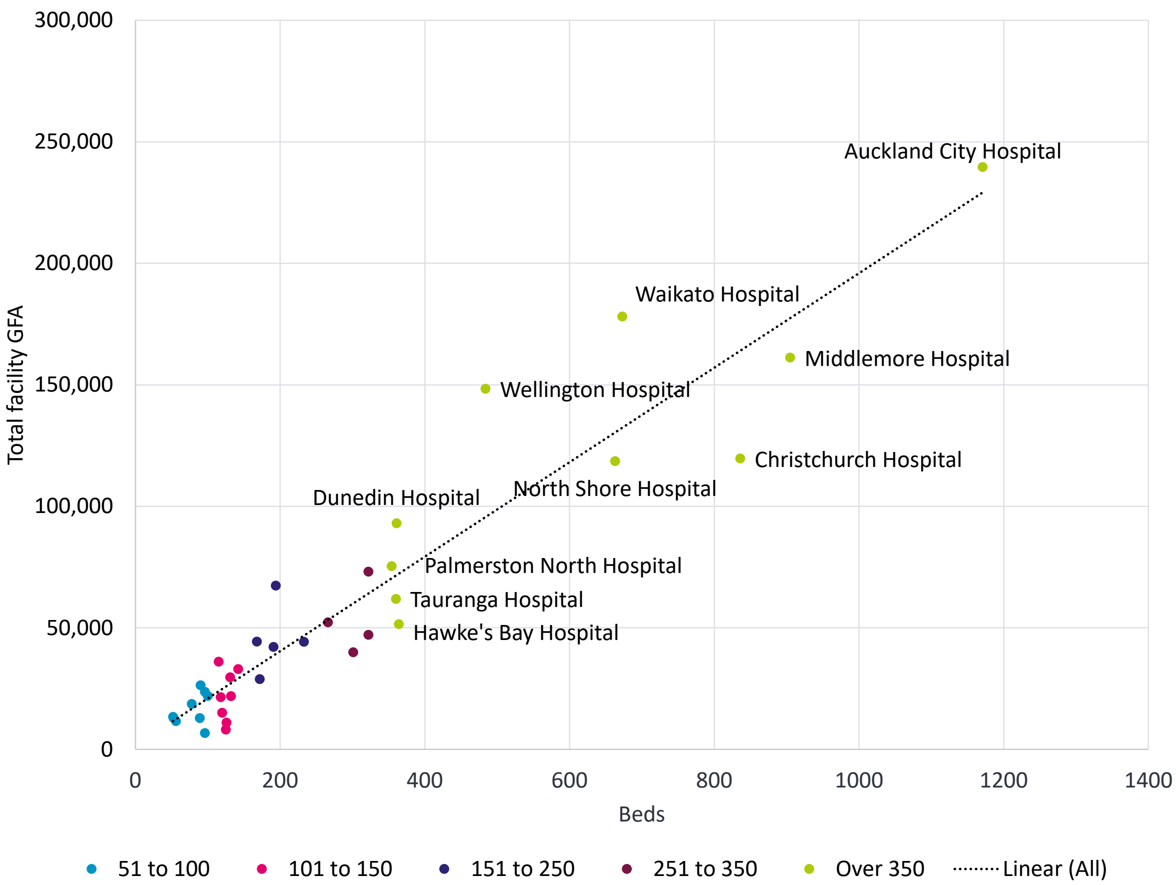
In this report, we differentiate between two concepts of GFA: 'total facility GFA', which is the total gross floor area of all buildings within a particular facility. 'Total facility GFA per bed', therefore, refers to the total gross floor area of the facility divided by the number of beds. We use 'inpatient GFA' to refer to the area around inpatient beds within an inpatient ward. This concept ignores other spaces across the facility but is useful for ensuring the specific space meets established standards.

3.5 Relationship between beds and total facility GFA

Focusing on facilities with inpatient services being a key function (those with over 50 beds), unsurprisingly, there is a positive relationship between total facility GFA and the number of beds in a facility. As shown in Figure 14 below, overall, the relationship appears to be moderate to strong and linear, indicating that our use of hospital beds as a unit of measure from which to estimate total facility GFA is reasonable at a national level.

Figure 14 Relationship between total facility GFA and number of beds

By facility size as measured by bed number



Source: NZIER, Te Whatu Ora and Ministry of Health data

But Figure 14 also shows some variation, with facilities below the trendline demonstrating a relatively high number of beds for their respective floor area (e.g. Christchurch Hospital) and those above the trendline demonstrating a relatively low number of beds for their respective floor area (e.g. Wellington Hospital). The variation appears to indicate that some efficiencies could be gained in using GFA.

The variation also shows that facilities with 0 to 50 beds likely offer a very different care model. For example, Greenlane Hospital is a major outpatient and day surgery facility with very few overnight beds. Removing facilities with 50 or fewer beds from the sample, to focus on facilities that are most appropriate for modelling based on inpatient care reduces the average slightly to 202 square metres per bed. This total facility GFA is used in our model.

Table 6 below shows the total facility GFA per bed in each facility, grouped by facility size.

Table 6 Average total facility GFA per bed in hospitals of different sizes

Size measured in number of beds

Size of the facility (number of beds)	Total facility GFA per bed	Number of facilities
0-50*	318.64*	30
51-100	208.09	9
101-150	174.40	8
151-250	236.78	5
251-350	175.28	4
>350 (all)	202.09	10
>350 and tertiary	220.90	5
Average	**206.23**	**66 (total)**
Average for facilities with >50 beds	**202**	**36 (total)**

* Category includes Greenlane Hospital (major outpatient and day surgery facility with very few overnight beds)

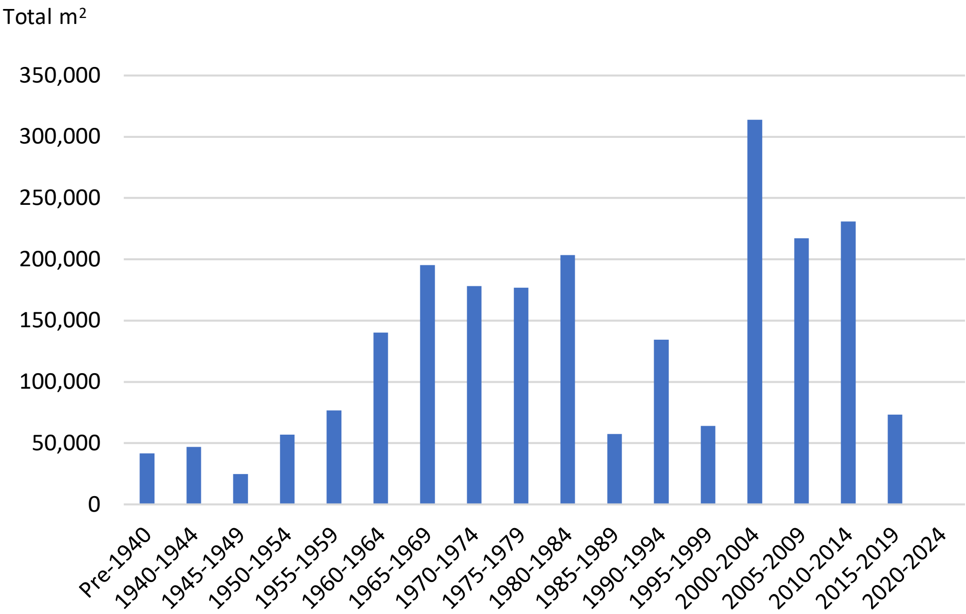
Source: NZIER, Te Whatu Ora data

3.6 Buildings

Many Crown-owned health facility buildings that support inpatient and other health services are old and in a very poor state. To model what investment may be needed, we assumed in our base case that buildings exceeding 50 years of age would be due for replacement (this was increased to 70 years in our sensitivity analysis).

Figure 15 below shows a large amount of demolition and rebuilding that a 50-year useable life for buildings would mean (anything built before 1972 is considered end-of-life in our base case).

Figure 15 Total GFA by year built



Source: NZIER

4 Future capital requirements

Our model estimates the level of capital investment required to meet the needs of the New Zealand population through to 2053 to the same extent that the health system was able to do in 2019 (based on 2019 rates of inpatient events and planned surgeries) with additional improvements in services and equitable service delivery as well as safer occupancy levels.

That is, the model estimates the level of capital investment required to:

- address the current deficit and maintain existing assets for the current population
- meet the needs of a growing population
- meet the needs of an ageing population
- meet the needs of an increasingly ethnically diverse population
- expand services and add new services as hospitals grow and change with the population centres around them
- improve safety and effectiveness by meeting established standards for floor area allocated to inpatient and mental health inpatient beds, and safer bed occupancy
- support new service offerings that are likely to occur, particularly as populations in some centres grow and the range of services offered locally can be safely and efficiently expanded
- support person- and whānau-centred care with new spaces designed to respond to cultural needs and improve patient experience of care
- support improved equity through equitable access to planned surgery.

To support broader health system decision-making, we also present in Appendix B estimates by decade over the next 50 years of the number of physical units (beds and GFA) needed to simply:

- address the current deficit and maintain existing assets for the current population
- meet the needs of a growing population
- meet the needs of an ageing population
- meet the needs of an increasingly ethnically diverse population.

4.1 Bringing the current stock up to date and maintaining existing and replacement assets

Because the sector faces a deficit in health infrastructure, including end-of-life assets due for replacement and many others overdue for refurbishment, considerable investment is needed even if the population remains constant over the next 30 years. This would include:

- 'catching up' on refurbishments that were needed but not carried out (we assume a decade of missed refurbishments prior to the NAMP (2008–2018)
- demolition and replacement of end-of-life buildings

- ongoing refurbishment of all buildings within their useable life according to the refurbishment schedule described in section 2.4.2, including all of those built to replace end-of-life assets as well as existing buildings that continue to be used.

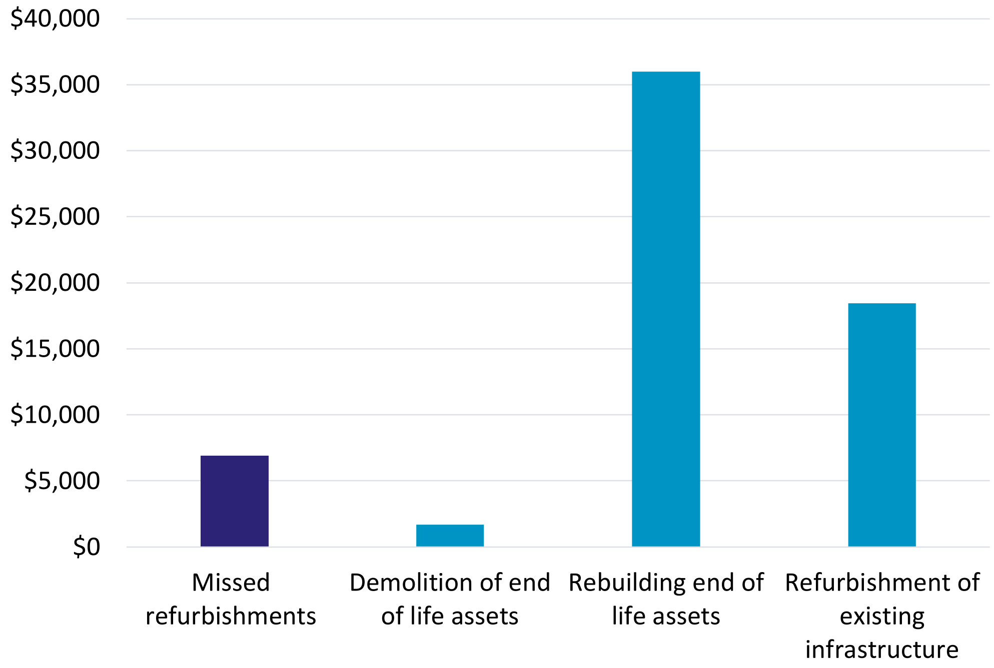
The final report of the Health and Disability Review noted that in addition to the $14 billion infrastructure deficit that had been estimated by the Ministry of Health based on buildings that had reached the end of their useable life, many buildings were in a poor state, having been poorly maintained for a long period of time. While the underlying assumptions of that estimate are unknown, our sensitivity analysis, which includes a range of potentially realistic scenarios for actual or expected refurbishment cycles, includes one scenario that is consistent with the $14 billion deficit (a 50-year life expectancy for buildings with two moderate and two major refurbishments over this time). Our model assumes that all buildings missed refurbishments that would have been expected under our base case refurbishment schedule (see section 2.4.2) from 2008 to 2022. The resulting investment required to 'catch up' on missed refurbishments is shown in Figure 16 below at almost $7 billion.

In 2018, the Ministry of Health estimated that the health sector had a $14 billion deficit of buildings needing replacement (Ministry of Health 2020) over ten years. Using our base case assumptions for building life expectancy and refurbishment cycle, Rather than input this value directly to our model, we estimate the cost of demolishing and replacing all buildings that have already reached or will reach the end of their useable life through to 2052/2053. The resulting estimated end-of-life demolition cost is approximately $2 billion over this timeframe, and the cost of replacing or rebuilding those assets is approximately $36 billion (see Figure 16 below). This means all assets needing replacement that the Ministry of Health identified are included in these estimates, but the cost of replacement reflects our updated cost estimates.

Finally, we estimate the cost of ongoing refurbishment for existing buildings that remain within their useable life and for buildings that have replaced those that have been demolished. The resulting estimated cost of ongoing refurbishment of all hospital assets from 2022/2023 to 2052/2053 is approximately $18 billion (see Figure 16 below).

Figure 16 Infrastructure investment required to address the current end-of-life asset deficit and maintain existing assets

2022/2023 to 2052/2053, $ millions



Source: NZIER

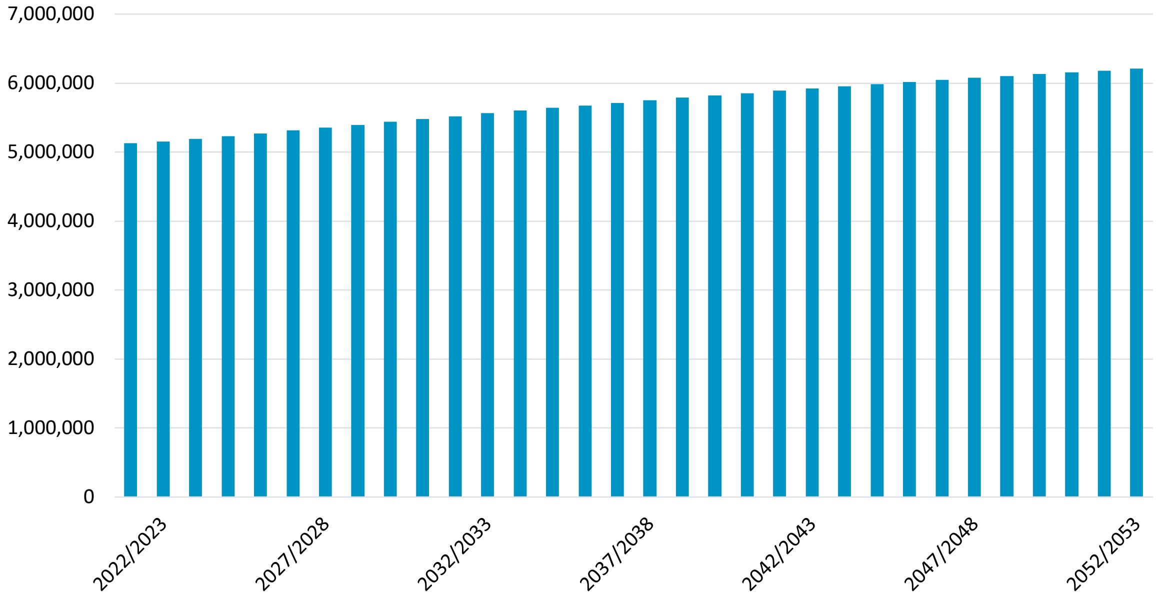
The cost of addressing the deficit and demolishing, rebuilding and refurbishing existing assets as expected with a 50-year useable life and the assumed regular refurbishment schedule is expected to be $63 billion.

4.2 Health infrastructure for a growing population

Between 2022/2023 and 2052/2053, the population of New Zealand is forecast to grow by 21 percent – an additional 1,060,000 people (see Figure 17).

Figure 17 Population projection in the model

Headcount of total New Zealand population, 2021/2022 to 2052/2053



Source: NZIER, Stats NZ data

Without considering ageing and the changing ethnic composition of the population, and without changes in the patterns of utilisation of health services, population growth alone is expected to put pressure on health infrastructure through greater demand for services.

Our model assumes each 5-year age-ethnicity subgroup of the population will continue to use health services at the same rate it did in 2019. The resulting total number of bed days then translates into a number of beds, which implies a national total facility GFA based on the average total facility GFA per bed in the current health system: 193 square metres per bed (excluding facilities with 50 or fewer beds (see section 3.5)).

The difference in total national GFA each year represents the need for new builds, the cost of which is estimated using the new build cost per square metre. These new builds then enter the refurbishment cycle, with costs calculated according to the assumed refurbishment cycle described in section 2.4.1.

Even without considering that the population is also ageing and changing in ethnic composition, population growth alone is expected to generate demand of just over $10 billion worth of new health infrastructure with refurbishment costs of almost $1.5 billion to 2052/2053. Both are small relative to the expected cost of replacing and refurbishing existing assets. In total, population growth alone is expected to create pressure for approximately $12 billion in infrastructure investment.

4.3 Health infrastructure for an ageing population

Between 2022/23 and 2052/53, New Zealand's population is expected not only to grow but to become older on average. This is due to the continuing ageing of the baby boom generation, continued advances in medicine that reduce mortality at younger ages, and a declining birth rate.

Isolating the impact of population ageing, we estimate that this trend is expected to generate pressure for $25 billion worth of infrastructure investment in new buildings and $3.7 billion worth of investment in the scheduled refurbishment of those buildings within the next 30 years.

4.4 Health infrastructure for a population with a changing ethnic composition

Over 30 years, the ethnic composition of the population can change significantly. Ethnicity is important where patterns of health service utilisation are concerned because genetic predispositions, socioeconomic differences, and institutional racism all contribute towards the different prevalence of disease, rates of complications, exposure to injury, access to preventive care, etc. Significant differences are observed in planned and acute hospitalisations and surgery rates, length of stay, and bed days per person.

In total, the changing ethnic composition of the population alone is expected to create pressure for approximately $3.6 billion in infrastructure investment, including new buildings and refurbishments needed to accommodate this change over 30 years.

4.5 Expanding services as hospitals grow

As the population grows, some centres may be able to support additional services being offered in their local hospital. We assumed this was most likely to occur in medium to large-sized hospitals. That is, hospitals with more than 350 beds that are not currently operating as tertiary facilities would provide services similar to those that currently operate as tertiary facilities, and hospitals with 251-350 beds would provide services similar to those that currently have 350+ beds but don't operate as tertiary facilities.

Table 7 below shows the hospitals that are modelled as expanding services in such a way that they take on the total facility GFA requirements of a tertiary hospital.

Table 7 Current tertiary, future tertiary, and other hospitals modelled as 'upgraded'

Current tertiary hospitals	Hospitals with >350 beds upgraded to tertiary hospital total facility GFA per bed	Hospitals currently with 251-350 beds upgraded to larger hospital total facility GFA per bed
Auckland	Hawke's Bay	Burwood
Christchurch	Middlemore*	Waitakere
Dunedin	North Shore	Whangarei
Waikato	Palmerston North	
Wellington	Tauranga	

* Middlemore does offer some tertiary services and would continue to expand these.

Source: NZIER, Te Whatu Ora data

In addition to growing bed numbers and associated total facility GFA to accommodate their growing populations, as shown in Table 8 below (extract from Table 6), these shifts would be expected to result in higher total facility GFA per bed.

Table 8 Average total facility GFA per bed in facilities of different sizes

Facility size measured in the number of beds

Size of the facility (number of beds)	Total facility GFA per bed (m^2)
251-350	175.28
>350 (all)	202.09
>350 and tertiary	220.90

* Category includes Greenlane Hospital (major outpatient and day surgery facility with very few overnight beds)

Source: NZIER, Te Whatu Ora data

Our estimate of the investment required is achieved by applying the building cost per square metre to the additional square metres required for the initial construction of expanded space and by applying the refurbishment costs to the additional square metres according to the refurbishment cycle described in Figure 10.

The result of this adjustment is an additional investment of over $4.3 billion by 2052/2053.

4.6 Improving safety and effectiveness by meeting established standards for bed space

With the data available in New Zealand, a comprehensive assessment of ward-level GFA per bed is not possible as a desk-based exercise. However, the NAMP undertook some specific investigations that identified that many New Zealand health facilities did not provide sufficient space in the immediate area of beds for clinical safety and effectiveness and identified the shortfall in square metres relative to the AusHFG guidelines. The calculated shortfall represents a deficit of 9 square metres per bed on average in inpatient facilities and 7 square metres per bed on average in inpatient mental health facilities.

Our estimate of the investment required is achieved by applying the building cost per square metre to the number of additional square metres required to meet the AusHFG guidelines and by applying the refurbishment costs to the additional square metres according to the refurbishment cycle described previously in Figure 10 over 30 years.

This adjustment results in an additional investment of $2.6 billion by 2052/2053.

4.7 Supporting person- and whānau-centred care

The health and disability system reforms envisage services that are person and whānau centred. A key element of this approach is the provision of spaces that allow whānau to be close to patients for long periods, even providing affordable on-site accommodation where patients and whānau have travelled long distances.

The Whangarei detailed business case showed how these improvements could be factored into our model. The business case details the GFA and cost requirements of these elements:

- a whānau room of 36 square metres for each inpatient ward
- a whānau house of 265 square metres.

Because our data do not allow inpatient wards to be specifically described, our model assumes an inpatient ward is approximately 30 beds, so one whānau room would be added for every 30 inpatient beds. We also assumed there would be only one whānau house per facility and that facilities with less than 50 beds most likely serve a very local community and, therefore, would not require one.

Our estimate of the investment required is achieved by applying the building cost per square metre to the additional square metres required to provide these spaces in every hospital and by applying the refurbishment costs to the additional square metres according to the refurbishment cycle described in Figure 10.

The result of this adjustment is an additional investment of $215 million by 2052/2053.

4.8 Supporting improved equity of access to planned care

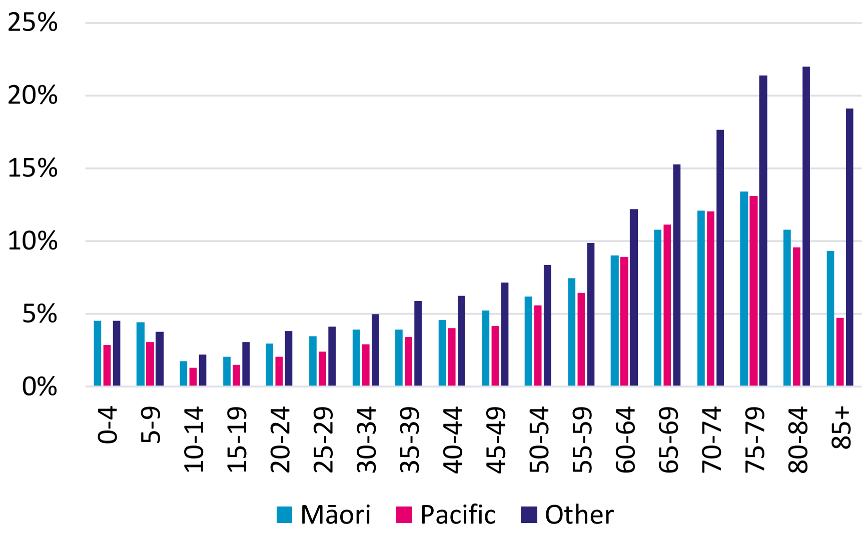
Planned surgeries are an area where inequitable access has been previously identified (Te Whatu Ora 2022). Our data analysis indicates wide variation in the planned care surgical discharge rates by ethnicity within 5-year age bands. Addressing inequities in access to planned care requires a system approach, including addressing access to primary care, access to radiology, referral processes, access to first specialist assessments, surgical eligibility criteria, and the workforce and infrastructure constraints contributing to these issues.

We use the 2018/2019 (pre-COVID) discharge rates combined with the 2022/2023 population data to illustrate what equity in planned surgeries would imply for inpatient beds and infrastructure costs in the current year.

In 2018/19, planned surgical discharge rates were significantly lower for Māori and Pacific people in almost every age group (see Figure 18 below).

Figure 18 Planned surgical discharge rates in planned care

By age group and ethnicity, 2018/2019



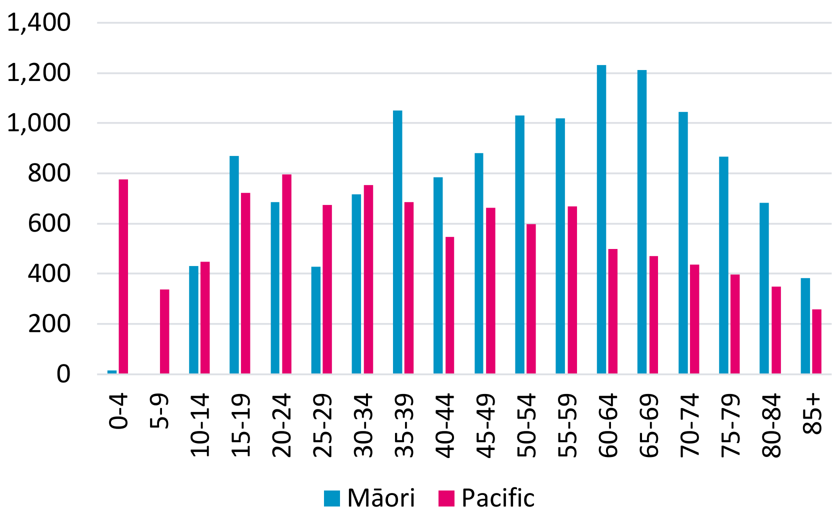
Note: Based on prioritised ethnicity. Other ethnicity is any ethnicity where Māori or Pacific ethnicity is not identified.

Source: NZIER, Te Whatu Ora data

Addressing the inequity of access to planned surgery will create additional demand for planned surgeries. To put this into perspective, if the 2018/2019 discharge rates remained for 2022/2023, equitable access would create additional demand amounting to nearly 23,409 additional events in 2022/2023 (see Figure 19 below). Most additional events would be in people aged 45 and older, but significant volumes would also be seen in 10- to 44-year-olds.

Figure 19 Additional surgical volumes resulting from equitable access to planned care

Total additional planned surgeries by age group, 2022/2023

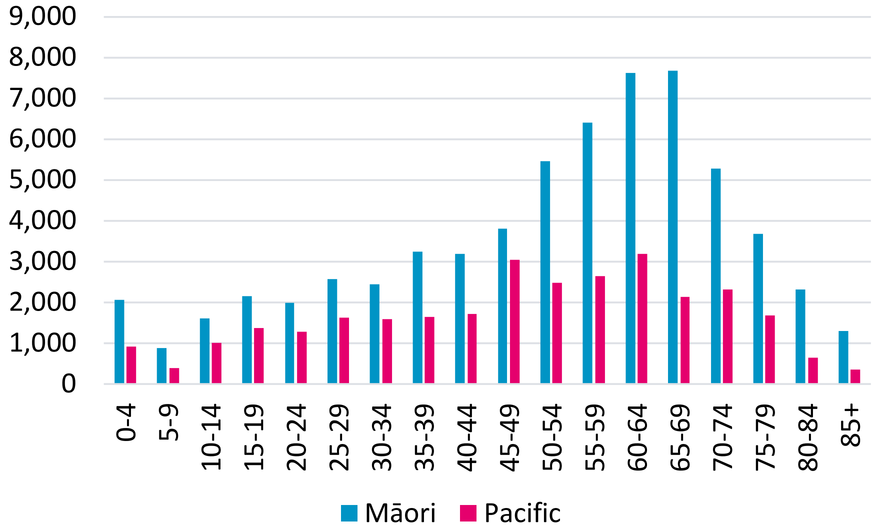


Source: NZIER

Based on the additional surgeries expected, additional inpatient bed days would occur in New Zealand's hospitals. These would amount to an additional 93,515 bed days in 2022/23. With people aged 45 and over benefiting from a disproportionate share of additional planned surgeries and lengths of stay for older patients often being longer, the additional bed days are concentrated in older age groups (see Figure 20 below).

Figure 20 Additional bed days associated with equitable access to planned care

Total additional bed days by age group, 2022/2023



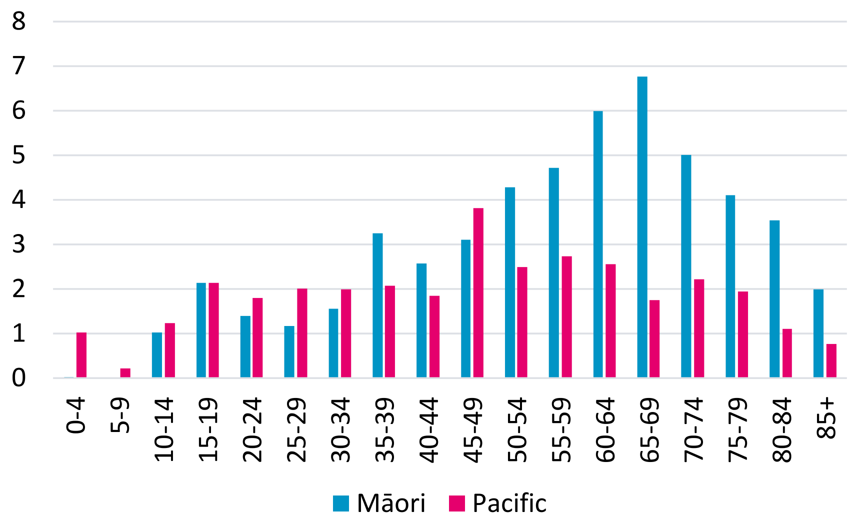
Source: NZIER

Based on beds being available 365 days per year (a reasonable assumption given most surgical bed days are in inpatient wards or ICU), the additional bed days translate into a need for 86 additional beds nationally in 2022/2023.

With an assumption of bed availability 24 hours per day, 365 days per year, these bed days translate into an additional 86 beds needed to support equitable access in 2022/23, with 61 percent of these beds expected to benefit Māori access to planned surgeries and 39 percent of these expected to benefit Pacific access to planned surgeries (see Figure 21 and Figure 22 below).

Figure 21 Additional beds associated with equitable access to planned care

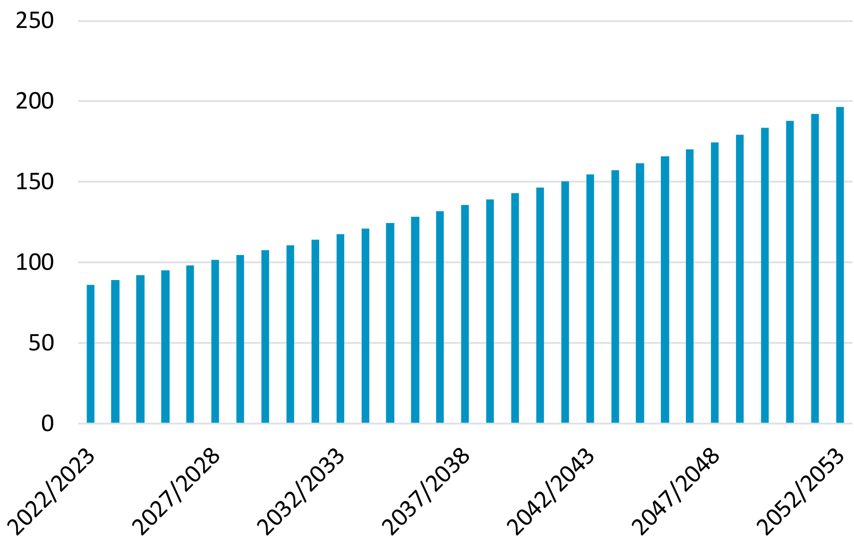
By age group, 2022/2023



Source: NZIER

Figure 22 Cumulative total additional beds required to support equitable access to planned surgery

2022/2023 to 2052/2053

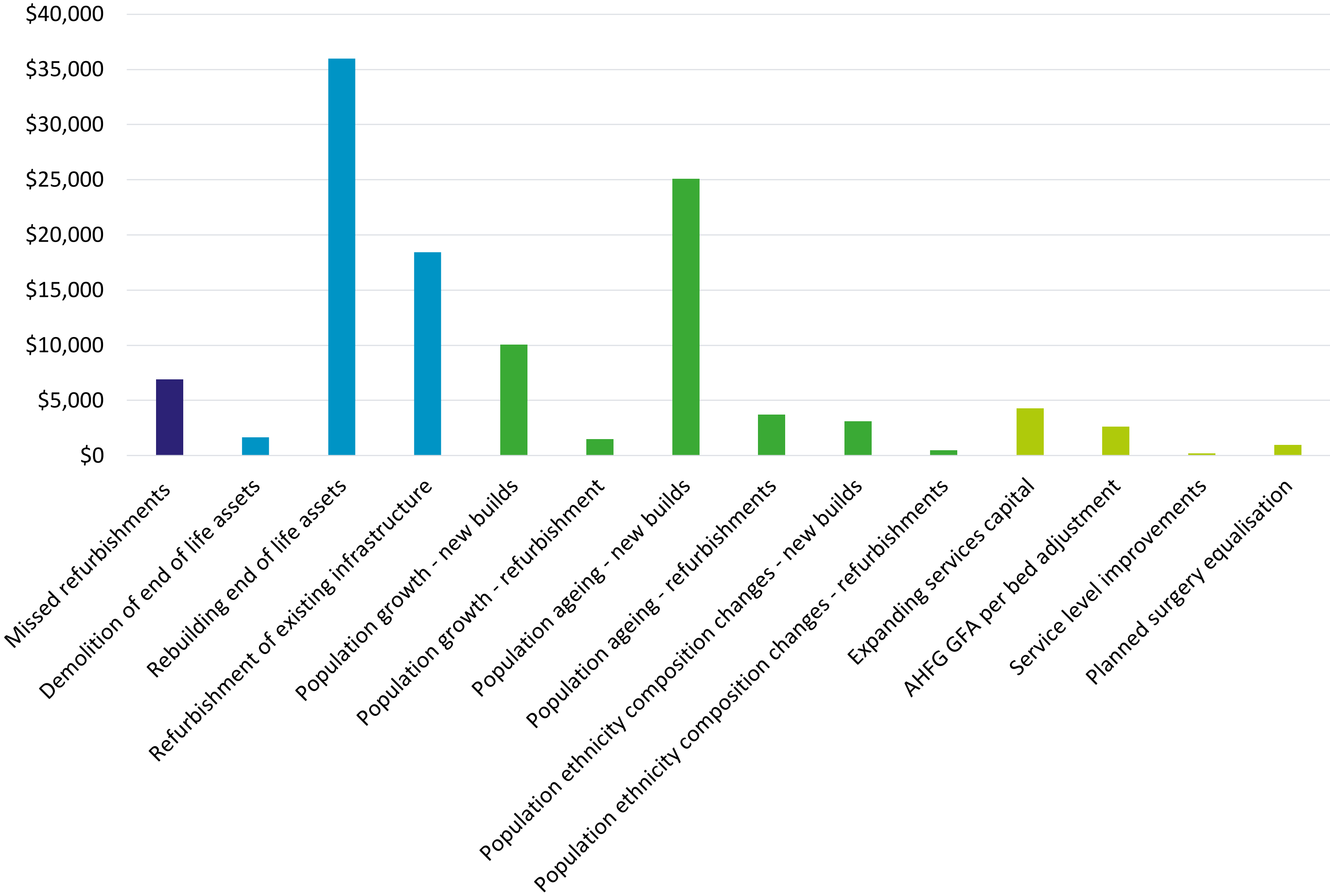


Source: NZIER

We estimate the infrastructure investment required to support this equity improvement using the average total facility GFA per bed and the costs of building and refurbishing over 30 years (see Figure 26 below). The result of this calculation is an additional investment of approximately $964 million by 2052/2053.

Figure 23 Additional health infrastructure investment required to support equitable access to planned care

2022/2023-2052/2053, $ millions



Source: NZIER

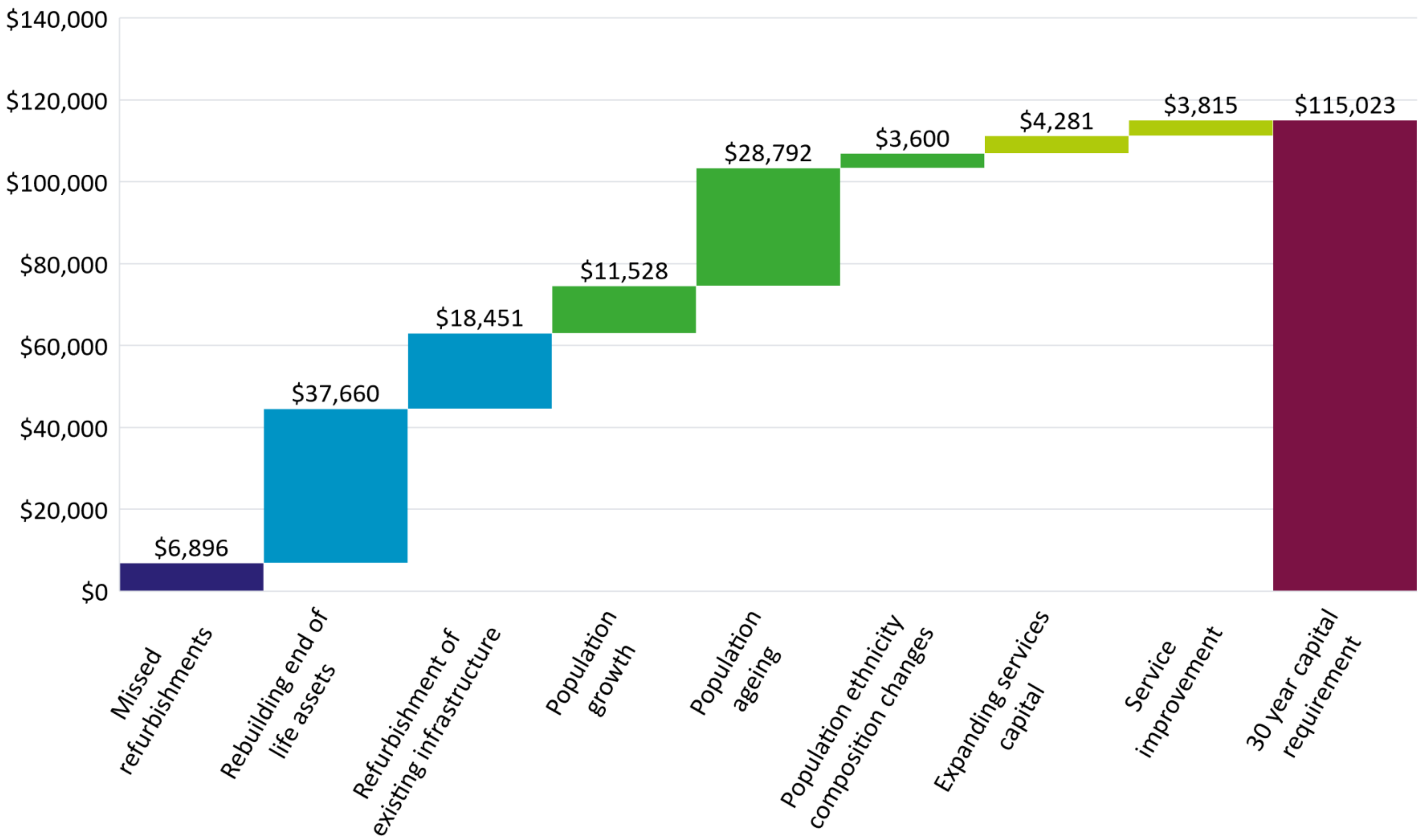
5 The potential total investment required over 30 years for an aspirational future hospital network

Adding up all the categories of investment produces over $115 billion that would be required to be invested in Crown-owned health infrastructure over the next 30 years (see Figure 24). Of this:

- $63 billion (55 percent) is required just to update, replace, and maintain the existing stock, including:
  - missed refurbishments on existing buildings, accounting for 6 percent of the total investment
  - rebuilding/replacing existing assets at end-of-life accounting for 32.7 percent of the total investment
  - ongoing refurbishment of existing and new buildings accounting for 16 percent of the total investment
- $44 billion (38 percent) is required just to accommodate a growing, ageing and demographically changing population's needs with the same level of services that the current population benefits from, including:
  - population growth accounting for 10 percent of the total investment
  - population ageing accounting for 25 percent of the total investment
  - changing ethnic composition of the population accounting for 3.1 percent of the total investment
- $8 billion (7 percent) is required to support the service expansion and service improvements we modelled:
  - expansion of services accounting for 3.7 percent of the total investment
  - service improvements with an equity focus accounting for 2.3 percent of the total investment

Figure 24 Total health infrastructure investment required over 30 years

2022/2023-2052/2053, $ millions



Source: NZIER

6 Reducing future capital requirements in the health sector

6.1 Individual interventions and double-counting

In identifying potential patient populations for a model of care changes, we noted that there could be considerable overlap, which would result in double counting of impacts when the scenario of combined interventions is presented. To deal with this, we present:

- the individual intervention values to demonstrate the impact that each intervention has if implemented alone
- the ranking of interventions by magnitude of impact
- the individual intervention values are based on an implementation order that prioritises those with the largest impacts first and shows the marginal impact achieved by proceeding with the next intervention.

6.2 Shifting capital expenditure to operating expenditure

An important point to note is that model of care changes that offer the potential to reduce Crown investment in hospital infrastructure may have implications that result in increased investment in private infrastructure or increased Crown operational expenditure. Because this report – and our model – focus on Crown hospital infrastructure requirements, these implications for private infrastructure investment and/or Crown operating expenditure are not estimated.

6.3 Impacts of individual interventions

6.3.1 Shifting care from hospitals to community contexts

Care delivered in hospitals is safe and effective, but for some patients, equally safe and effective care could potentially be delivered in other contexts, including community contexts, and this may be possible to achieve without Crown-owned infrastructure.

Te Whatu Ora indicated that inpatient groups that could potentially benefit from a significant shift towards care in a community context include:

- mental health patients
- psychogeriatric patients
- stroke patients
- surgical rehabilitation patients.

Te Whatu Ora also indicated that major shifts in the context of care for these patient groups are not currently under consideration and, therefore, had not been subject to a process of stakeholder engagement, service design, and assessment for clinical safety and effectiveness – processes that are essential to identifying where and how changes in the context of care might be appropriate. Consequently, any assessment of the potential impact of a change in the context of care on future investment in hospital facilities is a purely theoretical exercise, but one which nonetheless may offer important insights about the scale of impact of changes in the context of care for different groups of patients.

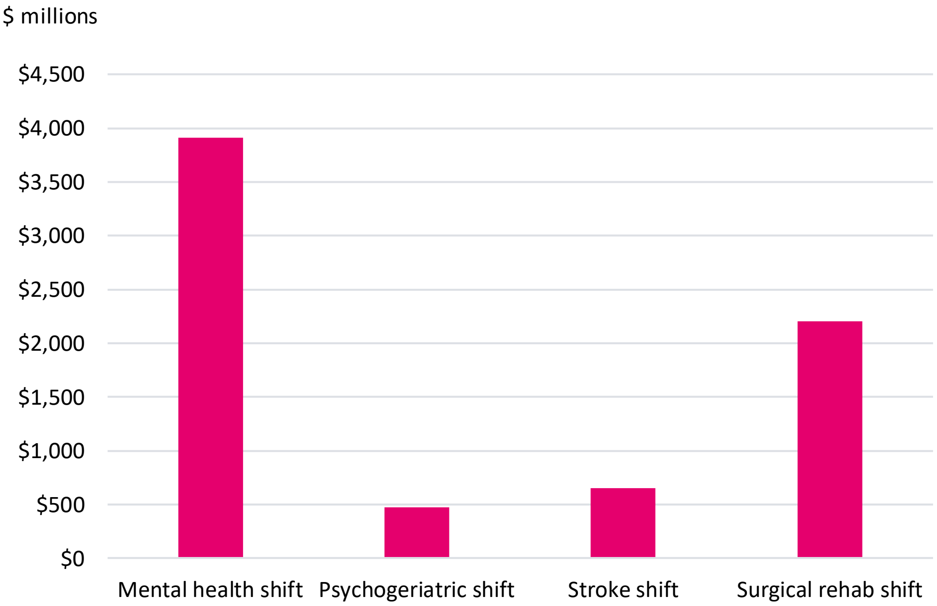
Furthermore, this is an example of an option that effectively shifts Crown capital expenditure to Crown operating expenditure due to the requirement for Te Whatu Ora to rent non-Crown-owned facilities or otherwise contract with private service providers who need to cover infrastructure costs.

Using the examples provided by Te Whatu Ora, we made several assumptions about how a shift in the context of care might occur:

- Mental health inpatient units are modelled as continuing to be used but not rebuilt/replaced at end of life. Community-based, non-Crown-owned facilities would be used instead of re-building/building new hospital-based facilities.
- Eighty percent of psychogeriatric bed days are modelled as managed in non-Crown-owned community contexts.
- Eighty percent of stroke patient bed days are modelled as managed in non-Crown-owned community contexts.
- Eighty percent of surgical rehabilitation bed days are modelled as managed in non-Crown-owned community contexts.

The impact of these shifts is shown in Figure 25 below.

Figure 25 Impact of shifting care to community contexts without Crown infrastructure investment



Source: NZIER

6.3.2 Child acute care and new Tier 1 acute care options

Acute demand is a major pressure on public hospitals. Some conditions and injuries that present to hospitals on an acute basis require hospital-level care, but some do not and could be dealt with in primary care. Emergency department presentations often result in admissions and overnight stays in cases where a patient could have been managed in a community context and returned home the same day.

We modelled the impact of new community services that could be developed for paediatric acute care and acute conditions, resulting in Ambulatory Sensitive Hospitalisations (avoidable through interventions that can be delivered in primary care) (ASH conditions). Extended primary care hours, 24-hour acute care clinics and coordinated response could divert many patients who would otherwise visit the emergency department to appropriate community-based care, ensuring good outcomes while reducing the pressure on Crown-owned infrastructure.

In this case, it may be possible for community-based services to handle increased volumes with additional workforce, but it is unclear whether a commensurate reduction in the hospital-based workforce could be achieved. So, while this option may not reflect a direct shift of Crown capital expenditure to Crown operating expenditure associated with increased use of non-Crown-owned facilities, some increase in Crown operating expenditure may be expected through contracts with service providers.

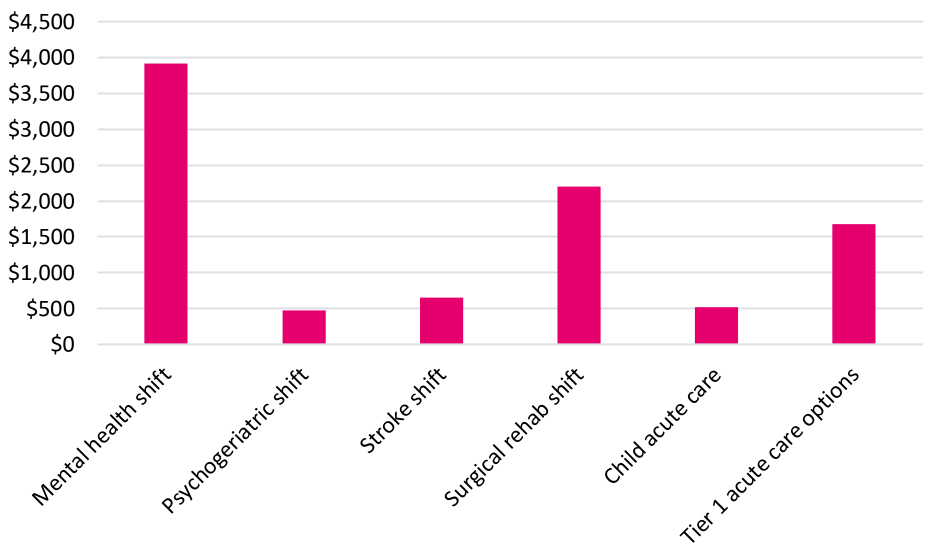
Our discussions with key Te Whatu Ora officials led to agreement on two assumptions about the potential impacts of an effective intervention of this type:

- 80 percent reduction in bed days for acute, non-surgical, short (1–2-days) paediatric hospital stays due to acute care options in the community
- 25 percent reduction in bed days associated with ASH admissions due to ASH acute care options in the community[7].

The impact of this model of care change is shown in Figure 26 below.

Figure 26 Impact of Tier 1 and Tier 2 acute care options

$ millions



Source: NZIER

7 See Appendix C for the list of ASH conditions modelled.

6.3.3 Improved health status

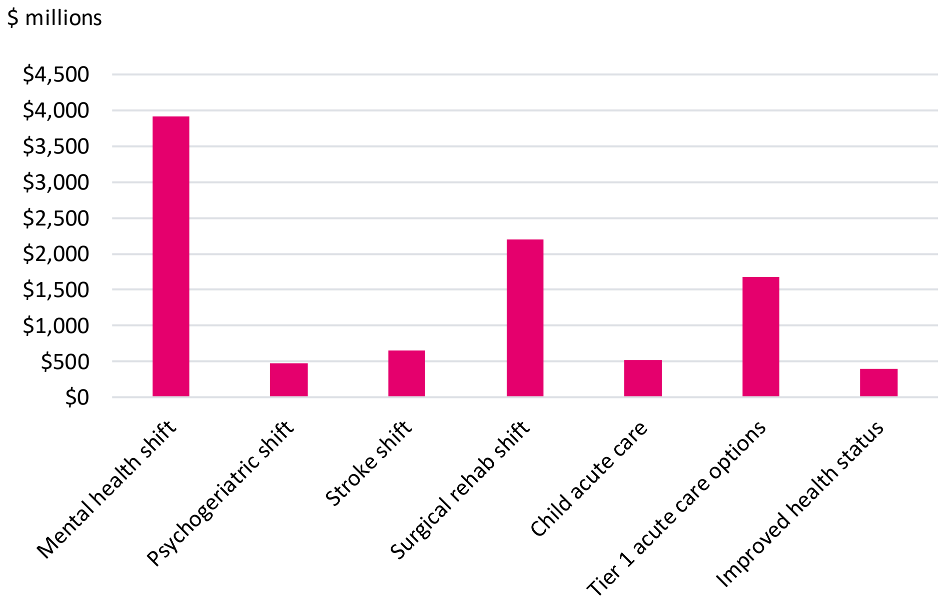
Improved health status can reduce the need for hospital care and, therefore, reduce the pressure on health infrastructure.

Population health improvement to reduce the need for hospital care is a major theme of the current system reforms, which envisage a greater role in preventing and managing long-term conditions through stronger primary care and other Tier 1 services. This intervention is different from the new community-based services to address acute demand that are modelled in the previous section. This intervention is focused on prevention: Primary prevention and secondary prevention, which are expected to result not only in reduced demand for hospital-based services but also for community-based acute care.

Our discussions with key Te Whatu Ora officials led to the agreement that the intervention would:

- focus on preventive care for asthma, congestive heart failure, COPD and diabetes
- be targeted to communities with a high prevalence of long-term conditions (communities with a high concentration of Māori and Pacific population and high deprivation (NZDep Q5))
- result in a 50 percent reduction in bed days for Māori, Pacific or NZDep Q5 patients with acute admissions for targeted conditions.

Figure 27 Impact of improved health status



Source: NZIER

6.3.4 Reducing unwarranted variation

The health and disability system white paper (Department of Prime Minister and Cabinet 2021) laid out a goal of achieving consistent, high-quality health services for all New Zealanders, particularly groups that have been traditionally underserved. The reforms envisage improvement in quality and equity as well as achieving "*excellence*" – ensuring “*consistent, high-quality care everywhere, supported by clinical leadership, innovation and new technologies to continuously improve services*”.

The Kings Fund (Appleby et al. 2011) has identified that “*many of the most significant opportunities to improve productivity will come from focusing on clinical decision-making and reducing variations in clinical practice across the NHS*” and recommended reducing variation as a key priority for the NHS.

Health care variation is typically expressed as a difference in the rate, or age-adjusted rate – of use, expenditure, activity or event—between two subjects of interest that could potentially be alike. Such comparisons can be made across patients, patient groups, population groups, clinicians and provider organisations, geographic areas and countries.

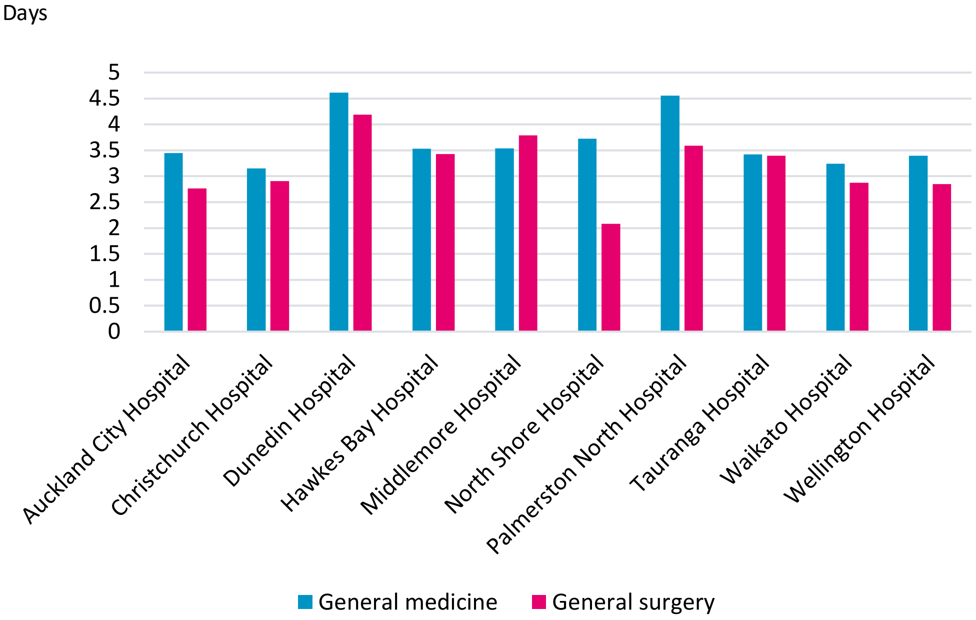
The potential to be alike is important: some variation is warranted. For example, variation in health service use between 30-year-olds and 80-year-olds is expected and would be observed in a system where older people’s health is well-managed as much as in a system that neglects to manage older people’s health. It is a finding of difference when similarity is expected that signals that something is amiss. These variations cannot be assumed to result from medical need, evidence-based practice, or patient preferences.

Unwarranted variation represents a major barrier to maximising the triple aim objectives of quality, safety and value:

- reduces health system productivity through excess use of limited resources
- leads to sub-optimal outcomes through less effective care and clinically unsafe practice
- contributes to access problems due to limited time and workforce required to address poor outcomes
- impacts negatively on patients’ experience of care and trust in the system
- widens equity gaps where unwarranted variation exists between population groups
- threatens system sustainability through waste, excess costs, and poor experiences for the workforce.

New Zealand’s health system demonstrates unwarranted variation in many areas, services, and outcomes, including variations by ethnicity and geographic area. We focus on one area of unwarranted variation: The average length of stay under the health specialities General Medicine and General Surgery. Figure 28 below shows that across a sample of larger hospitals, there is wide variation in the average length of stay under these two specialities.

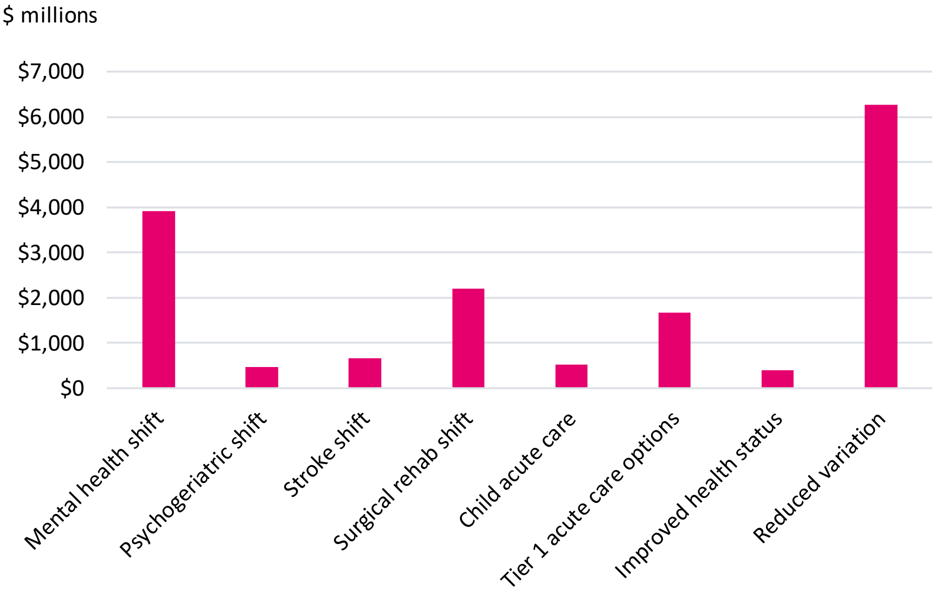
Figure 28 General medicine and general surgery average length of stay, sample of larger hospitals



Source: NZIER

Our modelling assumes that all hospitals with an average length of stay in General Medicine or General Surgery above the national lower quartile have an excess length of stay that is amenable to reduction to the national lower quartile. The impact of reducing variation from current levels to within the current national lower quartile is shown in Figure 29 below.

Figure 29 Impact of reducing unwarranted variation in general medicine and general surgery lengths of stay



Source: NZIER

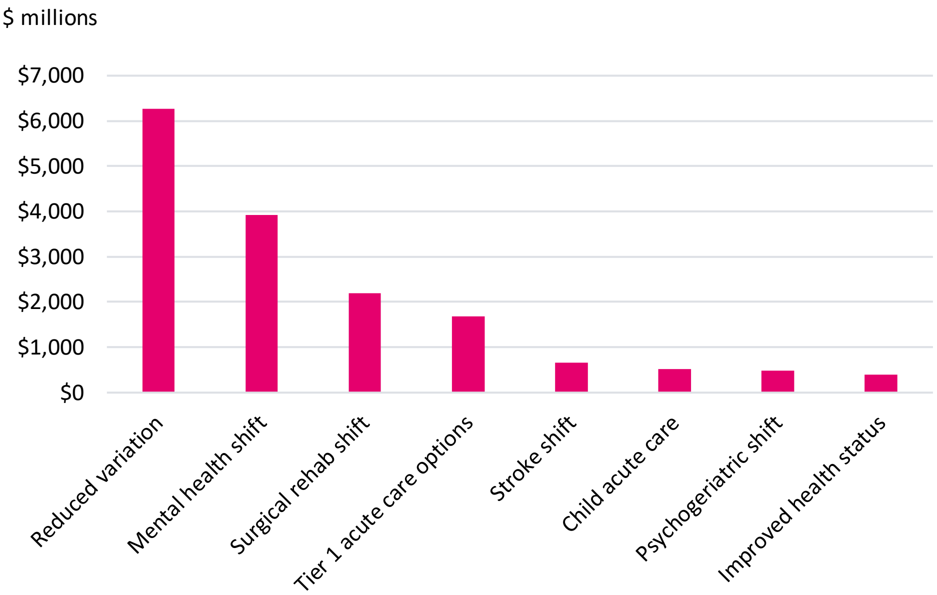
At a value of nearly $6 billion, an intervention that can reduce variation in lengths of stay for these two specialities has a far greater impact on the infrastructure investment requirements than any other model of care changes modelled.

6.4 Ranking of individual interventions

Because many of the interventions and model of care changes we modelled impact on the same patient populations (e.g. people with long-term conditions also present acutely and may have admissions under General medicine), there is significant overlap that would result in double-counting of impacts if these impacts are added unadjusted to the model's final calculation of the required investment.

To deal with this problem and avoid double-counting, we ordered the interventions to provide an order of implementation based on prioritising the interventions with the greatest impact. The ranking is shown in Figure 30 below.

Figure 30 Ranking of interventions and model of care changes by impact size



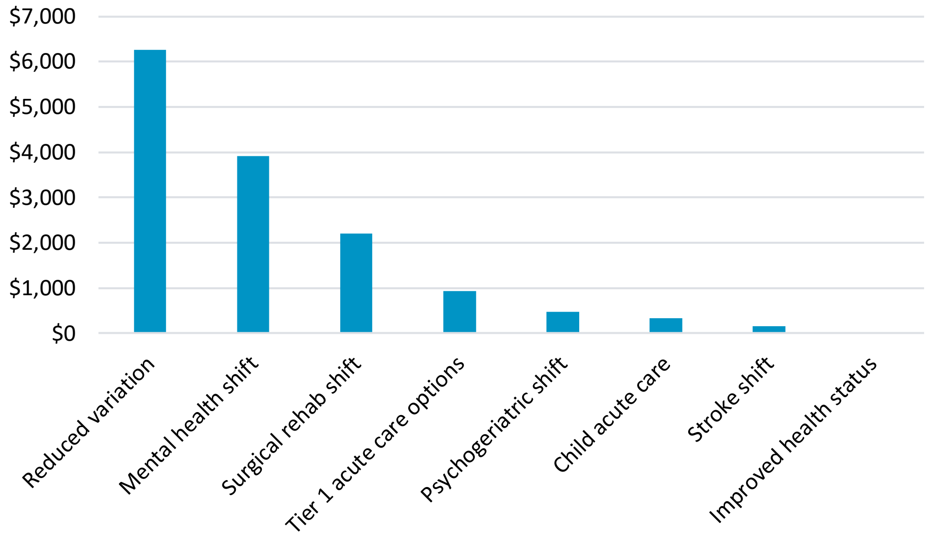
Source: NZIER

6.5 Prioritised implementation and marginal impacts of interventions

As a next step, we modelled the implementation of each intervention and model of care change in this order and calculated the marginal impact of each subsequent intervention or model of care change. Implemented in this order, a notable difference is that the value of Tier 1 investment to improve health status is reduced to close to zero (from $402 million to $5 million) due to the consequences of poor health status in the populations targeted by this intervention having been addressed through interventions that were modelled as more impactful (e.g. Tier 1 acute care options) (see Figure 31 below).

Figure 31 Marginal impacts with prioritised implementation

$ millions



Source: NZIER

7 Total investment required over 30 years with ambitious mitigation efforts

The interventions we modelled had a smaller impact on health infrastructure than might have been expected for such a wide range of health concerns (mental health, psychogeriatric, stroke, surgical rehab, acute demand, child acute demand, long-term conditions, general medicine and general surgery).

In total, the impact of these interventions reduced the 30-year infrastructure requirement by $14.3 billion to $101 billion (see Figure 32 below). Clearly, if the infrastructure investment requirement is going to be significantly reduced by model of care changes, those changes will need to be more extensive and more effective than what was proposed for this analysis.

The intervention with the greatest impact was the reduction in variation in the average lengths of stay in general medicine and general surgery (worth $6.3 billion in infrastructure investment over 30 years – 44 percent of the total reduction achieved by all the interventions we modelled).

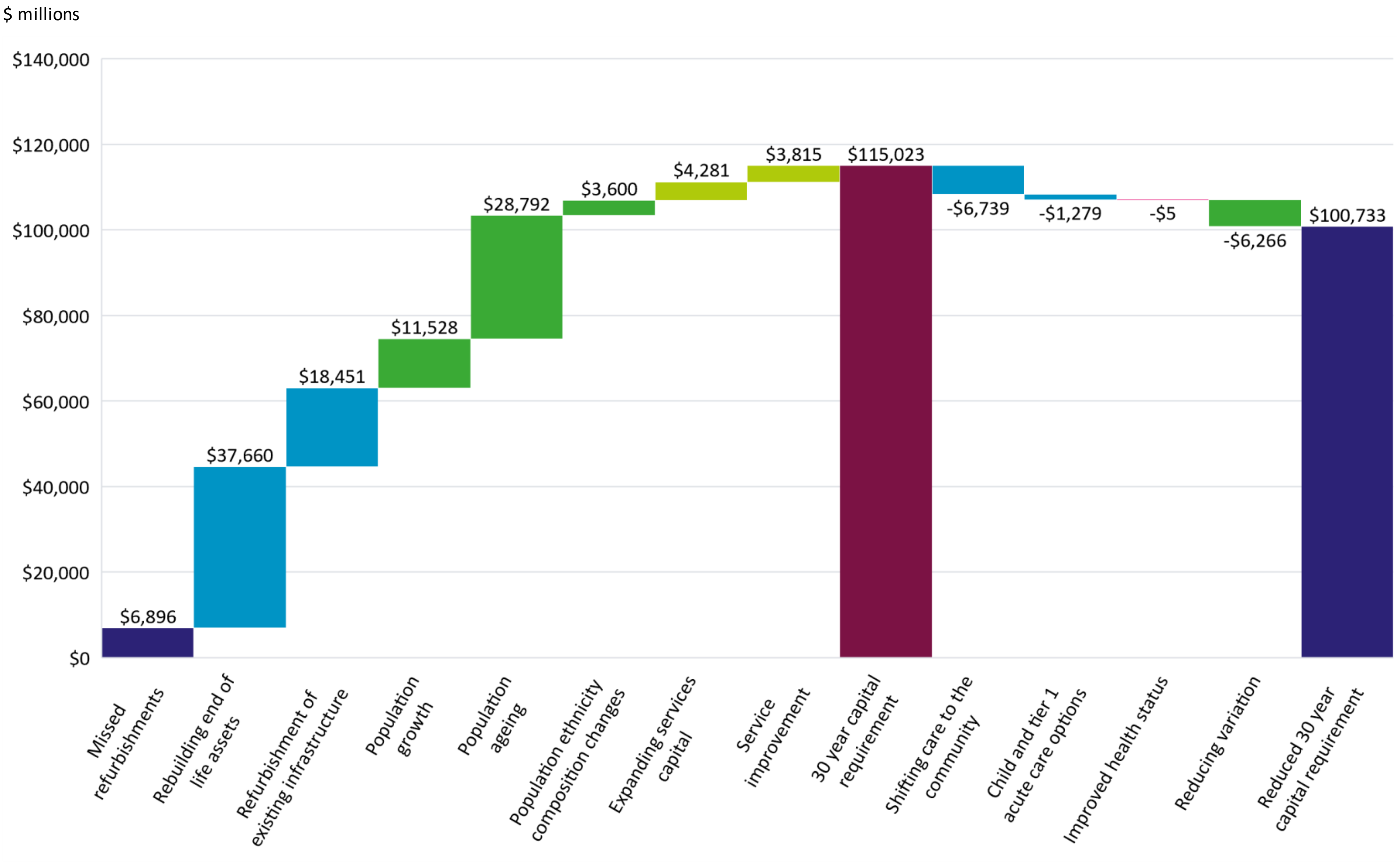
Reducing variation is well-recognised internationally as critical to improving health care quality, safety and value. A direct comparison with true model of care changes and implications for infrastructure specifically demonstrates how effective reducing variation can be and the importance of Te Whatu Ora working closely with the Health Quality and Safety Commission (HQSC) to identify and implement programmes to minimise unwarranted variation across the system. A key advantage of investing in this type of intervention is that leaders among providers have already demonstrated that outcomes can be achieved and may offer lessons that can be implemented more broadly.

A question that we do not explore in this report is whether this health sector scenario –with the extent of mitigation effort modelled – is achievable alongside all the nation's other infrastructure requirements. With an impact of only $14.3 billion, the extent of change required is likely to be far more radical, and this needs to be carefully explored.

The small impact of these interventions on hospital infrastructure requirements is particularly noteworthy, considering this was the full set of options presented by Te Whatu Ora and considered ambitious. While efforts to implement many other models of care changes that may improve system efficiency are no doubt underway, this set of changes that are considered ambitious provides a powerful indication that model of care changes may have less significant impacts on infrastructure requirements than on other health system concerns, like quality and experience of care.

However, model of care changes are enabled by advancements in health technology (e.g. improvements in medical knowledge, surgical techniques, medicines, medical devices, etc.), and these advancements have had significant impacts in the past, including contributing to reducing health systems' dependence on inpatient beds over the last 50 years. While advancements to come and their adoption by our public health system cannot be predicted, there will almost certainly be important opportunities. The challenge for the system is to recognise these opportunities and their value and respond appropriately.

Figure 32 Total health infrastructure investment required over 30 years with mitigation



Source: NZIER

8 Sensitivity analysis and scenario testing

Recognising that our base case represents an aspirational view of our future health system, we tested aspects of our modelling to identify the potential impacts of key assumptions to inform discussions about how health infrastructure is planned, built, maintained, and used to ensure financial sustainability. We consider the possible impacts of potential improvements, including:

- achieving a longer useable life for buildings
- maintaining current high occupancy in hospitals
- building at a lower cost per square metre
- using space more efficiently.

We also consider the potential implications of an increased frequency of refurbishment, which may result from poor building design, poor building quality, ineffective refurbishments, and a lack of effective planning and coordination across the sector.

From these assumptions, we developed seven scenarios described below.

8.1 Scenario 1: Extending the useable life of all buildings to 67 years

In the base case, we assumed that the average useable life of health facility buildings was 50 years. However, some buildings may last longer, offering lessons for future building projects. New buildings could be built differently, allowing them to be maintained in a way that extends their useable life or reconfigured more easily to remain fit for purpose. So, we tested the impact of assuming a 67-year useable life for buildings. We selected a 67-year useable life because this enabled the same refurbishment cycle as in the base case, with one additional refurbishment (moderate refurbishment at year 16, major refurbishment at year 33, moderate refurbishment at year 50) providing a further 17 years of use.

This assumption has several important implications:

- Fewer buildings would be considered at end-of-life now, resulting in savings on demolition and replacement
- Fewer buildings would reach end-of-life within 30 years, resulting in savings on demolition and replacement
- Our assumption is that shifting mental health inpatient beds into community-based, non-Crown-owned facilities when those buildings reach the end of their useable life means savings from this model of care change are reduced due to delays in implementation (we implicitly assume that finding alternative uses for those buildings is not possible)
- More refurbishments occur within the timeframe of our analysis, counterbalancing some of the savings achieved by not demolishing and replacing some buildings.
- With the increase in the useable life of buildings from 50 to 67 years, the assumed 'catch up' on maintenance and repairs will also increase, as more refurbishment is assumed to have not been completed on our schedule.

The change in assumption regarding the useable life of buildings interacts with how we modelled the shift in mental health inpatient care to community-based, non-Crown-owned facilities. In this scenario, we apply the 67-year useable life assumption to all buildings and health facilities. This means the shift in mental health beds towards community settings that our base case described would not occur until those buildings are 66 years old.

8.2 Scenario 2: Extending the useable life of all buildings to 67 years but retiring mental health inpatient facilities at 50 years

Because the change in assumption regarding the useable life of buildings interacts with the way we modelled the shift in mental health inpatient care to community-based non-Crown-owned facilities, we also tested this assumption by excluding mental health inpatient facilities from the increase to 67 years, allowing for mental health beds to be shifted to community-based, non-Crown-owned facilities at 50 years.

8.3 Scenario 3: Maintaining high occupancy in hospitals

Bed occupancy in hospitals is an issue of national concern with frequent media coverage, particularly during winter when seasonal illness creates spikes in demand.

Bed occupancy is measured in different ways. Within a hospital, it is generally measured by census at different times of the day. When wards are well run, discharges tend to be concentrated in the mornings and peaks in demand occur later in the day, resulting in peaks in admissions in the evenings. Occupancy at midday, therefore, can be drastically different from occupancy at midnight.

Because our modelling was concerned with national demand and supply and a timeframe of 30 years, we used an average annual occupancy of 85 percent. The NICE recommends this occupancy rate, although it notes that the convention of 85 percent occupancy as a safe upper limit is based on a theoretical model published in 1999 (Bagust, Place, and Posnett 1999).

We calculated the current national occupancy level from the number of bed days used (derived from patient lengths of stay) divided by the number of available bed days (derived from the number of beds). Based on this calculation, the average occupancy of our public hospitals is currently 91.1 percent.

A hospital ward with an average occupancy rate of 91.1 percent and makes no adjustment to deal with increased safety risks is likely to compromise patient care. However, the NICE indicates that it is possible to address increased safety risks and produces guidance on mitigating actions.

Acknowledging the challenges and risks associated with this issue, for the sake of sensitivity analysis and a better understanding of the implications of occupancy on infrastructure costs, we modelled a higher occupancy rate on the assumption that hospital-based improvements could make a 92 percent national average occupancy rate safer and more sustainable. To allow this assumption to be applied, we also removed the constraint in our model that prevented the bed-to-population ratio from falling below the 2021 ratio.

8.4 Scenario 4: Building at a lower cost per square metre

The building cost we assumed in our base case was $20,000 per square metre, a rounded building cost derived from the Whangarei Hospital 2022 detailed business case, which was thought to represent the square metre building cost for an average health facility building project (see section 2.3 for more detail).

The Whangarei detailed business case noted a significant increase in the cost per square metre from the first version of the document, which had a cost per square metre of approximately $15,000 and explained that this was partly due to higher-than-expected construction cost inflation had impacted on cost estimates. Te Waihanga research (Te Waihanga, forthcoming) has identified that in the short-run, there can be significant fluctuations in infrastructure construction prices due to local factors like investment demand or persistent labour shortages, underscoring the potential unreliability of a single point-in-time cost estimate from one region to estimate national investment requirements over a long period of time.

Beyond this uncertainty as to the appropriateness of the base case cost for modelling future health infrastructure requirements for New Zealand, there may also be potential to design and manage building projects to reduce building costs. Both are arguments for testing the effect of a lower building cost.

Our lower building cost estimate is derived from HART data. Despite the limitations of the HART data (described in section 2.3), if the identified "highest building service" (primary purpose of the building) is assumed to be accurate, then a weighted average building cost estimate can be calculated using the range of building costs for different types of buildings provided in the HART. This calculation produces a weighted average building cost of $15,136 per square metre (representing a reduction of approximately 24 percent relative to our base case).

In this scenario, we apply this lower estimated build cost while maintaining all other base case assumptions.

8.5 Scenario 5: Increased efficiency in the use of space

One option for reducing the Crown investment requirements for health infrastructure is to be more efficient in using space in hospitals. We did not have sufficiently detailed data to evaluate how efficiently space is currently being used, but we did observe significant variation between hospitals in the total facility GFA per bed (see section 3.5).

While our base case assumed all new building would be on the basis of total facility GFA of 193m^2 per inpatient bed, several large and moderately sized hospitals appear to achieve significantly lower total facility GFA per bed, including:

- Christchurch Hospital at 143m^2 per bed
- Hawkes Bay Hospital at 141m^2 per bed
- Tauranga Hospital at 172m^2 per bed
- Middlemore Hospital at 178m^2 per bed
- North Shore Hospital at 179m^2 per bed
- Whangarei Hospital at 146m^2 per bed

- Waitakere Hospital at 132m^2 per bed
- Rotorua Hospital at 189m^2 per bed
- Whanganui Hospital at 167m^2 per bed.

To support consideration of the potential savings that could be generated if a lower average total facility GFA per bed could be achieved and allowing for a total facility GFA per bed that is still likely to be able to accommodate clinically safe spaces throughout, we modelled the investment required to support all new builds to have a total facility GFA per bed of 170m^2 per bed – a reduction of 23m^2 of total facility GFA per bed. To put this into context, a new hospital with 300 beds would be 6,900 square metres smaller in total, occupying 51,000 metres instead of 57,900 as in our base case (an 11.9 percent reduction in overall floor space).

8.6 Scenario 6: Extended useable life, reduced refurbishment, and efficient use of space

Based on feedback from Te Whatu Ora, we model a scenario that reflects a range of efficiencies relative to our base case that could potentially be achievable, including the potential for more significant refurbishment to extend the useable life of buildings as well as the time between refurbishments, as well as more efficient use of space. Specifically, this scenario means:

- buildings have a 60-year useable life (up from 50 in the base case)
- a major refurbishment occurs at year 20 and year 40 (from a moderate refurbishment at year 16 and a major refurbishment at year 33)
- all new builds make more efficient use of space, bringing the average total facility GFA per bed down to 170m^2 in all newly built facilities (from 193m^2 in the base case).

8.7 Scenario 7: More frequent refurbishments

A significant source of uncertainty in our modelling is the refurbishment cycle of hospital buildings. Our base case assumed a moderate refurbishment would occur in year 16 and that a major refurbishment would occur in year 33, resulting in two refurbishments over the 50-year average lifespan of a building.

But if hospitals are not built to perform well between refurbishments, or unplanned, uncoordinated service changes create unanticipated pressure to alter the physical space, it may be that within the same 50-year average lifespan, the number of refurbishments could be doubled. For this scenario, we assume a refurbishment every 10 years: A moderate refurbishment would occur in years 10 and 30, and a major refurbishment would occur in years 20 and 40. All other assumptions remain as in the base case.

8.8 Results

Table 9 below shows the key assumptions and changes that we tested as well as the impact on the total investment required over 30 years, on the potential reduction in the investment required as a result of model of care changes, and the minimum investment required after implementing a model of care changes.

It is important to note that none of the scenarios tested can be confirmed as achievable at this stage. However, testing this range of scenarios does indicate some areas where the value of the opportunity indicates more attention is warranted.

Table 9 Results of sensitivity analysis

$ millions

Scenario	Scenario summary	30-year investment required	Potential reduction in required investment*	Minimum investment required
Base case	50-year useable life for all buildings, 85% bed occupancy, all buildings missed refurbishments from 2008 to 2022, moderate refurbishment at year 16, major refurbishment at year 33, new builds average 193m^2 total facility GFA/bed	$115,023	$14,290	$100,733
1	67-year useable life for all buildings, moderate refurbishment at years 16 and 50, major refurbishment at year 33	$109,449	$12,657	$96,792
2	67-year useable life for all buildings except inpatient mental health at 50 years, moderate refurbishment at years 16 and 50, major refurbishment at year 33	$109,449	$14,290	$95,159
3	Higher (92%) occupancy	$106,940	$13,202	$93,738
4	Lower build cost (approx. 24% reduction)	$95,455	$11,533	$83,922
5	More efficient use of space (average 170m2 for total facility GFA per bed in new builds – down from 193m2 per bed in the base case)	$87,349	$13,045	$74,304
6	60-year useable life for all buildings, major refurbishment at year 20 and year 40, and more efficient use of space (average 170m2 for total facility GFA per bed in new builds)	$86,122	$12,966	$73,157
7	More frequent refurbishment: 50-year useable life for all buildings, moderate refurbishment at years 10 and 30, major refurbishment at years 20 and 40	$156,076	$20,076	$135,399

*Scenarios may positively or negatively impact the potential reduction in required investment that can be achieved through the interventions described in section 6.

Source: NZIER

The results of the extension of useable life to 67 years in Scenarios 2 and 3, which indicate little savings, are surprising and counterintuitive and require the following explanation:

- The number of missed refurbishments increases substantially as more buildings remain in use, resulting in higher costs across the life cycle of buildings.
- A 67-year useable life delays the demolition and replacement of buildings, some of which will now be demolished and replaced beyond the 30-year timeframe of this analysis. But while those buildings remain in use for an additional 17 years, they will

require a further moderate refurbishment. The savings achieved by the additional refurbishment rather than replacing these buildings amount to less than $6 billion over 30 years.

- A 67-year useable life applied to all buildings (including inpatient mental health facilities) also affects the potential reduction in the investment required because it causes the loss of an opportunity to save by shifting mental health inpatient services into non-Crown-owned facilities earlier. The potential savings associated with this shift amounted to around $2.3 billion in the base case.

8.8.1 Key takeaways

Key takeaways from this analysis are that:

- Solutions that extend the useable life of buildings may offer little savings unless additional efficiencies can be gained by reducing the cycle of refurbishments.
- Reducing the average total facility GFA per bed by 11.9 percent (from 193m^2 to 170m^2 in Scenario 5) offers a an even greater reduction in the level of investment required as a 24 percent lower building cost.
- An unnecessarily high frequency of refurbishment, which may be a consequence of poor building quality, poor quality of previous refurbishments, or a lack of planning and coordination for major service redesign and model of care changes, poses a significant risk of major unanticipated additional investment requirements. The scenario we modelled for this possibility resulted in a larger increase in the investment requirements over 30 years than the savings that were estimated for any of the efficiency improvement scenarios.

8.8.2 Additional considerations: Control of cost factors

A scenario modelling exercise assumes a certain amount of control in introducing changes. In reality, many factors across the timeframe, from planning the construction of a health facility building to its eventual retirement and demolition, are difficult to control or predict.

A key insight highlighted by our scenario modelling is that a 12 percent reduction in the average total facility GFA per bed could be equivalent to a much greater building cost reduction under our other base case scenario assumptions. The physical scale of buildings may be more readily controllable than the time and cost of construction and the refurbishment requirements and costs. The degree of control of health system planners and funders should be a key consideration for Te Whatu Ora.

9 Limitations and further research needs

9.1 Major sources of cost uncertainty

Quite apart from the long-term uncertainty always present when gazing into a future in a world that can change unpredictably, with new medicines and procedures, potential for new diseases, and long-term economic conditions that are influenced by equally unpredictable global factors, the short-term cost estimates in this report are subject to a high degree of uncertainty due to:

- current uncertainty regarding costs of building and refurbishing facilities due to current economic conditions, including inflation and labour shortages
- potential opportunities to extend the useable life of some buildings by re-purposing, which are currently being explored
- the true refurbishment requirements of health infrastructure, which are unclear due to an extended period of under-investment, leaving a dearth of evidence regarding what best practice might look like
- potential opportunities to build differently to reduce whole-of-life costs, which are currently being explored.

Modelling always represents a 'best guess' based on the available data and information. We expect that over the next 12–36 months, new data and information will emerge that will require revisiting the modelling.

In the meantime, our sensitivity analysis provides some indication of the cost implications of alternative scenarios. This, too, can be revisited as new information emerges.

9.1.1 Construction cost inflation

Our modelling does not reflect any expected difference between construction cost inflation and general inflation, which can significantly impact current estimates of long-term costs.

Since 1995, the price of infrastructure construction has grown over 150 percent while economy-wide prices have grown 103 percent, with the gap increasing faster or slower over different periods. Te Waihanga research (Te Waihanga, forthcoming Research Insights paper) has identified that in the short-run, fluctuations in infrastructure construction prices are not strongly driven by material costs and global factors but rather local factors like investment demand or persistent labour shortages. In the long run, this research has also identified that slow productivity growth within the infrastructure construction sector has been putting upward pressure on output prices over the past 20 years (Te Waihanga 2022).

Even though we know that infrastructure construction costs have historically outpaced the economy, forecasting a future cost growth gap in the aggregate is difficult, particularly over an extended time horizon. The drivers of this cost gap are multi-faceted and nuanced, each of which would merit consideration: forecasts of key material prices (diesel, steel, aggregates, cement), forecasts of construction wages, labour productivity trends, and the composition of construction outputs. To apply these cost trends to public hospital projects, we would also need information on the mix of inputs needed to build or refurbish hospitals. We are not confident this analysis could be done with precision without more time and information.

9.2 National-level modelling

Analysis at a national or aggregate level has both strengths and weaknesses. A strength is that aggregation can potentially reduce the impact of under and over-estimation at the building, facility, or DHB level. However, until more robust data is available, it cannot be known to what extent this is true. A key weakness of aggregation is that the results of the analysis cannot point to immediate actions or support the prioritisation of projects. Further work will still be needed to determine where capital investment is needed and how much is needed at each site. Similarly, while aggregation allows the total impact of a potential model of care changes to be illustrated, achieving the estimated impacts will require localised solutions and implementation.

9.3 Excluded physical infrastructure

The HART data we used to model the 30-year investment requirements for health infrastructure was limited. A critical missing component is any investment in roading, carparks and reticulated infrastructure (plumbing, electrical, mechanical). These elements are subject to their own useable life constraints and require regular maintenance, repairs and costs. The exclusion of these elements from data collected under the NAMP was noted in the NAMP Current State Assessment (Ministry of Health 2020).

9.4 Continued shift towards more ambulatory care

Throughout high-income country health systems, a major development of recent years has been a significant shift from inpatient care with overnight stays to ambulatory care (day patient or outpatient, with no need for an overnight stay). Medical innovation and improvements in clinical procedures, including minimally invasive procedures, new anaesthesia techniques, and new medicines, have played an important role in enabling this shift, allowing many diagnostic, surgical and medical procedures to be safely delivered in an ambulatory setting. A McKinsey report (Kumar and Parthasarathy 2020) indicates that ambulatory care is expected to grow to 32 percent of total hospital activity over the next ten years.

Specialities with significant scope for shifting the model of care to ambulatory services include:

- Gastroenterology
- General surgery
- Oncology/haematology
- Rheumatology
- Endocrinology
- Urology
- Gynaecology
- Ophthalmology.

9.5 Unexplored models of care

According to a Nuffield Trust report (Edwards 2020) set a goal of reducing face-to-face outpatient attendance by 30 percent through greater use of ICT to support virtual care. The ability of services to deliver on an ambitious goal of replacing a large proportion of face-to-face outpatient care with telehealth or telephone consultations was confirmed by the COVID-19 pandemic, which saw outpatient services in many countries shift service delivery in line with such arrangements almost overnight (see for example, Baum, Kaboli, and Schwartz (2021), which describes a 56 percent reduction in face-to-face visits for USA veterans, and Schulz et al. (2022), which describes face-to-face delivery declining from 95 percent of all delivery of outpatient care to 29 percent during the pandemic in Australia, and Pendrith et al. (2022), which describes an 80 percent reduction in face-to-face visits in Ontario, Canada). Furthermore, there is evidence that patients prefer telehealth or telephone delivery of services that can be safely delivered this way (see, for example, Tyler et al. (2021)and Bate et al. (2021)).

While the pandemic saw a high proportion of outpatient care delivered virtually, in the absence of pandemic restrictions and concerns, a proportion of what was delivered virtually would likely be delivered more safely and with greater effectiveness face-to-face.

Due to the limitations of outpatient data discussed earlier, it is impossible to model telehealth's potential impact on the infrastructure requirements for outpatient services. While the levels of telehealth observed during the lockdowns of the COVID-19 pandemic may not be safe to sustain long-term, outpatient services are likely to present a significant opportunity to change the delivery model with substantial impacts on infrastructure. Modelling this, however, requires an approach that considers each speciality in turn and identifies with clinical advice how services could be reconfigured and what the impact of greater community and home-based services would be on the hospital-based team and the spaces currently being used.

There are many other potential models of care changes that could be considered, and these could be modelled in future.

9.6 Unexplored efficiency gains

Within a typical hospital, there are myriad processes and systems that support the safe and efficient running of services. Efficiency improvements in processes and systems are virtually impossible to identify outside the hospital. Our modelling approached this by assuming that hospitals with significantly shorter stays for general medicine and general surgery patients have implemented efficient systems and processes, such as early discharge planning, and that lessons from these could be applied more broadly to reduce lengths of stay in other facilities.

One major opportunity for efficiency gains that we considered but were unable to explore was the possibility of extending the hours of operating theatres. Many hospitals have acute operating theatres that run 24 hours per day, seven days a week, but operating theatres that focus only on planned surgeries (and many that see a mix of acute and planned surgeries) typically run on an eight to nine-hour day, five days a week, and sit unused the rest of the time. For example, in some countries and many UK hospitals, operating theatres run 12-hour days. Mathematically, two theatres running 12-hour days could accommodate as many surgeries as three theatres running 8-hour days, so the implications for capital investment are clear. Modelling this, however, using National Collections data is impossible:

The DHBs have detailed operating room data, but this is not submitted to National Collections.

9.7 International comparison of total facility GFA per bed

While guidelines to support the planning and design of inpatient wards provide GFA per bed thought to be associated with efficient and safe care, these measures only capture the area immediately surrounding inpatient beds. They represent ward-level GFA per bed.

Total facility GFA per bed – the amount of GFA across an entire facility, including all buildings and services on a hospital campus – per bed is a more useful measure to estimate capital requirements since investment is needed to support more than just bed spaces. This measure, however, is not widely used.

Our literature search identified three sources of unknown quality that provided total facility GFA per bed:

- an analysis of Japanese compact hospital design, comparing Japanese hospitals to a hospital in Singapore presented in a slide deck by a Japanese hospital architect (Komatsu n.d.)
- a US building reference website that offered rules of thumb for US hospitals.

Together, these provide some context for interpreting total facility GFA per bed. The information provided in those sources is summarised in Table 10 below.

Table 10 International estimates of total facility GFA per bed

Hospital/country	Beds	Total facility GFA	Total facility GFA per bed	Source
Mount Elizabeth Novena Hospital (Singapore)	300	74,000	246.7	Komatsu (n.d.)
Red Cross Ashikaga Hospital (Japan)	555	51,804	93.3	Komatsu (n.d.)
Sakakibara Memorial Hospital (Japan)	320	27,637	86.4	Komatsu (n.d.)
Nagoya City West Medical Centre (Japan)	500	42,590	85.2	Komatsu (n.d.)
Matsudo City Hospital (Japan)	600	45,000	75.0	Komatsu (n.d.)
University hospital (Japan)	740	75,700	102.3	Komatsu (n.d.)
Small hospital (US)	60	13,935	232	Construction website*
Medium hospital (US)	120	27,871	232	Construction website*
Large hospital (US)	150	46,452	310	Construction website*

* https://www.fixr.com/costs/build-hospital#hospital-construction-cost-per-bed

Source: As shown

Compared with New Zealand's average GFA per bed of 206m^2 (202m^2 when very small facilities are excluded), US and Singapore hospitals appear to be very spacious and Japanese hospitals appear very compact. As shown in section 3.5, even within New Zealand, the variation in total facility GFA per bed is unexplained and warrants further investigation to understand the space requirements of all components of hospitals and major facilities. This is an important contributor to maximising the benefits of changes like the introduction of standardised design. Our sensitivity analysis indicates that a 15–16 percent reduction in the average total facility GFA per bed could be equivalent to a much greater building cost reduction under our other base case scenario assumptions.

9.8 Further scenario analysis

In section 8, we considered a range of hypothetical scenarios and their impact on the infrastructure investment needed. Many more scenarios could be tested through various combinations of minor alterations to our model, and this type of modelling could support decision-making. The challenge is for Te Whatu Ora to identify which scenarios are most realistic and likely to be prioritised.

9.9 Regional and local level analysis

As the information on health infrastructure improves, there is likely to be a need for modelling at the regional and local levels to better understand the impacts of specific investment decisions. The modelling described in this report can be easily adapted to regional and local needs, and an improved information base will ensure more granular modelling delivers deeper insights.

9.10 Cost shifting

As indicated in section 6.2, some of the models of care we analysed implicitly assume that other health system enablers can be stepped up to support a reduction in the need for capital investment in physical infrastructure. All our models of care that involve community-based services are likely to require a larger health workforce to deliver new services (community acute care options), increased levels of care (e.g. expanded primary care management of long-term conditions), or more dispersed community versions of services currently concentrated in hospitals (e.g. rehabilitation in the community, which could involve a combination of in-centre rehabilitation and early supported discharge to rehabilitation at home). Some require non-Crown-owned infrastructure. All of these shift Crown capital expenditure to some form of Crown operational expenditure. The balance of values remains to be determined.

10 Recommendations

The health system reforms have so far enabled centralised decision-making with the creation of Te Whatu Ora with a focus on better support and oversight of projects and programmes, improved service and investment planning, asset management and facility design advisory, and investment monitoring. These are important first steps to address the significant challenge ahead.

Even with the ambitious mitigation efforts modelled in this report, there are no models of care scenarios big or bold enough to overcome the impacts of ageing on demand for infrastructure. Infrastructure-specific decisions have more potential than service redesign to bridge the health infrastructure affordability gap.

This report shows we will need more. Far more radical change will need to be explored than we covered in this report. In this respect, New Zealand faces the same challenge as all advanced economies with similar age structures. To the extent that our model has described an aspirational view of our future health system, it has also provided an indication of the challenge that faces Te Whatu Ora.

It is unlikely that $115 billion – or even the reduced figure of $101 billion (after implementing a range of model of care interventions to reduce the use of Crown-owned infrastructure) – can be invested over this timeframe into hospital buildings alone. The service expansions and improvements that are wanted and needed to serve a growing, ageing, and more ethnically diverse population in a health system focused on equity are achievable, but only if considerable and sustained efforts are made to reduce infrastructure costs.

The health infrastructure knowledge base is in the early stages of development, and health system data is not designed to support an understanding of how the system uses physical assets. Nevertheless, marrying infrastructure data with health service utilisation data, population data, and estimates of unmet need for services is essential to optimise health infrastructure decision-making.

Our effort – intended as a first step only on a long journey to improve health infrastructure planning – is based on hospital beds as a unit of measure, the only physical element that allows service utilisation data to be linked to physical space.

Our analysis reveals that no single model of care solution (of those modelled) will make a big enough difference and that even a range of these solutions implemented with a high degree of effectiveness makes only a moderate impact. Other system shifts and model of care changes are possible, as are changes in how infrastructure projects are planned and executed. Further modelling of well-defined and detailed scenarios could support service planning and prioritisation with infrastructure implications better reflected in decision-making.

We recommend that:

- Te Whatu Ora:
  - considers a short-to-medium-term objective of reducing health equity gaps as a priority in infrastructure investment decisions
  - develops a deeper understanding of
    - the space requirements of health facilities and, in particular, components and service areas, with outpatient spaces being a priority, and with a view to more efficient use of space in health facilities
    - options to reduce the cost of construction and refurbishment cycles (working with Te Waihanga as these factors share commonalities with other sectors)
  - works towards:
    - incorporating infrastructure investment modelling in its service planning to better inform decision-making
    - more detailed outpatient data that can support the modelling of future infrastructure requirements with a consistent recording of resource use based on spaces used and time dimensions of outpatient visits, as well as procedures undertaken
- Te Waihanga undertakes further modelling of potential scenarios as new evidence emerges to refine the sector's understanding of trade-offs and opportunities.

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Appendix A Review of Health Asset Register Tool data

A.1 Purpose of this review

This report is based on data from the Health Asset Register Tool (HART), which records data on all public hospital buildings. This is a key input into long-term health infrastructure investment requirement estimates.

A.2 Overview of the HART data

In total, there are 1,245 buildings in the HART, totalling 2,277,747.5 sqm of gross floor area (GFA).

A.2.1 Primary function of buildings

70.9 percent of the total space accounted for in the HART is hospital, mental health, and community hospital buildings. The primary function of the buildings is captured as 'highest building function'. Many of these buildings can and often do include space for administrative, support, and back-of-house services as well as space for inpatient services, outpatient services, and other clinical functions.

Administration, the largest non-hospital category, is a grouping of back-of-house services such as laundries and kitchens, along with storage facilities, retail areas, clinical support services, office administration, and carpark buildings.

The largest Administration building is Auckland City Hospital Carpark Building A, which is 16,732 sqm. While this building is listed as administration and not parking, on Google Maps it does appear to be a carpark with a small retail area attached. It is impossible to investigate all buildings' functions using Google Maps or other tools available within a desk-based research project.

The next nine largest administration buildings comprise four clinical services buildings, two office administration buildings, two back-of-house buildings and one more carpark building with retail attached.

Industrial buildings make up 3.2 percent of the total floor area. These are mostly workshops, boiler houses, storage, generator rooms, garages, and other infrastructure.

Residential buildings are houses and motels, primarily accommodation for families of patients, while a few are listed as staff quarters.

Buildings in the "Nil" category are mostly leased and vacant buildings. 25,528 sqm of the total 68,652 sqm in the Nil category are Princess Margaret Hospital buildings due to be demolished.

Table 11 GFA by highest building function according to the HART

Highest building function	GFA (m^2)	% of total
Hospital	1,435,828	63.0%
Administration	357,592	15.7%
Mental Health	148,450	6.5%

Highest building function	GFA (m²)	% of total
Parking	128,035	5.6%
Industrial	73,940	3.2%
Nil	68,652	3.0%
Community Hospital	32,234	1.4%
Residential	27,803	1.2%
#N/A	5,214	0.2%

Source: HART (Te Whatu Ora)

Ten percent of hospital buildings, 2 percent of mental health buildings, and 40 percent of community hospital buildings are missing floor area data.

Overall, the mental health buildings have the most complete data, whereas the most concerning category is community hospitals, where 40 percent of buildings are missing GFA data. It should be noted, however, that the community hospitals as a group represent a very small fraction of national inpatient bed capacity.

Table 12 Zero or missing GFA by highest building function

Function	Percent of category with zero or missing GFA
Hospital	10%
Administration	12%
Mental Health	2%
Parking	23%
Industrial	19%
Nil	22%
Community Hospital	40%
Residential	26%
#N/A	25%
Total	14%

Source: HART (Te Whatu Ora)

Sixteen of the 40 hospital buildings missing data are actually community dental clinics. The rest appear to be normal hospital buildings. These clinics, along with the community hospital buildings, are typically small, ranging between 72 and 2,747 sqm.

Overall, the buildings with missing GFA are likely smaller than the buildings with GFA data. Some are valid zero GFA. For example, maintenance tunnels, chimneys, and other infrastructure.

Ten largest buildings

The ten largest single buildings in the HART together account for 21 percent of the total gross floor area in the data set. Eight of the buildings provide hospital and administrative/support services, and two are carpark buildings. Two of these, including the

Auckland City Hospital Support Building and a ward block at Dunedin Hospital, are due for demolition in our model due to being over 50 years old.

Table 13 Year built and GFA of 10 largest buildings in the HART

Campus	Building name	Function	Year built	GFA
Auckland City Hospital	Auckland City Hospital - Main Building	Theatre, Ward/Inpatient, Intensive, Emergency Department, Clinical Support Services, Administration	2003	80,860
Wellington Hospital	NRH Main Hospital Building	Theatre, Ward/Inpatient, Clinical Support Services, Intensive	2005	60,430
Auckland City Hospital	Auckland City Hospital Support Building	Ward/Inpatient, Outpatient, Theatre, Administration, Retail	1969	54,445
Dunedin Hospital	Ward Block	Ward/Inpatient, Administration	1976	50,258
North Shore Hospital	B15N - TOWBL - Main Hospital Building	Ward/Inpatient, Intensive	1983	46,604
Christchurch Hospital	Parkside (including ED extension)	Intensive, Theatre, Ward/Inpatient, Clinical Support Services	1991	37,508
Hamilton Hospital	Meade Clinical Centre (outpatients)	Theatre, Intensive, Clinical Support Services	2010	36,920
North Shore Hospital	B26N - Carpark building	Parking	2011	35,308
Middlemore Hospital	Harley Gray (Theatres and Critical Care)	Theatre, Intensive, Ward/Inpatient, Clinical Support Services, Administration, Back of house, Specialist Plant Buildings	2011	34,152
Auckland City Hospital	Helipad Carpark building (Carpark Blg B)	Parking	2001	33,482

Source: HART (Te Whatu Ora)

Ten largest hospital campuses

Fifty-seven percent of the total GFA in the HART is contained within the ten largest campuses. These ten campuses also contain over half of New Zealand's hospital beds. There is an average GFA per bed of 217 sqm (excluding Greenlane Clinical Centre – a major outpatient centre).

Table 14 Ten largest campuses in the HART (including mental health buildings)

Campus Name	GFA	Beds	Mental health beds	Total beds	GFA/Beds
Auckland City Hospital	239,606	1,171	96	1267	205
Hamilton Hospital	186,129	759	140	899	245

Campus Name	GFA	Beds	Mental health beds	Total beds	GFA/Beds
Middlemore Hospital	161,199	905		905	178
Wellington Hospital	152,070	484	29	513	314
Christchurch Hospital	119,653	836		836	143
North Shore Hospital	118,561	683	35	718	174
Dunedin Hospital	92,988	361		361	258
Greenlane Clinical Centre	87,174	31		31	2,812
Palmerston North Hospital	75,342	354		354	213
Hutt Hospital	73,041	322		322	227

Source: HART (Te Whatu Ora)

Smaller buildings

691 buildings have a listed floor space between 1 and 1000 sqm. Randomly selecting ten of these buildings shows they are a mix of functions. The ten buildings include two storage sheds, three speciality hospital inpatient buildings, a records building, a vacant building used for parking, a speciality outpatient building, a pharmacy, and a generator house.

Overall, the data for the small buildings appears correct. The GFA listed looks appropriate for the building function. One building is missing a construction year, six have condition data, and six (not the same six) have NBS data.

Table 15 Random selection of 10 small buildings (GFA between 1m^2 and 1,000m^2)

Campus	Building name	Function	Year built	GFA (sqm)
Point Chevalier	Rehab Plus Occ. Therapy Shed	Back of house	1998	40
Papakura	Papakura Birthing Unit	Ward/Inpatient	1890	639
Timaru Hospital	Records Building	Administration	2016	408
Middlemore Hospital	Building 47 Filter Storage Shed	Administration	1974	112
Taumarunui	Undercover parking (Ex Laundry Block)	Vacant, Parking	1970	685
Tauranga Hospital	T04 Specialist Mental Health For Older People	Ward/Inpatient, Mental health	1955	317
Tokoroa	Pharmacy Building	Clinical Support Services	1966	212

Campus	Building name	Function	Year built	GFA (sqm)
Waitakere Hospital	B22W - HAEUN - Haemodialysis Unit - Building 22	Outpatient	2003	350
Mason Clinic - 81A Carrington	B11C - Generator House	Specialist Plant Buildings	2000	65
Point Chevalier	Ahurere-Lotofale Two	Mental Health	1965	225
Campus	Building name	Function	Year built	GFA (sqm)

Source: HART (Te Whatu Ora)

Condition assessment

Te Whatu Ora advised NZIER that not all the condition assessments contained in the most recent version of the HART at the time this project was undertaken were based on a thorough assessment of buildings. It was also unclear what criteria or considerations were reflected in condition assessments.

For buildings with a condition assessment and a year built, the relationship between condition and building age is unclear. There is a wide range of assessed conditions regardless of the year built. Buildings constructed after 2000 do tend to be in better condition, but there are still buildings constructed after 2000 that are in poor or worse condition. Conversely, there are buildings constructed before the demolition cutoff that reportedly remain in good to very good condition.

Appendix B Estimated baseline infrastructure requirements over 50 years (physical units)

The tables below present the estimated infrastructure requirements over each decade of the next 50 years in terms of physical units (inpatient beds and total facility GFA):

- to address the current deficit and maintain existing assets for the current population
- to meet the needs of a growing, ageing and increasingly ethnically diverse population
- under base case assumptions of:
  - maintaining the 2021 beds-to-population ratio (2.29 per 1,000)
  - maintaining the average total facility GFA per bed (193 square metres) based on facilities with over 50 beds
  - carrying out a moderate refurbishment at year 16 and a major refurbishment at year 33
  - replacing buildings at or beyond the end of their useable life (50 years)

Note that:

- these estimates do not include service expansion, service improvement or mitigation options
- the refurbishment cycle does not factor into the calculation of the number of beds or GFA needed, but it affects the number of beds and GFA of spaces due for refurbishment
- the figures presented in the report for the investment required to meet this need are based on a phased investment response to the need, whereas the beds and GFA estimated presented here represent the actual estimated need within each decade.

Table 16 Inpatient bed requirements over 50 years

	Beds in spaces due for moderate refurbishment	Beds in spaces due for major refurbishment	Beds from new builds (incl. replacement)	Beds in spaces due for demolition (50+ years old)
2023–2033	1,960	1,147	7,552	6,103
2034–2043	3,106	2,938	1,974	1,018
2044–2053	4,669	1,270	2,397	1,586
2054–2063	1,767	2,339	3,309	2,573
2064–2073	3,077	2,270	1,215	656
Total	**14,579**	**9,965**	**16,446**	**11,935**

Source: NZIER

Table 17 GFA requirements over 50 years

	GFA due for moderate refurbishment	GFA due for major refurbishment	New build GFA (incl. replacement)	GFA due for demolition (50+ years old)
2023–2033	378,350	221,439	1,457,504	1,177,823
2034–2043	599,405	567,083	380,919	196,551
2044–2053	901,117	245,124	462,581	306,007
2054–2063	341,077	451,472	638,678	496,592
2064–2073	593,863	438,205	234,437	126,525
Total	**2,813,812**	**1,923,323**	**3,174,119**	**2,303,498**

Source: NZIER

Appendix C ASH Conditions used in modelling

Table 18 ASH Conditions by chapter

ASH chapter	ASH condition
Cardiovascular	Angina and chest pain
	Congestive heart failure
	Hypertensive disease
	Myocardial infarction
	Other ischemic heart disease
	Rheumatic fever/heart disease
Dental	Dental conditions
Dermatological	Cellulitis
	Dermatitis and eczema
Gastrointestinal	Constipation
	Gastroenteritis/dehydration
	GORD (gastro-oesophageal reflux disease)
	Nutritional deficiency and anaemia
	Peptic ulcer
Respiratory	Asthma
	Bronchiectasis
	COPD
	Lower respiratory infections
	Pneumonia
	Upper and ENT respiratory infections
Vaccine preventable disease	Vaccine preventable MMR
	Other vaccine preventable disease*
Other	Cervical cancer
	Diabetes
	Epilepsy
	Kidney / urinary infection
	Sexually transmitted infections
	Stroke

*Excludes COVID-19

Source: Ministry of Health (2022)