Radiation Oncology
National Linear Accelerator and Workforce Plan

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Executive summary

This Radiation Oncology National Linear Accelerator and Workforce Plan ('the Plan') is intended to inform a nationally coordinated approach to radiation oncology service and capacity development, within the context of the National Cancer Programme. The Plan builds on initial capacity planning of radiation therapy services published in 2012 by the regional cancer networks, and provides national guidance and a national tool (the 'National Linear Accelerator & Workforce Capacity Model')[1] to support further development of local and regional service and capacity planning by district health boards (DHBs). The Plan will also inform national decision-making by the Ministry of Health (the Ministry) and other central agencies on radiation oncology services over the next 5–10 years.

Radiation therapy is one of the main treatments for cancer, and is both clinically and technically complex. It is used as part of an overall treatment plan, generally in conjunction with surgery and chemotherapy. The majority of treatments are carried out using a linear accelerator ('linac') to deliver ionising radiation by external beam to destroy or damage cancer cells. Treatment can be curative or palliative, and is tightly controlled to maximise damage to the cancer cells and minimise damage to the surrounding tissue.

Cancer is the leading cause of death in New Zealand (30 percent of all deaths), and a major cause of hospitalisation. While the overall cancer registration *rate* in New Zealand is generally decreasing, New Zealand has an increasing *number* of people who are developing cancer, mainly because of population growth and ageing. The total number of cancer registrations is projected to increase by approximately 30 percent between 2012 and 2022.

New Zealand has six DHB cancer centres offering multiple treatment modalities – including radiation therapy – across all tumour types. Over recent years provision of radiation therapy services has widened with the development of private radiation therapy units in Auckland and Christchurch. An additional private radiation therapy service will be operational from 2014 in Tauranga to serve both privately and publicly funded patients. Overall there were 29 linear accelerators across New Zealand in 2012, which delivered 11,876 radiation therapy courses at an estimated operating cost of $103 million.

Radiation therapy intervention rate

A key metric for radiation oncology is the radiation therapy utilisation rate or intervention rate (IR), defined as the proportion of all people with cancer who receive at least one course of radiation therapy during their care. The current New Zealand average of 37% is similar to that seen in Australia and the UK. Individual DHB radiation therapy intervention rates range from 30 to 45%, similar to the range of intervention rates seen by area within Australia and England.

[1] See Section 4.1 for further discussion of the Model, its functionality and limitations.

The reasons for variation in access to radiation therapy by DHB are not clear. There is no evidence of patients requiring radiation therapy being 'turned away' by a cancer centre for reason of workforce or linac capacity shortages. The health target for radiation therapy wait times is also being achieved nationally. The variation in access may relate to clinical practice by referrers, the cancer centre's model of care, patient distance from cancer centre, patient choice, tumour type, ethnic group, deprivation level, and/or differences in reporting. Investigation of the reasons for significant variation in intervention rates will be important.

Variation in clinical practice

In addition to variable intervention rates, cancer centres also vary significantly in their retreatment rates, treatment times and numbers of treatments per course. A centre may offer 15 treatments in a course, while another delivers 25 treatments for the same cancer. While some variation in clinical practice is expected, the possibilities of increased standardisation and centres learning from each other warrants further investigation. There appear to be opportunities for operational efficiency gains.

Scenario modelling

International expert opinion suggests that 45–52% of people with cancer might benefit from radiation therapy at some stage in their treatment. Scenarios modelled in the development of this Plan include maintaining the current DHB national average IR of 37%, and moving to 40%, 45% or 50%. There is the potential for changes in technology and techniques to impact on IRs and productivity. Future planning will need to adjust accordingly.

Scenario	Rate	Added linacs	Total linacs in 2022	Operating cost in 2022	Capital costs 2013–2022
Base	Current IR and RTR	8	39	$144m	$236m
Modest growth	40% IR	10	41	$156m	$258m
Growth	45% IR	17	48	$181m	$328m
Maximal growth	50% IR	20	51	$200m	$361m

IR = intervention rate – % all cancer registrations with at least one course of radiation therapy; RTR = retreatment rate. All costs in 2011/12 $ – ie not inflation-adjusted; capital costs include 28 replacement linacs ($152m). The development of 2 linacs in Tauranga is assumed in the base, so is not included in the 'added linac' column, nor in capital costs.

Significant increases in linac numbers are projected under current operating parameters. If the current intervention and retreatment rates were maintained to 2022 (Base scenario), eight new linacs would be required over the next 10 years. This is effectively the capacity growth due to the increases in expected cancer registrations. The Growth scenario of moving to a 45% IR would see the need for 17 additional linacs over the next 10 years.

The Growth scenario is considered to provide the best foundation for DHB and national planning purposes – achieving a 45% national average IR by 2022.

Several DHBs are already at or near 45% IR (Southern, Capital and Coast, Waikato), and a natural increase in the IR is expected at other DHBs due to:

- multidisciplinary team meetings and tumour standards being implemented and embedded
- new technologies and techniques being developed
- clinical practice becoming more standardised across New Zealand.

Cost impacts

The expected increase in cancer registrations through incidence changes and population growth is estimated to result in approximately $41 million extra in operating costs per year by 2022, bringing the total spend to $144 million (Base scenario). Some or all of this increase may already be covered in the demographic adjustments to the DHB population-based-funding formula each year. Moving to a 45% IR would require an extra $36 million in operating costs over the Base scenario ($77 million compared with $41 million).

Workforce

Planning for workforce requirements is perhaps the single most important aspect of selecting likely future scenarios. There are three core workforce groups:

- radiation oncologists, who are doctors who specialise in treating cancer with radiation therapy
- medical physicists, who are scientific specialists in the therapeutic application of radiation sources and the equipment involved
- radiation therapists, who are allied health practitioners involved in planning and delivering the radiation treatments.

Each year New Zealand currently produces four net graduate radiation oncologists, three net graduate medical physicists, and 25 net graduate radiation therapists. The Base scenario shows that New Zealand is currently training sufficient radiation oncologists and radiation therapists to take into account changes in cancer incidence and population ageing. However, New Zealand needs an additional three medical physicists per year just to keep up with the increasing cancer incidence and population ageing.

Based on the current proportion of training output retained in the New Zealand health system, and planning for the Growth scenario's 45% IR, by 2022 there will be a shortfall of seven radiation oncologists, 30 medical physicists, and 25 radiation therapists. If the medical physicist growth was achieved through increasing the training programme intake, nine graduates per year would be required (ie, the existing three, plus another six). For sustainability there will need to be improved retention of existing staff across all workforce groups, and/or an increase in training places – most urgently for medical physicists.

Maximising performance

The Model results show the increase in required linac numbers projected under current operating parameters. Notable reductions to the projected increase of linacs occur if operational efficiency and 'tipping point' assumptions are included. The Model's assumptions for meeting waiting time targets mean that each centre is expected to have the capacity to deal with its highest monthly totals in that year without needing to transfer patients elsewhere. This means that one month's overflow can 'tip the balance' of needing more capacity. The new build requirements can be delayed by incorporating measures such as using a centre's linacs up to 10 hours a day in the busiest months (possibly 2–3 months a year) prior to a new linac being commissioned, or 'subcontracting' the equivalent overflow volumes to another centre for those months.

The variability in treatment times and treatments per course noted above means that there are likely to be aspects of service operations that could be changed to achieve efficiency gains. For example, cancer centre average treatment times range from 14 to 18.7 minutes (average 15.9 minutes). Decreasing treatment time may produce an efficiency gain. To model this, the Plan assumes a 1% per year (or 10% over 10 years) efficiency gain in treatment times, and/or treatments per course.

Combining the operational gains and tipping point assumptions would reduce the Base scenario's need to three additional linacs rather than the eight forecast, and for the Growth scenario a reduction from 17 additional linacs to six. The reduction has little effect on the operating costs noted above, as a similar volume of work is expected, but does have a strong effect on capital costs. The overall capital investment over the 10 years is estimated at $217m, which includes $152 million for upgrades and replacement of 28 linacs over the 10-year period. Without the efficiency and tipping point measures, the capital cost could be as high as $328m over the next 10 years, $111million greater. For the Base scenario, the operational efficiency assumptions reduce the number of linacs required over the next 10 years from eight to three, and reduce the capital costs by $53 million ($236 million less $183 million).

The first builds suggested by the model for the Growth scenario (given the operational efficiency and tipping point assumptions) would come in 2016, nominally at MidCentral and Capital and Coast DHBs.

The operational gains do not affect radiation oncologist requirements, but do have an effect on medical physicist and radiation therapist numbers, with 'savings' of one to two medical physicists and four to five radiation therapists per year with each scenario. For example, for the Growth scenario there is a suggested need for five additional medical physicists per year rather than six, and four radiation therapists per year rather than nine.

Possible year	Indicative new linac location
2016	MidCentral Capital and Coast
2017	Auckland ARO
2018	Canterbury
2022	Auckland

These potentially large impacts on capacity requirements mean that operational efficiency and the potential for tipping point actions will need careful consideration by the regional cancer networks and cancer centres.

Recommendations

Plan and Model development

1. The Ministry should maintain the currency of the Plan and Model through regular review and updates.

2. The Ministry should ensure that future iterations of the Plan take a broader service perspective than the predominant capacity focus of this Plan. The Ministry should also investigate how best to include consumer representation in the radiation oncology planning process.

Operating environment

3. The national radiation oncology service specification should be reviewed by the Ministry and DHBs to ensure it remains relevant.

Access to radiation therapy

4. A national radiation therapy IR goal and individual DHB IR targets for accountability purposes should not be set at this time because of uncertainty as to the reasons for and impact of current variation. However, a national IR should be confirmed by the Ministry and DHBs for service and capacity planning purposes.

5. The Growth scenario should be adopted by the Ministry and DHBs as the preferred scenario for planning purposes, meaning a national IR of 45% by 2022, and maintenance of current DHB retreatment volumes (national average 31% of treatments being retreatments).

6. The Ministry's Cancer Services Team should advise Health Workforce New Zealand of the Growth scenario's implications for workforce capacity requirements, and in particular the need to improve retention rates and to urgently increase medical physicist training numbers and training places.

7. The Ministry's Cancer Services Team should advise the Capital Investment Committee of the Growth scenario's implications for capital expenditure – that is, an additional $64 million over and above the $152 million needed for existing equipment upgrades and replacement over the next 10 years.

8. DHB IRs and retreatment rates (RTRs) should be monitored nationally by the Radiation Oncology Work Group (ROWG), and by the regional cancer networks working with the DHBs and cancer centres. The regional cancer networks should be required to report to the Cancer Programme Steering Group on the acceptability of the regional or DHB variation in IR and RTR where this is more than 5 percentage points above or below the national average prevailing at the time of measurement, and the reasons for the variation.

Use of robust information

9. An end-to-end review of the national radiation oncology KPIs should be undertaken by the Ministry, including:
    - purpose of the collection
    - confirmation that the KPIs are fit-for-purpose
    - barriers to accurate reporting
    - how use of the information for performance improvement and planning can be strengthened at local, regional and national levels.

A high quality service

10. A set of radiation oncology service standards should be considered by the Ministry and DHBs for adoption in New Zealand, including identification of their cost implications related to promulgation, compliance and accreditation.

11. The Ministry and DHBs should encourage increased standardisation of clinical practice, with a focus on the treatment course for common tumour sites.

Technology assessment

12. The Ministry's Cancer Services Team should discuss annually with the National Health Committee and National Health Board how a national approach to evaluation and implementation of new radiation therapy technologies and techniques could be maintained. The approach should be established for 2014/15.

Securing investment

13. The Ministry and DHBs should use the Model to inform local, regional and national planning and business case development. Consistent assumptions and metrics should be used in planning, based on the national KPI dataset and Model standardisation.

14. The Ministry and DHBs should place greater emphasis on benchmarking of radiation therapy services to inform identification at regional and national levels of opportunities for improved access and productivity.

National planning and action

15. The Ministry should produce an annual national radiation oncology implementation plan, as part of the Cancer Programme.

1 Introduction

Section 1 of the Plan introduces its purpose, why radiation oncology is being planned nationally, the focus of the Plan, and how the Plan and associated Capacity Planning Model were developed.

1.1 Purpose of the Plan

This Radiation Oncology National Linear Accelerator and Workforce Plan ('the Plan') is intended to inform a nationally coordinated approach to radiation oncology service and capacity development, within the context of the National Cancer Programme. The Plan builds on initial capacity planning of radiation therapy services published in 2012 by the regional cancer networks,[2] and provides national guidance and a tool (the 'National Linear Accelerator and Workforce Capacity Model') to support further development of local and regional service and capacity planning by DHBs. In addition, the Plan will inform national decision-making by the Ministry of Health (the Ministry) and other central agencies on radiation oncology services over the next 5–10 years.

This is New Zealand's first dedicated national radiation oncology plan (although a Non-Surgical Cancer Plan developed in 2001[3] did include coverage of radiation oncology). The Plan focuses in particular on projected demand growth for radiation therapy, its implications for linear accelerator ('linac') and workforce capacity, and associated cost impacts. It also considers issues arising from this capacity modelling, including:

- variation in access to radiation therapy
- radiation therapy intervention rates
- development of national benchmarking and standards to support performance and quality improvement
- evaluation and uptake of new techniques and models of care
- fostering of national collaboration.

While the Plan focuses primarily on radiation therapy capacity, in practice radiation oncology is a complex multi-step process requiring a larger complement of equipment (including simulators and planning systems, and imaging) and alternate modalities (eg, kilovoltage treatment, brachytherapy, stereotactic therapy), and close linkages with other cancer services and clinical support services.

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2 *Northern Cancer Network Linear Accelerator Modelling – 2012 to 2020*. Northern Cancer Network, 2012. *Midland Radiation Oncology Demand and Capacity Modelling 2012–2020*. Midland Cancer Network, 2012. *Central Cancer Network Linear Accelerator Modelling – 2012 to 2020*. Central Cancer Network, 2012. *South Island Radiation Oncology Modelling – 2013 to 2022*. Southern Cancer Network, 2012.

3 *Improving Non-surgical Cancer Treatment Services In New Zealand*. Ministry of Health, 2001.

1.2 Why national planning for radiation oncology?

To date planning for radiation oncology has been undertaken mostly at a local level by the cancer centres, and more recently at the regional level by the four cancer networks. The decision to take a strategic national approach to planning of radiation oncology services has been made because:

- radiation oncology is highly capital intensive, in terms of the infrastructure costs in establishing and developing the specialist buildings, and the radiation therapy and imaging equipment
- the forecast significant growth in demand for radiation therapy will bring the need for an equivalent supply response, with investment required in increased workforce, linac and facility capacity – all of which have long lead times
- the catchment population required to support clinically and financially sustainable radiation oncology services and avoid duplication of high cost infrastructure means planning is best undertaken across DHBs and cancer centres
- the need to align the assumptions and methodologies used by DHBs in their radiation oncology service and capacity planning, and in particular to inform workforce planning which must occur at the national level
- the need to ensure access across DHBs and population groups for patients who would benefit from radiation therapy, and to minimise unwarranted access variation
- the opportunity to strengthen national collaboration between radiation oncology providers in their use of available capacity, sharing of knowledge and innovation for performance improvement, and planning across centres (for example, in the assessment and application of specialised technologies).

The aims of national planning for radiation oncology services are to support:

- provision of high quality services, including timely and equitable access to radiation therapy for all patients for whom it is clinically appropriate
- development of the linac and workforce capacity required to meet future cancer incidence and radiation therapy intervention rates, including effective linkage of local, regional and national planning and decision-making within the framework of the Cancer Control Programme
- improved service performance through adoption of innovative approaches to patient care and resource use, and agreed quality standards
- planned evaluation and uptake of effective new techniques and technologies, and development of sub-specialisation by cancer centres where appropriate.

1.3 Focus of this Plan

The focus of this first Radiation Oncology National Linear Accelerator and Workforce Plan (the Plan) is linked strongly to the development and application of the accompanying National Linear Accelerator and Workforce Capacity Model ('the Model'). The Plan describes key elements of the national operating environment for radiation oncology, and progress to date with local, regional and national planning and service delivery. It then considers the outputs of the Model in respect of future demand for radiation therapy, and the implications of this for linac and workforce capacity, and for service operational and capital costs.

The Plan provides a national view, and is intended to be supportive of DHB-led service and capital planning and decision-making at local and regional levels. In presenting a scenario of future demand and supply at national and regional levels, the Plan is based on:

- current capacity
- forecast cancer incidence
- demographic projections
- a national intervention rate
- current referral patterns, modified to reflect the redirection of Tairawhiti patient demand to Waikato, and development of the Tauranga radiation therapy service
- consideration of both public and private capacity.

The Plan concentrates on the external beam radiation therapy dimension of the radiation oncology service – the linear accelerators and key staff groups. Aspects that are not specifically covered include other staff groups such as radiation oncology nursing, and other service dimensions such as brachytherapy, superficial treatments, stereotactic services, and detail such as courses by major tumour types or specialties such as head and neck or child cancers (see also Section 2.5 below). Overall workforce needs for each cancer centre remain the preserve of local and regional planning and were outside the scope of the Plan.

1.4 Planning process

The Plan was developed under the aegis of the National Cancer Programme, and overseen by a Project Steering Group chaired by Dr Andrew Simpson, National Clinical Director of the Cancer Programme, and with membership from the Ministry of Health, DHBs and the private radiation therapy sector (see Appendix 1).

Development of the Model was guided by an Expert Advisory Group (see Appendix 1) comprising members of the Radiation Oncology Working Group (ROWG) from both public and private radiation therapy sectors. The Model was informed by the four regional radiation oncology capacity plans.

Finalisation of the Plan followed consultation with the sector on a draft, including engagement with the groups noted in Appendix 2.

The Model and Plan were authored by Health Partners Consulting Group for the Ministry of Health.

Recommendations: Plan and Model development

1. The Health should maintain the currency of the Plan and Model through regular review and updates.
2. The Ministry should ensure that future iterations of the Plan take a broader service perspective than the predominant capacity focus of this Plan. The Ministry should investigate how best to include consumer representation in the radiation oncology planning process.

A brief description of radiation therapy

Radiation therapy is one of the main treatments for cancer, and is both clinically and technically complex. It is used as part of an overall treatment plan, generally in conjunction with surgery and chemotherapy. The treatment regimen selected for a patient with cancer depends on a number of factors including the type of cancer; location and grade of the tumour, and spread of the cancer; patient health and age; availability of accommodation and transport, and of a carer or support network to assist the patient; and patient choice. International expert opinion suggests that 45–52% of people with cancer would benefit from radiation therapy.

Radiation therapy uses ionising radiation to destroy or damage cancer cells so they cannot multiply. Radical radiation therapy is given to try to cure a cancer, as a stand-alone treatment; to shrink a cancer before surgery; to reduce the risk of a cancer coming back after surgery; and/or to complement or enhance the effects of chemotherapy. Palliative radiation therapy is used to control symptoms and improve quality of life if a cancer is too advanced to cure.

Radiation therapy may be delivered externally using a linac, or internally as brachytherapy (which involves the placement of implanted radioactive materials inside the body, in, or near, the cancer). The delivery of radiation therapy is very precise in order to limit harm to surrounding healthy tissues. For this reason, treatment for individual patients is carefully planned using imaging systems such as computed tomography (CT), magnetic resonance imaging (MRI) and positron emission tomography (PET), and is given in many fractions over a course, allowing healthy tissue to recover between treatments. The course may last for up to 5–8 weeks, and treatments given up to 5 days each week over that period.

Linacs have a high capital cost, must be replaced at regular intervals (approximately every 10 years), and require custom-built facilities (‘bunkers’) that ensure staff are protected from radiation. The linac is a mature technology, although developments in medical imaging have produced a range of new linac techniques to deliver more precise dose delivery for radical treatments, and fractionation has become more sophisticated. (These new techniques are discussed further in Section 5.3.)

Radiation oncology requires a highly specialised workforce working in a multi-disciplinary team, with core team members being the radiation oncologist, radiation therapist, and medical physicist (see Section 3.3).

Given the common use of radiation therapy as part of a combination treatment, radiation oncology exists within a wider cancer service that makes use of multidisciplinary meetings (MDMs) to plan and monitor patient treatment. Disciplines within a comprehensive cancer service can include medical oncology, paediatric oncology, surgical oncology, clinical haematology, and palliative care.

Radiation therapy is usually an outpatient treatment, but is centralised because of the technology required. Patients have multiple doses or fractions of treatment over an extended period. Together these two factors require radiation oncology services to have a large population catchment and wide referral network, and to provide support for travel and accommodation of patients and their families/whānau. Because of the large catchment area, the radiation oncology service will usually provide outreach clinics to improve access for patients living in rural and smaller urban areas, and link strongly with local specialist and primary health care services.

2 Operating environment

Section 2 describes the context within which radiation oncology services operate in New Zealand, including cancer incidence and impact; the Cancer Control Strategy and Cancer Programme; national health sector agencies with an interest in radiation oncology; national service development initiatives; the regional cancer networks; and radiation therapy service configuration.

2.1 Cancer in New Zealand

Cancer is the leading cause of death in New Zealand (30%),[4] and a major cause of hospitalisation. Cancer incidence and mortality rates are higher for Māori than non-Māori. Māori are also more likely to have their cancer detected at a later stage of disease progression. Residents of more socioeconomically deprived areas are more likely to develop cancer, are less likely to have their cancer detected early, and have poorer survival than residents of less deprived areas.

While the overall cancer registration *rate* in New Zealand is generally decreasing, New Zealand has an increasing *number* of people who are developing cancer, mainly because of population growth and ageing. The total number of cancer registrations is projected to increase by approximately 30% between 2012 and 2022.

People with cancer are surviving longer, and being treated for longer. However, Māori are benefitting less than non-Māori from this gain.

The Organisation for Economic Cooperation and Development (OECD) Health Care Quality Indicators Data 2009 used three cancers as indicators of how well countries were delivering cancer care (breast, cervical and colorectal cancer). The indicators showed New Zealand's relative survival ratios for all three cancers were above the OECD average. The OECD data also showed improved survival rates for patients with breast and cervical cancer from 2002 to 2007 compared to 1997 to 2002 (the data was unavailable for colorectal cancer).

International studies suggest that the costs of treating cancer in New Zealand are increasing at a faster rate than overall health spending, due mainly to the effect of population ageing, plus adoption of new treatment technologies. The Ministry estimates public expenditure on cancer treatment services will increase by 23% between 2008 and 2021, based on current models of care and cancer incidence.[5]

[4] Ministry of Health. 2013. *Cancer: New registrations and deaths 2010.* Wellington: Ministry of Health, August 2013.

[5] This forecast does not include consideration of the impacts of new technologies, improved survival, reduced mortality, or earlier detection. As a result the estimated expenditure for 2021 is likely to be an underestimation.

2.2 Cancer Control Strategy

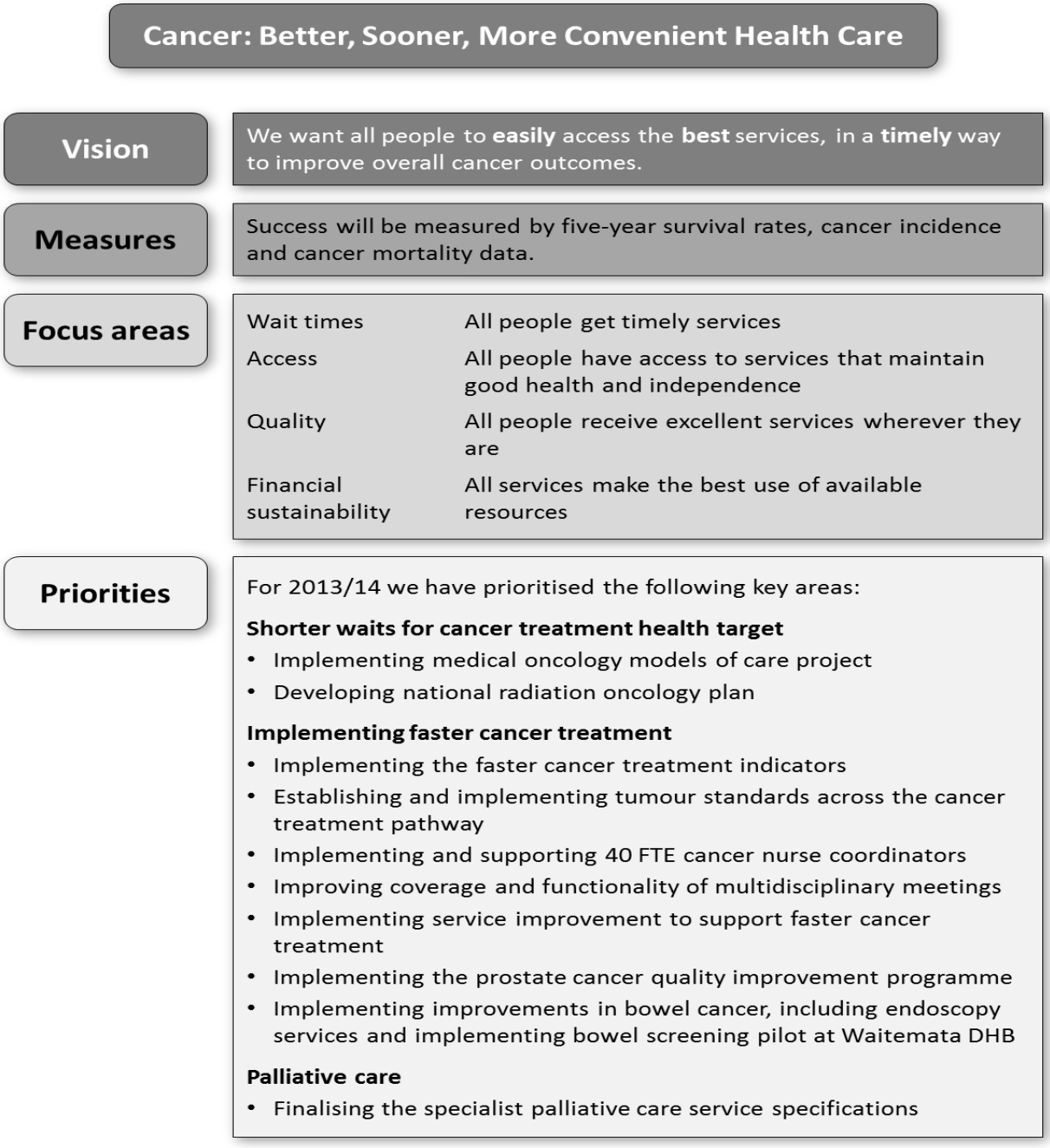
The New Zealand's Cancer Control Strategy was developed in 2003 with the purpose of reducing the incidence and impact of cancer, and inequalities associated with cancer.

The Ministry, DHBs, regional cancer networks, primary health organisations (PHOs), non-governmental organisations (NGOs) and consumer groups all have a role in implementing government priorities within the Cancer Programme. The Ministry provides national leadership for the Cancer Programme, including:

- policy development across the cancer control continuum
- monitoring of DHB performance
- implementation of national programmes (eg, screening)
- management of the Cancer Registry and data analysis
- national service and capital planning.

The Cancer Programme covers Ministry, DHB and regional cancer network activity across the cancer continuum to implement the New Zealand Cancer priorities. The need for a National Radiation Oncology Plan was identified in the 2012/13 Cancer Programme work programme.

Figure 1: The focus of the Cancer Programme in 2013/14



The Ministry has established the Cancer Treatment Advisory Group (CTAG) to provide clinical advice on cancer treatment to the Cancer Programme Steering Group. In turn, CTAG establishes and coordinates groups to provide advice on specialist areas within cancer services. One of these is the Radiation Oncology Working Group (ROWG).

ROWG's members include the clinical directors of the radiation therapy services of the six cancer centres; a representative from each private radiation oncology service; lead Medical Physicists and Radiation Therapists; a cancer centre manager; and an oncology nurse.

ROWG has a mandate to provide expert clinical advice on:

- achievement of the Shorter waits for cancer treatment health target, including monitoring performance and advising on relevant clinical and service delivery issues
- specific areas that relate to cancer treatment, such as clinical effectiveness, service improvement, service development, treatment guidelines, and service standards
- technology change for cancer treatment as part of the Cancer Programme's horizon scanning function
- services/initiatives for prioritisation to be considered as part of strategic and annual planning and prioritisation processes.

2.3 Recent changes to the New Zealand health system

The Plan links with the current and potential roles of a number of national agencies, as described in Appendix 3.

2.4 National service development to date

Foundational elements of a national radiation oncology framework for New Zealand have been developed over the past 15 years, and are discussed below.

2.4.1 National principles

The Ministry and DHBs defined overarching national principles at the time of development of two national protocols (see below). These principles, which provide an important foundation for national planning, are:

- equitable access for all New Zealanders to publicly funded radiation oncology services
- radiation oncology treatment for all New Zealanders to be commenced within nationally agreed waiting times targets
- radiation oncology treatment for all New Zealanders to be provided to meet internationally accepted quality standards
- radiation oncology treatment for all New Zealanders to be provided in accord with the Code of Health and Disability Services Consumers' Rights.

The protocol guiding public use of private capacity (see below) also contained further principles of significance for the Plan:

- access to radiation oncology services will be available through the public sector to meet population need
- use of private facilities to meet public service obligations must ensure equitable access for all New Zealanders through publicly funded services
- planning of future public radiation oncology services should ensure equal access for all New Zealanders to these services, through provision of sustainable public radiation oncology infrastructure.

2.4.2 National protocols

Two interlinked protocols[6] were developed by the New Zealand Cancer Treatment Working Party (and approved by the Cancer Control Implementation Steering Group) to guide radiation oncology service provision. These protocols and their implications for national planning are:

- *Sharing of public radiation oncology capacity between cancer centres*: This recognises that public linac capacity develops in steps reflecting installation of new machines and availability of staff, and that meeting the waiting time target may require short-medium term sharing of capacity between cancer centres – which is preferred over utilisation of private or overseas capacity. Sharing of spare linac and/or workforce capacity will include agreement on patient referral/transfer protocols and tumour management pathways. Centres will take a shared strategic approach to linac capacity planning to ensure complementary development. Patients will be given a choice of referral or remaining on a local wait list, and are to be supported in their travel and accommodation needs when accessing another centre.
- *Public interface with private radiation oncology services*: This complements the first protocol, and ensures that publicly funded use of the private sector does not distort equity of access and follows public prioritisation criteria; is used temporarily and only when capacity at a neighbouring DHB cancer centre is not available; and is based on guidelines, treatment protocols, and clinical audit. Patients are to be fully informed about treatment options, and the relationship between public and private services.

2.4.3 National radiation oncology service specification

A national service specification for radiation oncology has been published in the National Service Framework Library, and was last updated in 2001. A notable feature of the service specification of relevance for the Model and Plan is inclusion of workforce ratios required at that time.

2.4.4 Faster cancer treatment

The Government is committed to Better, Sooner, More Convenient Health Care. For the National Cancer Programme this means improving access to, and shorter waiting times for cancer treatment. Streamlined pathways of care that are based on well-coordinated services are crucial to timely diagnosis and management of cancer. This programme takes a patient pathway approach that covers surgical and non-surgical cancer treatment. The programme aims to improve services so that over time, all patients will have access to the same quality care within the same timeframes, no matter where they live.

DHBs are now routinely collecting and reporting information on patients who have been referred urgently with a high-suspicion of cancer.

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[6] The *Public/private radiotherapy protocol* and *Public capacity sharing protocol* are both published in the Reference Material section of the Specialist Medical and Surgical Service Specifications, available at http://www.nsfl.health.govt.nz/apps/nsfl.nsf/pagesmh/300

DHBs will measure their performance against a set of measures known as the Faster cancer treatment indicators. These indicators are:

- 62-day indicator: all patients referred urgently with a high-suspicion of cancer receive their first treatment (or other management) within 62 days of the referral being received by the hospital
- 31-day indicator: all patients with a confirmed diagnosis of cancer receive their first cancer treatment (or other management) within 31 days of a decision-to-treat.

A national health target has been in place for access to radiation therapy since 2008. Initially the target was for patients needing radiation treatment to have this within 8 weeks of first specialist radiation oncology assessment. This maximum waiting time has since been reduced to 6 weeks and then 4 weeks.

From 2012/13 the target was redefined as: *all patients, ready-for-treatment, wait less than 4 weeks for radiotherapy or chemotherapy*.

2.4.5 National radiation oncology dataset

Since 2008, the Ministry has supported the public and private radiation therapy services to develop and report a consistent set of Key Performance Indicators (KPIs). This data has been collated nationally, and fed back to the services and ROWG. Issues relating to reporting and review of the KPIs are discussed further in Section 5.2.

2.4.6 National radiation oncology prices

As part of the National Pricing Programme (NPP) to set annual Inter-District Flow (IDF) prices, 14 DHBs with costing systems that meet national requirements report purchase unit cost and volume information to the Ministry. Four cancer centres (Auckland, Hamilton, Wellington and Christchurch) report radiation oncology purchase unit cost and volume information. The Model associated with this Plan uses four NPP purchase units:

- radiation oncology first attendance (FSAs)
- radiation oncology subsequent attendance
- radiation therapy (Megavoltage) attendance
- radiation therapy (Orthovoltage) attendance
- and 2011/12 cost and volume information reported against these purchase units and cost categories (described further in Section 4.2.6).

2.5 Regional cancer networks and radiation therapy planning

Formal regional structures have been established to work across DHB, provider and consumer organisational boundaries to promote cooperation and collaboration in cancer service planning and delivery. Network configuration follows geographical coverage areas, and patient flows to the cancer centres.

The four regional cancer networks all published linac capacity plans in 2012 using an initial modelling tool developed for the Ministry, and are at varying stages in considering the workforce impacts of their predicted demand growth, and in undertaking radiation oncology service planning.[7]

Areas identified by the regional networks for inclusion in future radiation oncology service planning include:

- model of care (including outreach and satellite services)
- strategies to lift intervention rates
- governance
- capacity planning for other treatments (eg, brachytherapy) and support services (eg, imaging)
- linkage of forecasts with contracted IDF volumes
- patient accommodation
- private sector impacts and relationships
- linkage of radiation therapy with other cancer treatments, including through development of tumour care pathways and use of multidisciplinary meetings (MDMs)
- building public understanding of radiation therapy
- promoting research.

Recommendations: Operating environment

3. The national radiation oncology service specification should be reviewed by the Ministry and DHBs to ensure it remains relevant.

[7] The Northern region has progressed service planning to the greatest extent, producing their *Regional Strategic Plan: Sustainable Delivery of Radiation Therapy in the Northern Region – 2019* in June 2010.

3 Current radiation therapy services

Section 3 describes the current configuration, capacity and workforce of radiation therapy services in New Zealand.

3.1 Current configuration

Historically New Zealand has had six cancer centres offering multiple treatment modalities (including radiation therapy) across a wide range of tumour types. The cancer centres, which are focal points for cancer treatment and care, training, continuing education and research, are located in:

- Auckland (Auckland DHB)
- Hamilton (Waikato DHB)
- Palmerston North (MidCentral DHB)
- Wellington (Capital and Coast DHB)
- Christchurch (Canterbury DHB)
- Dunedin (Southern DHB).

Over recent years provision of radiation therapy services has widened with the development of private radiation therapy units in:

- Auckland, with Auckland Radiation Oncology as a partnership between MercyAscot and Southern Cross hospitals
- Christchurch, at the St George's Cancer Care Centre.

In addition a private radiation therapy service is being developed at Tauranga Hospital, serving both privately and publicly funded patients. It will be operational from 2014 as the Kathleen Kilgour Centre.

Table 1: Radiation therapy locations and activity (2012 and 2014)

Centre	Public/ private	Total linacs	Active linacs*	Courses in 2012	Courses per linac
Auckland DHB	Public	6	6	3,072	512
Auckland Radiation Oncology	Private	3	2	722	361
Waikato DHB	Public	4	4	1,910	478
Kathleen Kilgour Centre	*Private*	*2 (2014)*	*2 (2014)*		
MidCentral DHB	Public	4	3.5	1,480	422
Capital and Coast DHB	Public	3	3	1,456	485
Canterbury DHB	Public	4	4	1,830	458
St George's Cancer Care Centre	Private	2	1	313	313
Southern DHB	Public	3	2.5	1,093	437
Total 2012		**29**	**26.5**	**11,876**	**448**
Total in 2014		**31**	**28.5**		

* *'Total' linacs refers to the number that are installed and operational, 'active' the number effectively utilised based on that centre's normal operating configuration in 2012. Kathleen Kilgour Centre (Tauranga) linacs are expected to be operational July 2014. Courses per linac based on the active linac figure (average is 410 if based on total linacs).*

Current linac locations and activity for both public and private providers are shown in Table 1. Radiation therapy treatments provided in New Zealand's private sector are reported within the national KPI data collection (and hence are able to be included in the Model – see Section 5.1.5 for further discussion on the inclusion of privately-funded volumes). Overall 11,876 courses of external beam radiation therapy were given in 2012, 448 per active linac. By comparison, Australia plans on 414 courses per linac per year,[8] a level exceeded by all New Zealand DHB cancer centres. The 11,876 courses involved 176,047 attendances for treatment – an average of 14.8 attendances per course.[9]

Table 2 compares current linac capacity to indicative DHB cancer centre catchment populations and estimated cancer registrations. It shows that the South Island has greater capacity relative to population and estimated cancer registrations. Waikato currently has the least capacity based on registrations per linac, but this will change with the planned radiation therapy service establishment in Tauranga from 2014. On average Australia has 135,000 persons per linac,[10] a slightly higher capacity than New Zealand's 153,000, while the UK has less supplied capacity at 197,000 people per linac.[11]

8 *RANZCR. Planning for the Best: Tripartite National Strategic Plan for Radiation Oncology 2012–2022*, version 1. Sydney: RANZCR (2012), page 80.

9 A note on terminology – in the past the attendances that make up a course have sometimes been counted in 'fractions', whereas the more easily defined visit-based 'attendance' is used in this document.

10 *RANZCR* page 79.

11 *NRAG. Radiotherapy Services in England 2012*. London: Department of Health, 2012.

Table 2: Linac capacity relative to indicative radiation therapy centre catchment populations and estimated cancer registrations in 2012

Centre (DHB)	Number of linacs (2012)	Catchment population (2012)	Population per linac '000	Estimated cancer registrations (2012)	Registrations per linac
Auckland (including ARO)	9	1,678,820	187	7,297	811
Waikato	4	732,565	183	3,877	969
MidCentral	4	498,335	125	2,820	705
Capital and Coast	3	481,985	161	2,545	848
Canterbury (including St Georges)	6	733,625	122	3,826	638
Southern	*3*	307,485	102	1,527	509
New Zealand	29	4,432,815	153	21,934	756
Waikato + Tauranga (2014)	6	*732,565*	122	*3,877*	646

Notes: The cancer registration column total is slightly different to New Zealand due to a small number of registrations being unallocated to a DHB of domicile. Population 'catchments' for the purposes of this table have Nelson-Marlborough DHB split between Capital and Coast and Canterbury, and Tairawhiti is allocated to Waikato. Two linacs are planned for Tauranga's Kathleen Kilgour Centre for 2014. While Southern has three linacs installed, only two operated for nine months of 2012.

Treatment courses are divided into those delivering treatment for the first time, and those for people having their second or subsequent courses for the same cancer (Table 3). Overall 31% of all courses delivered were retreatments, including 32% of courses in the public sector and 17% of courses in the private. Retreatment courses tend to be for palliative care and usually have fewer treatments per course than first courses. Privately funded radiation therapy made up 8.7% of all courses delivered in 2012 in New Zealand, including 10.5% of first treatments and 4.8% of retreatments.

Table 3: Radiation therapy courses delivered in 2012 in New Zealand

	First course	Retreatment	Total	% retreatment	First as a % of estimated registrations
Publicly funded	7,346	3,495	10,841	32%	33.5%
Privately funded	860	175	1035	17%	3.9%
Total	**8,206**	**3,670**	**11,876**	**31%**	**37.4%**
% Private	10.5%	4.8%	8.7%		

The final column of Table 3 displays a key metric for radiation oncology, known as the radiation therapy utilisation rate or intervention rate (IR), with the latter being the term used in this Plan. This is defined as the proportion of all people with cancer (ie, those having had a cancer registration) who receive at least one course of radiation therapy during their care. The current national average of 37% is similar to that seen in Australia and the UK (see Section 5.1.3). Internationally, the desired (or 'optimal') IR is seen as the outcome of best clinical practice in use of radiation therapy for cancer treatment, and becomes a key variable in deciding on possible future planning scenarios. This is discussed further in Section 5.1.3.

3.2 Courses by DHB

The number of courses delivered by DHB is shown in Table 4 along with the calculated intervention (IR) and retreatment rates (RTR).

Estimated IRs by DHB for 2012 vary from 27% to 45%. In practice, a DHB's actual IR level in any one year will be based on the mix of tumours in that year, treatment modalities available, local clinical practice, and patient choice. This variation is discussed further in Section 5.1.1. The IR has likely to have increased in most DHBs over the past 10 years, although precise figures are not available.[12] RTRs also vary significantly, from 22% to 41% of all courses, probably related in part at least to locally available palliative care resources.

3.3 Workforce

Three workforce groups are covered in the Plan and associated Model: radiation oncologists, medical physicists and radiation therapists. Radiation oncologists (ROs) are doctors who specialise in treating cancer with radiation therapy. Medical physicists (MPs) are scientific specialists in the therapeutic application of radiation sources and operating the associated equipment. They are integral to treatment planning and measurement, and the use, calibration, and commissioning of linear accelerators and other radiation therapy equipment. Radiation therapists (RTs) are allied health practitioners involved in planning and delivering the radiation treatments. They provide specific care to patients throughout the course of their treatment and educate patients on the management of any treatment related side-effects. Each workforce group is an essential component in the multidisciplinary care that is needed for radiation therapy.

[12] See for example *Regional Strategic Plan: Sustainable delivery of radiation therapy in the Northern Region – 2019.* Northern Cancer Network (2010). Appendix II has some DHB IR estimates based on total courses, using an estimated retreatment rate of 25%. In 2006 the overall New Zealand IR was estimated at 35%.

Table 4: Courses and estimated intervention rate (IR) and retreatment rate (RTR) by DHB of domicile for 2012

DHB of domicile	First treatment	Retreatment	Total	% privately funded	IR	RTR
Northland	316	133	449	8%	34%	30%
Waitemata	894	381	1,275	21%	35%	30%
Auckland	689	319	1,008	27%	38%	32%
Counties Manukau	720	332	1,052	14%	36%	32%
Waikato	802	257	1,059	0%	44%	24%
Lakes	190	64	254	0%	36%	25%
Bay of Plenty	447	133	580	0%	34%	23%
Tairawhiti	91	25	116	0%	38%	22%
Hawke's Bay	317	96	413	0%	36%	23%
Taranaki	229	74	303	0%	36%	24%
MidCentral	361	162	523	0%	39%	31%
Whanganui	142	52	194	0%	37%	27%
Capital and Coast	543	271	814	0%	45%	33%
Hutt Valley	275	132	407	0%	41%	32%
Wairarapa	65	40	105	0%	27%	38%
Nelson-Marlborough	256	138	394	9%	30%	37%
West Coast	59	35	94	4%	30%	37%
Canterbury	990	564	1,554	17%	35%	36%
South Canterbury	132	90	222	5%	35%	41%
Southern	688	372	1,060	1%	45%	35%
Total	**8,206**	**3,670**	**11,876**	**9%**	**37.4%**	**30.9%**

Note: IR and RTR also shown graphically in Figure 5. IR is based on first courses divided by the estimated cancer registration volumes projected from 2007-2009 actuals; RTR is retreatment courses as a percentage of all courses.

3.3.1 Radiation oncologist supply

There were 50.5 FTE radiation oncologists in post at the end of 2012 according to cancer centre returns, similar to the 49 noted by the Royal Australian and New Zealand College of Radiologists (RANZCR) in their recent workforce publication.[13] There are currently 22 trainees in the five-year programme, producing between four and five consultants a year. Five registrars withdrew from the programme in the three years from 2009 to 2011, meaning a 10% attrition rate and leaving around four per year graduating. The RANZCR report notes on average one graduate per year migrating, mainly to Australia. Based on the age profile of the workforce and assuming an average retirement age of 65, RANZCR expects an average of one radiation oncologist per year to retire. No change in part-time rates is anticipated.

Overall, this creates a net forecast 'natural' growth of around **two specialists per year**.

[13] *The Radiation Oncology Workforce in New Zealand: Projecting Supply and Demand 2012–2022*. RANZCR, 2013.

3.3.2 Medical physicist supply

There were 52 FTE medical physicists in posts at the end of 2012 (public and private), with a further seven vacancies. Workforce and training data was obtained from medical physicist heads of departments around the country.[14] A Bachelor of Science or equivalent degree is required before entering medical physicist training. Each registrar is then five years in training, including one full-time year at the university (Canterbury), and then four registrar years based in the cancer centres. There were 17 registrars in the training scheme out of 18 available posts in 2012. On average from 2004 to 2012 there were 3.3 new registrar starts per year (30 in the 2004 to 2012 intakes) for 3.25 registrars qualifying per year (13 in last 4 years). There is a very low training attrition rate – almost all registrars who start successfully complete the programme.

Following graduation there is a distinct emigration pattern, with six of the above 13 graduates from the past four years going overseas. No prior graduates returned during that time. At the same time there was ongoing loss of existing medical physicists – in the three-year period 2009 to 2011 there was a 10% pa loss; of the 11 in total, eight left the country, one retired and two left the profession. This net shortfall each year has had to be made up from international recruitment – approximately 50–60% of positions are filled with overseas physicists. However annual turnover can be high in this group, and the vacancy rates noted above reflect the long lead times to recruit to vacancies. Vacancy rates have varied between 10 and 22% over the past few years. The modelling requires that the centres keep on recruiting internationally to restrict the shortfall to only one to two per year.

Overall, no **net 'natural' gain of medical physicists** is apparent, and there is a significant risk of net losses.

3.3.3 Radiation therapist supply

At the end of 2012 there were 252 FTE radiation therapists in the New Zealand workforce (public and private). There are currently only a few vacancies noted in the KPI reporting; these have been ignored in this analysis. The radiation therapist workforce is very young (median age 31 years) and predominately female (85% of the current FTE).[15] There is a single provider of radiation therapist training – Otago University (based at the Wellington School of Medicine) – that currently has 30 places per year for the three-year course. Places are limited by the need for clinical placements in years two and three. New graduates also require support in their first year of practice, some of which is provided by Health Workforce New Zealand (HWNZ). At present the intake of 30 is producing around 25 graduates at the finish of the course.[16]

[14] Personal communication. Lynne Greig, 2013.

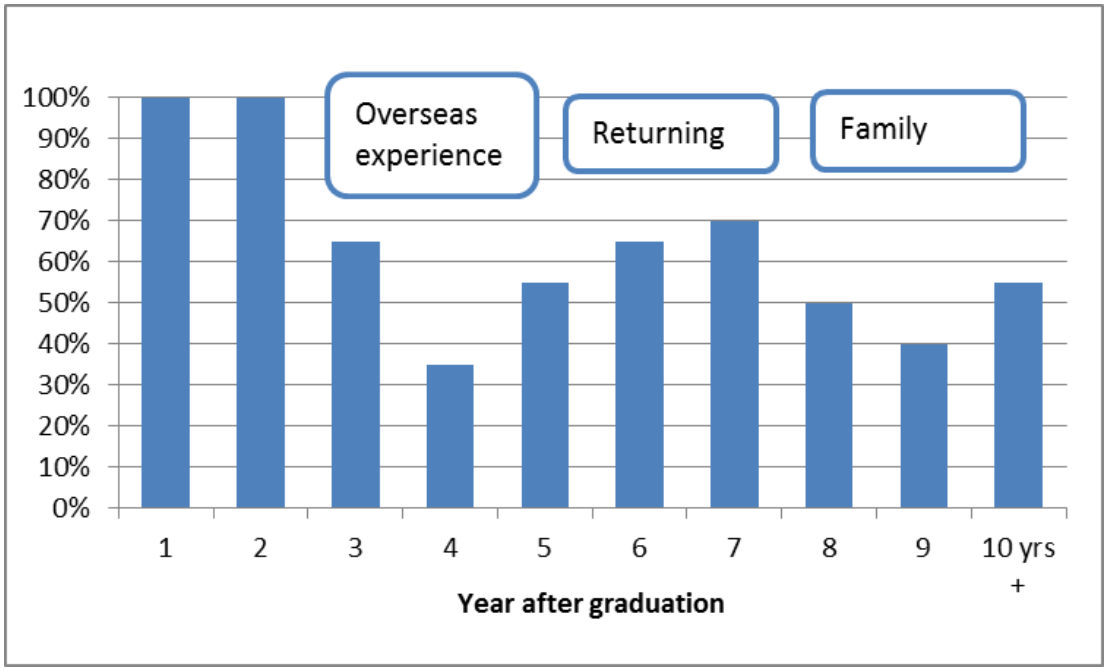
[15] *Radiation therapist workforce survey 2011*. Unpublished Excel sheet. Hallinan R, 2011.

[16] *Radiation therapy student enrolment numbers 1993–2013*. Unpublished report. Coleman K, 2013.

HWNZ Annual Practising Certificate (APC) numbers from the Medical Radiation Technologists Board (MRTB) were examined for 2011,[17] and compared with the graduation numbers of the corresponding years. A bimodal function was evident – radiation therapists drop registration from years three to five post graduation, start returning, then drop again years eight to nine (and with a possible further smaller drop around years 11–12) after graduation. This pattern might be explained by overseas experience and family responsibilities (Figure 2). At the low point, only about one-third of the radiation therapist graduates were in New Zealand by their fourth year after graduation, but this recovers to a longer term 'in-workforce' of around 55%. While international recruitment has been used in the past to bolster staffing, slight improvements in existing staff retention would obviate that need.

With other retirements and incorporating part-time rates, a net '**natural' gain of around 10 radiation therapists per year** is expected to 2022.

Figure 2: Radiation therapist retention after graduation



Source: HPCG analysis based on radiation therapist Annual Practising Certificate holders, 2009–2011, from HWNZ.

[17] *Workforce forecasting: radiation therapists.* Unpublished report draft version 2. HWNZ, 2011.

4 National capacity requirements

Section 4 describes the modelling work undertaken to define and project national capacity requirements, and the assumptions used. Linear accelerator and workforce capacity, and costs impacts are modelled for a range of scenarios to give a national picture of what is expected through to 2022 using the stated assumptions. Results of the modelling work are summarised, including potential operational performance factors that might ameliorate the growth, and a synopsis of the sensitivity analyses undertaken. Implications flowing from the results are discussed in Section 5.

4.1 Introduction to the Model

The National Linear Accelerator and Workforce Capacity Model ('the Model') has been developed to project national capacity requirements for a range of future scenarios. It also allows exploration of these and additional user-created scenarios by DHBs at the local and regional levels. Key illustrative scenario results are described here.

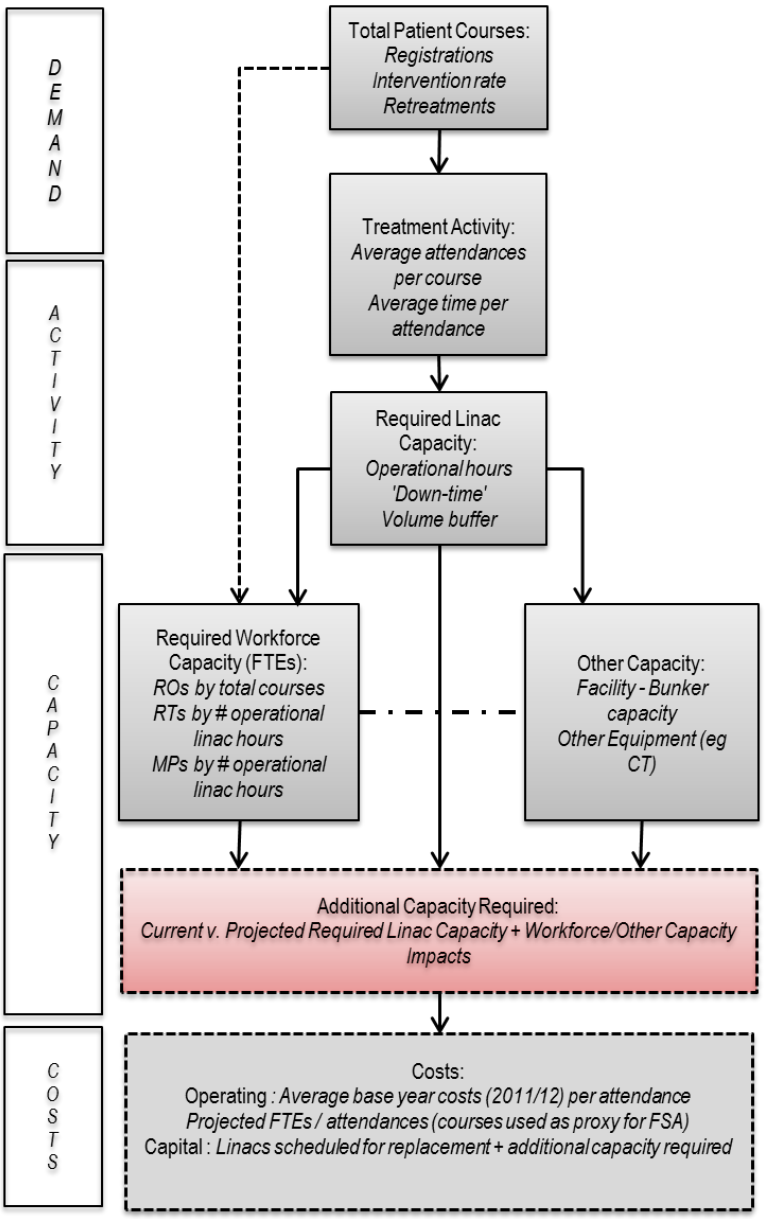
The Model is shown schematically in Figure 3. It estimates the likely number of cancer registrations through to 2022, the number that are likely to receive radiation therapy, and therefore the number of linacs likely to be needed to provide those treatments. It provides an update to the regional modelling work, adds workforce and capital and operating cost components, and allows common assumptions to be used by the DHBs across New Zealand.

Development of the Model and Plan has required nationwide consistency in data elements. However, moving from local and regional perspectives to a national view has revealed variation between regions and between cancer centres. The four regional cancer networks used different metrics and assumptions in undertaking their capacity modelling in 2012, which is to be expected as they have different configurations and start points. These have been merged to create the national Model, leaving potential differences between the regional and national analysis.

The national radiation oncology Key Performance Indicator (KPI) data collection is of relatively recent origin. Some data items are of variable quality in how they are reported; others are not reported by all radiation therapy centres. In developing the Model, a specific template was developed and sent to the centres to check their 2012 data; this then became the base year for modelling purposes. Where possible, data from 2011 was used as a cross-check. Limitations in the data used – for example, hours worked outside normal work days; exact FTE definitions used; and how linac hours were recorded in the KPI data set – required simplifying assumptions. The Model does not attempt to simulate day-to-day workings of each cancer centre, but to allow a reasonable annual picture to be constructed.

Volumes of other aspects of radiation oncology treatment were not explicitly modelled – for example, brachytherapy and stereotactic treatment, treatment for non-malignant conditions, and kilovoltage treatments. No net change in external beam volumes is assumed to arise due to any changes in these over the next 10 years. Workforce projections assume that the same proportion of staff time spent on these activities will continue into the future. Stereotactic volumes are not included in the analysis – Southern DHB capacity may be slightly overstated as a result, appearing available when in fact in use.

Figure 3: The structure of the National Radiation Oncology Capacity Model



4.2 Modelling variables and assumptions

Key variables and assumptions used are shown in Table 5 keyed to the four main areas in Figure 3, with further explanations below.

Table 5: Model variables and assumptions

Type	Variable	Comment	Figures used
Demand			
1	Cancer incidence	Ministry of Health projected cancer incidence to 2016 (see below). Grown from 2007–2009 base by DHB	Average growth, sensitivity: +5%, -5%
2	Demography	Statistics New Zealand median projections for growth and aging by DHB to 2022	Median projection
3	Intervention rate (IR)	See scenario discussion below. Stereotactic volumes not included.	Current, 40%; 45%; 50%
4	Retreatment rate (RTR)	Current rates assumed. Potential for some increase, eg through survivorship – tested in sensitivity analyses	Current; sensitivity – 35% public, 25% private
5	Brachytherapy, stereotactic radiation therapy	Changes in rates of other radiation modalities may occur; assumed this does not impact on external beam treatment volumes or workforce unduly	No change
6	Screening activity	Changes in screening activity might change cancer treatment needs	No change
7	Non-malignancies, skin cancers	Radiation therapy treatment for non-malignancies and superficial treatment for skin cancers are relatively small volumes and assumed to not add to maximal month pressures.	No addition
Productivity			
8	Average treatment attendances per course	By centre, public range 12.8 to 16.8 attendances (average 14). Potential for changes in average number explored	Current by centre; sensitivity allow +/- 10% variation over 10 years
9	Annual operational days	5 days per week, no statutory holidays	249 days per year
10	Daily operational hours	By centre. 8 hour day assumed for workforce planning	Usual hours; sensitivity 9 and 10 hours modelled
11	Average time per attendance	By centre, range 14 to 18.7 minutes (average 15.9). Potential for changes in average times explored	Current by centre; sensitivity allow +/- 10% variation over 10 years
12	Linac down time	For maintenance, testing, unplanned outages – as proportion of total available hours	13%
13	Impacts of new technologies	New technologies (eg IMRT, VMAT, RapidArc) have the potential to both increase and decrease treatments per course and times per treatment	See 8 and 11 above
Capacity			
14	Catchments	Tairawhiti DHB patients assumed to flow to Waikato; Nelson Marlborough maintains current split	As noted
15	Planning ratio for radiation oncologists per course	Current ratio assumed at each centre, to allow for non-external beam work. Lower ratios tested	Current (1/213 total courses); sensitivity 1/175-200
16	Planning ratio for radiation therapists per linac	Current ratio for each centre assumed, to allow for non-external beam work	Current (average 9.4 per linac)

Type	Variable	Comment	Figures used
17	Planning ratio for medical physicists per linac	Current ratio for each centre assumed, to allow for non-external beam work	Current (average 2.3 per linac)
18	Life of a linac	Reasonable operating life of a linear accelerator	10 years
19	Linac capability	Capability of current stock reasonable – unlikely to be a requirement to update machines early. Replacement plan at MidCentral not confirmed at date of writing	No change
20	Associated equipment	Current ratio of key equipment items to linacs (eg CTs, MRIs, simulators) continues	No change
21	Peak demand – health target waiting times	No one may wait more than 4 weeks for treatment. Centre must be able to treat everyone in their maximal months	Use current Network modelling method of 1 standard deviation of treatment volumes added
22	Public/private proportion	Assume same market share by DHB over the planning period	Current by DHB (8.7% of courses nationally)
23	Kathleen Kilgour Centre, Tauranga (KKC)	Assume all Bay of Plenty residents' courses attend Tauranga; plus a small private component from adjacent DHBs – 10% of Waikato, 10% of Lakes, 5% of Tairawhiti. Assume Waikato's treatments per course and average times	As noted
Costs			
24	Purchase units	Averaged costs from National Pricing Project for 4 DHB cancer centres (Auckland, Waikato, Capital & Coast, and Canterbury)	Average per unit DHB costs
25	FSAs/follow-ups	Assume increase is in proportion to increase in courses, and follow-ups remain at same ratio to FSAs	Average per unit DHB costs
26	Inflation	Discounted cashflows are used with assumption that inflation will average at the mid-point of the RBNZ band	2%
27	Linac price	Cost of new or replacement machine and associated software	$4 million
28	Facility costs	Bunker/facility cost per new linac	$2 million
29	Associated equipment costs	Upgrades, maintenance, software costs during useful life of linac	$1 million in fifth year for each linac
30	Consequent impacts on other oncology services	No evidence of changes in usage rates of other services as a result of changing IRs	No change
31	Other costs	Marginal incremental cost for refurbishment and upgrades	$300,000
32	Cost of capital	Interest costs (used as discount rate)	8%

4.2.1 Demand

Demand for radiation therapy is based on the number of cancers expected (ie, cancer registrations). Cancer incidence changes over time were modelled by the Ministry of Health, and projected to 2016.[18] The demographic factors of population growth and ageing were calculated for each DHB using updated population projections[19] by cancer type, and then summed. Haematological and child cancers were included, differing slightly from previous projections used for medical oncology.[20] The projections were extended to 2022, assuming the same trends continued (see Appendix 4).

Survivorship was not explicitly modelled. If this becomes a factor, it might present as an increase in RTR – the longer the survival, the more chance a person has of receiving subsequent treatment courses. However given the absence of any clear evidence base for increasing the RTR, or centres specifically looking to increase their RTRs, the Model assumes that current rates will continue. Note that as IRs increase so too will the retreatment numbers, with more people able to be treated subsequently.

No assumption was included in the Model regarding any impact of screening programmes and earlier diagnosis. Should the current trial of screening for bowel cancer be followed by a national screening programme, this has the potential to change radiation therapy demand, but it is too soon to estimate any quantum. Testing for prostate cancer has led to a large increase in cases found over the past 10 years, with concomitant increases in radiation therapy treatments (among other modalities). The Ministry's incidence modelling assumes a slowing in the rise in such cases over the next 10 years (a pool of slow-growing cancers having now been found), but prostate cancer still makes up a quarter of the new cancer growth projected. Variations on this incidence growth were explored in sensitivity analyses (see Section 4.6).

Non-melanoma skin cancer (NMSC) is not included in cancer registration data. A few cases each year do progress to the stage of needing radiation therapy via external beam. These treatments are counted, so are being included in the current IR estimates, over-stating them slightly. To the extent that radiation therapy-treated NMSC rates are rising at a similar rate to other cancers as the population ages, it will have little effect on the Model.

4.2.2 Impact of new technologies

As further discussed in Section 5.3, radiation oncology as a discipline is experiencing significant development of new technologies and techniques. Intensity modulated radiation therapy (IMRT) and image guided radiation therapy (IGRT) have been introduced at all of New Zealand's cancer centres, with a resulting increase in treatment planning complexity. The planning complexity proportions reported in the KPI dataset differ significantly by cancer centre; at face value the data suggest little effect on numbers of treatments per course or treatment times.

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[18] *Cancer Projections: Incidence 2004–08 to 2014–18*. Wellington: Ministry of Health, 2010.

[19] Population projections commissioned from Statistics New Zealand. Unpublished Excel spreadsheet. Ministry of Health.

[20] *Report to the Ministry of Health: New models of care for medical oncology*. Cranleigh Health, 2011.

There can be courses with complex planning requirements (taking up more workforce time) but relatively simple treatment (low machine time), and vice versa.

There is likely to be a significant 'learning' effect – in other words, as centres do higher volumes of the more complex plans, the faster they will be able to process them. Reported rates of plan complexity varied across the cancer centres, but the data was difficult to interpret so planning complexity rates and change over time were not included in the Model.

How the impact of new technologies was handled in regional modelling by DHBs varied by region. One of the regional plans assumed a net reduction in treatments per course (termed 'hypofractionation'), while the other three made no specific adjustment while noting likely increases in planning complexity. In the absence of expert consensus, the Model has made no adjustment for complexity changes or other technology adjusters. Technology change may decrease as well as increase workload, and current data collection does not allow empirical analysis of time and staff needs for differences in complexity of treatment. However some gains in operational efficiency may well be possible, and are discussed further in Section 4.5.

4.2.3 Capacity

Each radiation therapy centre is modelled separately with the private proportion of each DHB's population usage held at 2012 levels, meaning that there are no planned transfers of 'market share' from public to private or vice versa. If the public centre is 'full' then a new linac is suggested by the Model, even if capacity exists in a private facility in the same city. The future linac requirements forecast are not specific as to whether the capacity development would be in public or private sectors, only that there will be the need for such an expansion.

Current (2012) catchment flows are used, apart from the planned redirection of referrals for Tairawhiti residents to the Waikato centre from 2013. Nelson-Marlborough is assumed to maintain its present proportional split between Capital and Coast and Canterbury cancer centres. The planned Tauranga private facility with two linacs is assumed to treat the majority of Bay of Plenty residents' publicly-funded volumes from mid-2014. It is also assumed that around 10% of the demand from Waikato and Lakes DHB residents and 5% from Tairawhiti might be carried out as privately funded courses (based on rates of use for residents of non-local DHBs of the current private facilities). The average attendances per course and time per attendance for the Waikato centre are used as the base for the Tauranga figures. The two Tauranga linacs are not counted as 'added linacs' as they are already catered for in the Model.

While patient flows may change in the future – for example, for regional capacity planning purposes – those described above are used for national modelling purposes.

A factor is added to allow for the maximum four-week waiting time for radiation therapy. Each cancer centre is expected to have the capacity to deal with its highest monthly total in that month without needing to transfer patients elsewhere. This is operationalised by adding one standard deviation's-worth of courses to each centre – effectively the capacity to carry out the

maximum month's volumes on any month of the year.[21] Treatment for non-malignant conditions and superficial treatment (SXR) – for example, for skin cancers – are relatively low in volume and assumed to have little impact on the maximal months so have not been added in further.

Based on the current working hours per day and days per year, the number of linacs required is estimated from these linac-hours. Generally linacs are operated on weekdays only, with work days ranging from 8 to 10 hours depending on the centre. Most do not run on public holidays. There is allowance of 13% downtime for machine testing and outages for each linac.

4.2.4 Workforce supply

The relatively small workforces involved, particularly for radiation oncologists and medical physicists, preclude elaborate workforce modelling, but a straightforward picture with a range of likely scenarios can be developed. New Zealand's workforce planning is based on the aim of self-sufficiency. This principle is applied to modelling of the radiation oncology workforce; however significant international recruitment of medical physicists is still needed for balance if current outflows continue. Both public and private workforces are included as they come from the same training pool.

The number of trainee positions is known and relatively stable, with the key variable being the retention of those trainees – in other words, how many will remain working in New Zealand. The past is used as a guide for this, but changes in employment demand in key overseas destinations such as Australia and the United Kingdom could easily change the historical flows. Planning documents from both these nations assume that the predicted growth in their workforce requirements will be able to be met internally,[22] [23] but this has not been the case in the past. It is too early to assess the impact on retention rates of the expansion of the bonding scheme offered by Health Workforce New Zealand (HWNZ) to include medical physicists and radiation therapists from 2012.

Workforce numbers are calculated as full-time equivalents (FTEs) with a base 40-hour working week, while training numbers are calculated as headcount. The entire radiation oncologist, medical physicist and radiation therapist workforce is modelled (not just their proportion of time involved in external beam treatments), so current workforce ratios are used. Radiation oncologists are grown in proportion to total courses delivered, while radiation therapists and medical physicists are grown in proportion to total linac-hours. Diagnostic imaging medical physicists (DIMPs) are not considered.

4.2.5 Costs

Radiation oncology operating costs are estimated using cancer centre costs and volumes reported to the Ministry by four DHBs – Auckland, Waikato, Capital and Coast, and Canterbury – as part of the National Pricing Programme (NPP). Costs reported by these DHBs are used to

[21] As more monthly volume data becomes available over time, a more empirical time trend analysis will become possible, allowing further refinements of this methodology.

[22] *National Cancer Workforce Strategic Framework*. Health Workforce Australia, 2013.

[23] *Radiotherapy Services in England 2012*. NRIG. Department of Health ref 18206, 2012.

set annual Inter-District Flow (IDF) prices, which are used to inform purchasing decisions between DHBs and public purchasing from private providers.

The Model uses four public sector radiation oncology purchase units segmented by cost type to estimate average costs. The four purchase units are:

- first specialist assessment (FSA) – Radiation Oncology
- specialist follow-up – Radiation Oncology
- orthovoltage radiation therapy
- megavoltage (linac) radiation therapy.

Average per unit costs excluding linac depreciation and costs of capital for the four reporting centres are used to estimate the costs incurred by other cancer centres including the two private centres (ARO and St Georges).[24] Depreciation and costs of capital for existing, replacement, and any additional linacs are separately modelled based on the assumptions listed in Table 5. Depreciation and interest costs at a centre level will depend on depreciation methods and financing arrangements used at time of purchase and over the useful life of the linac. These modelled costs are therefore indicative only. The interest costs are best considered as an indication of the opportunity cost of capital to funders of different Model scenarios.

Public and privately funded radiation therapy costs are included in the Model. For simplicity, the Model uses the average of the four reporting cancer centres, regardless of whether a DHB or a private funder is paying for the service from a public or private provider.

Transport and accommodation costs to DHBs, private insurers and patients have not been included in the Model, nor have any other diagnostic costs such as additional MRIs and CT scans apart from those included in the first specialist assessment and specialist follow-up appointments. Further, patient out-of-pocket payments for private health insurance or other direct treatment expenses have not been included.

Capital investment costs are estimated based on the price assumptions listed in Table 5 and capacity requirement outputs from the Model (replacement and additional linac requirements). The two-linac private development currently underway in Tauranga is assumed in the base, and so these are not included as added linacs in the scenarios, nor as added capital costs.

Based on the approach described above, the Model estimates radiation oncology FSAs, specialist follow-up appointments, and ortho/mega-voltage treatment attendances cost approximately $73 million in 2012/13. This excludes linac-related depreciation and interest on borrowing. When these latter costs are included, total annual costs are estimated to be $103 million in 2012/13 but it should be noted that as per above, this estimate is indicative only and interest costs are best considered as an indication of the opportunity cost of capital to funders.

[24] For radiation oncologist, medical physicist, and radiation therapist unit costs, Auckland DHB was not included in the average given some differing MECA rates between Auckland and the other centres.

4.3 Model scenarios

The volume of radiation therapy courses has risen steadily over the past 10 years in step with the increased investment in cancer services through the Cancer Control Strategy and widening scope of radiation therapy treatment. If this trend continues it is expected that the next 10 years will see a further lift in courses per 100 registrations unless prevented by capacity constraints. Scenarios have been constructed to illustrate this potential growth, using the intervention rate (IR) as the key driver. Table 6 shows the scenarios, starting with the current rate as the Base scenario. The Modest Growth scenario – to 40% IR – is suggested by the past IR rises. Any activity that increased IRs further would suggest that the Growth scenario (45% IR) would come to the fore. The Maximal Growth scenario at 50% IR is around the highest rate suggested in the international literature and is considered less likely. Scenarios explored in the Model assume reduction in variation between DHBs over time. The assumed path forward is discussed further in Section 5.1.

Table 6: Model scenarios

Scenario	IR	RTR	Comment
Base	Current	Current	Each DHB's intervention rate (IR) and retreatment rate (RTR) and all other linac operating parameters are assumed to stay the same as in 2012. This is effectively showing the capacity growth due to the increases in cancer registrations expected.
Modest growth	40%	Current	Assumes the national average IR moves to 40% by 2022.
Growth	45%	Current	IR moves to 45% by 2022.
Maximal growth	50%	Current	IR moves to 50% by 2022.

4.4 Model results

4.4.1 Linac capacity requirement

The scenario results are shown in Table 7. If the 2012 IR and RTR were maintained to 2022, and all other linac operating parameters were maintained at current rates, including current operating hours, the Base scenario indicates a need for eight additional linacs over the next 10 years, beginning in 2013 (in addition to the two in Tauranga in 2014 which are already factored in). The Model nominally suggests the first builds will be needed in Auckland, MidCentral and Capital and Coast DHBs. This is effectively the capacity growth due to the increases in cancer registrations expected – mainly the result of population growth and ageing.

Table 7: Additional linac capacity suggested under Model scenarios

Scenario	Rate	Added linacs	Total linacs in 2022
Base	Current IR and RTR	8	39
Modest growth	40% IR	10	41
Growth	45% IR	17	48
Maximal growth	50% IR	20	51

IR = intervention rate – % all cancer registrations with at least one course of radiation therapy; RTR = retreatment rate.

The Modest Growth scenario, raising the average IR to 40%, would suggest the need for two more linacs – increasing to 10 the new builds required. The increase in IR compounds the RTR even when held at current rates – as more people have first treatments, more are eligible for retreatments.

Increasing the IR to 45% in the Growth scenario would suggest the need for seven further linacs, or 17 additional in total. The Maximal Growth scenario at 50% IR would suggest adding a further three, taking it to 20 additional linacs overall.

4.4.2 Workforce capacity requirement

Based on the scenarios described above (Table 6), the radiation oncology workforce will need increased capacity if New Zealand is to be self-sufficient (Table 8). The additional workers needed might come through added trainees graduating, or through higher retention of existing graduates and the established workforce. For example, the Growth scenario would require recruitment of an additional six medical physicists per year. If that was done through increasing the training programme intake, nine graduates per year would be required (ie, the existing three, plus another six). There is a clear need for a swift increase in medical physicist training numbers and improvements in retention, even if there is no or little increase in the average IR. This may require examination of the entire structure of the training programme given the feedback received on likely future shortages in clinical placement opportunities. Overseas recruitment may also become more difficult in the future; no change assumption about this has been included in the current Model.

Table 8: Workforce training needs by scenario, average per year increase to 2022

Scenario	Rate	Radiation oncologists		Medical physicists		Radiation therapists	
		Increase per year	Net total per year	Increase per year	Net total per year	Increase per year	Net total per year
Current net graduates per year			4		3		25
Base	Current IR and RTR	0	4	3	6	0	25
Modest growth	40% IR**	0	4	4	7	2	27
Growth	45% IR**	1	5	6	9	9	34
Maximal growth	50% IR**	3	7	8	11	16	41

Increase per year = new trainees graduating, and/or the net result of existing graduates/staff retained/returned. The 'Net increase per year' adds the existing numbers graduating per year. IR = intervention rate; RTR = retreatment rate.

4.4.3 Cost impacts

The operating costs of the radiation therapy services in 2012 was estimated to be $103 million. This includes linac-related depreciation and costs of capital. The expected growth in cancer registrations through incidence changes and the population growth is estimated to be around **$41** million extra in operating costs per year by 2022 (see Table 9), including linac-related depreciation and costs of capital for radiation oncology, bringing total spending to $144 million (in 2011/12 $$). Total capital costs are estimated at $236 million over the 10-year period, a net present value (NPV) $184 million.

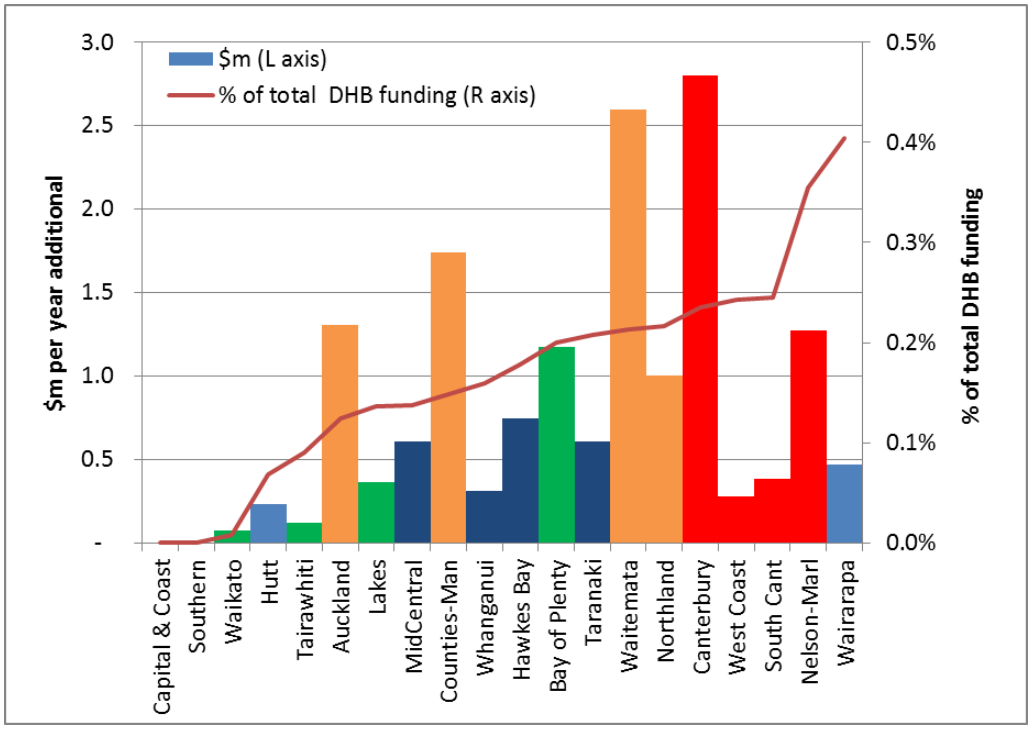
Moving to a 45% IR would require an extra $36 million in operating costs per year over the Base scenario ($77 million additional compared with $41 million), but with a large increase of $92 million in capital spend (an increase of $62 million in NPV).

The $36 million additional operating cost spend if the national average moved to a 45% IR by 2022 can be apportioned amongst DHBs based on the population growth and current distance from the IR and RTR. Using only publicly funded volumes and current IDF costs, there would need to be a shift of funding from other services to radiation oncology to cover the additional expenditure (Figure 4). The demographic costs (ie, as in the Base case) are assumed to be covered through annual demographic adjustment to the Population Based Funding Formula (PBFF). The DHBs close to the 45% IR cluster at the left hand end of the graph in Figure 4, while those requiring a larger proportionate spend on radiation oncology are at the right hand end. For example, Nelson-Marlborough DHB would be spending around $1m a year in additional IDF costs for radiation therapy (around 0.3% of its total funding) if its population were accessing radiation therapy at a 45% IR.

4.5 Operational performance

Cancer centres will always seek improvements in operational performance. Two specific factors are discussed here – variations in treatment times, and 'tipping point' conditions.

Figure 4: Indicative national radiation oncology funding changes by DHB under the Growth scenario



Notes: Assumes all residents of each DHB are receiving 45% IR; 2011/12 IDF price x current attendances per person; that demographic growth is already funded; and 2011/12 constant $$. The % of total DHB funding is based on the total 2012/13 PBFF revenue for each DHB. Sorted in order of proportion of total funding for that DHB that would need to be added to its radiation oncology spend (additional to the estimated demographic growth). Colour-coding indicates the DHBs served by each cancer centre.

4.5.1 Treatments per course and treatment times

The Model assumes the status quo – that is, centres will carry on at the same rate of treatments per course and time taken for each treatment as they do now. However, the DHB centres currently vary significantly in these metrics, with treatments per course ranging from 12.8 to 16.8 (a national average of 14), and average treatment times ranging from 14 to 18.7 minutes (average 15.9). Taken as a 'treatment minutes per course' (excluding planning time), the national average is 223 minutes, with a range of 194 to 291. Given this variability across centres, there are likely to be many aspects of service operations that could contribute to achieving efficiency gains. DHB cancer centres will be constantly looking for operational gains to make best use of scarce workforce and financial resources, particularly before committing to new capital infrastructure. Business cases for new builds will be likely to require details of comparative operational performance. The Model enables assessment of the effects of varying treatments per course (eg, hypofractionation) and changes in the times per treatment.

4.5.2 Tipping point

As a radiation therapy service reaches the point of needing a new linac, it is likely there would be changes in operations to delay the need for the next large capital spend, and to ensure that when the new linac commences operation it carries a reasonable load. Examples of such 'tipping point' operational changes might include running a 10-hour day in the months of highest volumes (as was done in Waikato in 2012 and 2013), evenings/weekends shifts, working public holidays, or subcontracting volumes to other centres. Note that the Model without a tipping point added assumes a new linac is required when the hours of operation needed in the busiest month of the year is exceeded (derived using one standard deviation added to the average). On average this might occur or be close to occurring in 2–3 months of the year. The tipping point measures described (such as subcontracting or extending operational hours) would come into play for these maximal months. For the remainder of the year the centre will presumably be able to operate its normal hours.

Table 9: National radiation oncology capacity model scenario costings

Scenario	Rate	New linacs	Replacement linacs	Operating cost in 2022 $ current^	Incremental operating cost $ current^	Capital costs 2013–2022 $ current*	Capital present value	Operating present value#
Base	Current IR	8	28	$144m	$41m	$236m	$184m	$1,107m
Modest growth	40%	10	28	$156m	$52m	$258m	$200m	$1,144m
Growth	45%	17	28	$181m	$77m	$328m	$246m	$1,216m
Maximal growth	50%	20	28	$200m	$96m	$361m	$271m	$1,280m

Notes:

Based on a 2% inflation rate per annum, and an 8% discount rate. IR = intervention rate

* *Includes scheduled linac replacements (28 existing linacs to be replaced over the planning period = $152m) and software upgrades for existing linacs; includes bunker construction costs for new builds. The 2014 Tauranga linacs are assumed to have been financed and are not included here.*

^ *2012 operating cost estimated at $103m. Includes additional operating expenditure arising from increased linac and workforce capacity including linac-related depreciation and costs of capital.*

\# *Total cashflow for 10-year period, which includes estimated current operating expenditure.*

4.5.3 Operational gains

As an example, a conservative approach might assume a 1% improvement per annum, or 10% over 10 years at a national level in either treatments per course, or times per treatment, or a combination of the two. Individual centre rates will vary, but the national average should be modifiable. To this might be added the equivalent tipping point response of running the existing linacs at 10 hours per day, as has been done at Waikato.[25] Actual tipping point changes would vary from centre to centre as noted above, but for modelling purposes are assumed to have the impact equivalent to the 10 hours a day operation. Based on these changes a new capacity forecast is shown in Table 10, with concomitant new workforce and cost estimates (Tables 11 and 13).

Table 10: Model scenarios with operational gains and/or tipping point measures

Scenario	Rate	Added linacs			
		Current parameters	1% pa operational gains	Tipping point	1% and tipping point
Base	Current IR and RTR	8	6	4	3
Modest growth	40% IR	10	7	5	4
Growth	45% IR	17	11	7	6
Maximal growth	50% IR	20	17	11	7

IR = Intervention rate, RTR Retreatment rate. Operational gains are in reduced treatments per course, or reduced treatment times. 'Tipping point' includes capacity-increasing measures set at the equivalent of running existing linacs to 10 hours per day.

The model is very sensitive to the tipping point and operational changes that might be possible. If able to be implemented, this would see a dramatic fall in the number of new linacs being needed. For the Base scenario, it would reduce the eight additional linacs to an additional three over the next 10 years. The timing of the build would shift back, the Model nominally suggesting one new linac in 2019 at Capital & Coast, and two in 2022 at Auckland in the Base scenario including operational gains and tipping point changes. The recent investments in linacs, and the two additional being commissioned for Tauranga, would be largely sufficient for current average IR given the assumed productivity gains.

The Modest Growth scenario with the average IR increasing to 40% would mean a further two linacs added to get 10 new builds. Including tipping point and operational gain assumptions add only one more linac to four new builds – nominally one for Auckland in 2018, one for MidCentral and another for Auckland in 2019, and one for Canterbury in 2020.

[25] Each staff member at Waikato still works a base 40-hour week, but in the form of a 4-day week of 10 hours per day rather than 5 days at 8 hours.

Adding the tipping point and operational gains to the 45% IR Growth scenario would drop the additional 17 linacs to a suggested need for six. These would come in earlier than in the Modest Growth scenario, with the Model suggesting three for Auckland (two in 2017, and one in 2022), one for MidCentral in 2016, one for Canterbury in 2018, and one for Capital and Coast in 2019 (Table 14 below). The Maximal Growth scenario at 50% would suggest the need for one additional linac rather than three without the tipping point and operational gain assumptions, coming in around a year earlier than in the Growth scenario.

Table 11: Workforce increases needed by scenario, average per year increase to 2022 including operational performance gains

Scenario	Intervention rate	Radiation oncologists (increase per year)		Medical physicists (increase per year)		Radiation therapists (increase per year)	
		Current parameters	1% pa operational gains*	Current parameters	1% pa operational gains*	Current parameters	1% pa operational gains*
Base	Current	0	0	3	1.5	0	0
Modest growth	40%	0	0	4	3	2	0
Growth	45%	1	1	6	5	9	4
Maximal growth	50%	3	3	8	7	16	10

Increase per year is the additional needed, either new trainees graduating, or additional existing graduates/staff retained.

* *Assumes 10% operational gain over 10 years or 1% pa – eg, through fewer attendances per course (hypofractionation) or less time per attendance.*

IR = intervention rate; RTR = retreatment rate.

While adding the 1% pa operational gains does not affect radiation oncologist requirements, it has a strong effect on medical physicist and radiation therapist numbers (Table 11). A ‘saving’ of one to two medical physicists and four to five radiation therapists per year might be possible within each scenario. Medical physicist numbers still look very low though. Overall the shortfall by 2022 per discipline for the Growth scenario compared to the current workforce numbers and expected proportion of training output retained in the New Zealand health system is seven radiation oncologists, 30 medical physicists, and 25 radiation therapists. It is unlikely that the shortfall of medical physicists will be able to be made up simply by increasing training places (Table 12), but a near-doubling of training places over the next five years would go some way to improve matters. Increased efforts on retention of new graduates and of existing staff are essential.

Table 12: Training places needed by scenario to 2022 if all workforce gains were to come from increased training numbers

Scenario	Rate	Radiation oncologists		Medical physicists		Radiation therapists	
		Total	Increase	Total	Increase	Total	Increase
Current training places		22		18		90	
Base	Current IR and RTR	22	0	35	17	90	0
	As Base, plus 1% pa operational gain**	22	0	26	8	90	0
Modest growth	40% IR plus gains**	22	0	35	17	90	0
Growth	45% IR plus gains**	28	6	47	29	105	15
Maximal growth	50% IR plus gains**	40	18	58	40	126	36

Increase is the number of training places needed at current attrition rates to supply the workforce needs should current graduate/staff retention rates not improve – ie all increases need to come through the training programmes.

** *Assumes 10% operational gain over 10 years or 1% pa – eg, through fewer attendances per course (hypofractionation) or less time per attendance.*

IR = intervention rate; RTR = retreatment rate.

If the operational gain and tipping point assumptions were able to be achieved, the fall in linacs required noted in Table 10 would lead to significant capital cost savings nationally (Table 13). The Base case would see a savings of $53 million over the 10 years, while in the Growth scenario $111 million in capital costs would be saved. Operating costs are little changed;[26] it is in the capital spend area that savings are evident.

Table 13: National radiation oncology capacity model scenario costings

Estimated capital costs of added and replacement linacs (current $)					
Scenario	**Rate**	**Current parameters**	**1% pa operational gains**	**Tipping point**	**1% and tipping point**
Base	Current IR and RTR	$236m	$215m	$193m	$183m
Modest growth	40% IR	$258m	$225m	$206m	$204m
Growth	45% IR	$328m	$268m	$227m	$217m
Maximal growth	50% IR	$361m	$328m	$267m	$227m

Based on a 2% inflation rate per annum, and an 8% discount rate. IR = intervention rate, RTR = retreatment rate.

Includes 28 existing linacs to be replaced over the planning period and software upgrades for existing linacs; bunker construction costs for new builds. The 2014 Tauranga linacs are assumed to have been financed and are not included here.

[26] Using particularly the example of Waikato Cancer Centre, which seems to have similar operating costs to the other centres despite using a 10 hour working day – staff still have a base 40 hour week though.

The operational details will vary from centre to centre and be dependent on workforce flexibility, availability, and arrangements. All will entail additional operating costs and may be more or less feasible for any given centre's circumstances. No change in the quality of care provided is anticipated. The Model assumes that additional staff full-time equivalent (FTE) and operational costs will rise at the same rate as if the new linac had been built; only the capital cost is delayed. If local circumstances make it difficult to change current work patterns, meaning it might be the lower cost option to build the new linac, then local business cases will no doubt reflect that in their options analysis. These will be operational and investment decisions for each DHB cancer centre.

It should be noted that running linacs for longer periods each day may increase the need for maintenance stoppages. In addition, commissioning a new or replacement linac can take around 6 months. Unless there is a decanting bunker available the temporarily reduced capacity may be more difficult to make up if the other machines are already working extended hours.

4.5.4 Timing and location

The Model is built up from the results for each cancer centre, so it does suggest the location and timing of new builds, as shown for example in Table 14. Note that these are suggested locations and timing only as arising from the modelling work; actual build locations and timing will be dependent on DHB business cases and actual service demand related to service capacity. Also shown in Table 14 is the additional pressure cancer centres will be facing in the lead up to the indicative build dates. The light shading indicated that operational gains and/or tipping point activities will likely be needed to stay within capacity. As the capacity comes closer to 100% utilisation the shading darkens. The model suggests that MidCentral, Capital and Coast and Canterbury DHBs will already be instituting some operational gain measures in 2013 to maintain service delivery.

Table 14: Linear accelerator additions suggested by the Model

Region	Centre	2014	2015	2016	2017	2018	2019	2020	2021	2022
Northern	ADHB				+1					+1
	ARO				+1					
Midland	WDHB									
	KKC									
Central	MDHB			+1						
	CCDHB			+1						
South Island	CDHB					+1				
	SGC									
	SDHB									
Cumulative total NZ				**+2**	**+4**	**+5**				**+6**

Key:

Operational gains and tipping point activities required
Within 95% of capacity
Model suggests new linac may be needed

Assumes Growth scenario (45% IR), with 10% operational gains and tipping point changes up to the equivalent of 10 hours operation per linac. Suggested locations and timing only; actual build locations and timing will be dependent on DHB business cases and actual service demand.

ADHB = Auckland DHB, ARO = Auckland Radiation Oncology, WDHB = Waikato DHB, KKC = Kathleen Kilgour (Tauranga), MDHB = MidCentral DHB, CCDHB = Capital & Coast DHB, CDHB = Canterbury DHB, SGC = St Georges, SDHB = Southern DHB.

4.6 Sensitivity analyses

Many of the variables and assumptions can be adjusted in the Model. Effects of some key variables are shown here – most have some effect, but the core Model findings seem robust.

4.6.1 Linac hours per day

The numbers of hours per day that linacs operate is a significant determinant of the timing of the new linac needs, as the change from current hours to an average of 10 hours demonstrates. Even if the tipping point effective average operating time for linacs in the maximal-months was nine hours per day prior to commissioning a new one instead of the equivalent of 10 hours as used above (and no subcontracting took place), the Growth scenario would see the need for **seven additional linacs.** That is one more than the six in the Model with the tipping point and operational gains included (with the first ones needed in MidCentral and Capital and Coast DHBs), but still significantly less than the 11 linacs suggested without adding in the tipping point adjuster.

4.6.2 Centre catchments

The policy assumption that patients should not need to move out of their cancer centre catchment for treatment does have an additional cost. For example, the Modest Growth scenario would need no additional linacs if patients were able to move to use spare capacity at other centres (including private), and centres were able to run their linacs up to 10 hours per day in the maximal-months as needed. In the Growth scenario **four additional linacs** would be avoided, with only two being needed instead of six.

4.6.3 Registrations

Reducing registration growth by 5% – for example, by assuming that prostate cancer growth returned to the average growth of all other cancers – removed **one linac** from the Growth scenario with operational gains included. Conversely, if registrations grew by 5% more than expected there would be no additional linacs in the Growth scenario but an extra four in the Maximal scenario (from seven to 11 added linacs).

4.6.4 Workforce ratios

The ideal patient load for a radiation oncologist is considered to be 175–200 patients per year, while the current national average is 214 patients per year. If the lower ratio was achieved over time, an additional 17 radiation oncologists would be needed by 2022, or roughly **two extra graduates per year**. Moving to the suggested staff ratios of two medical physicists per linac and nine radiation therapists per linac makes little difference to workforce projections.

4.6.5 Retreatment rates

The current national average retreatment rate (RTR) is 31% of all courses, but this ranges from 22 to 41% by DHB. There is potential for the retreatment rate to rise, but no specific case has been made as to what might be a desired level. By way of example, if one assumed a 35% RTR in public centres, and 25% in private centres, this would see an increase of **one linac** needed in the Growth scenario, and three in the Maximal Growth scenario (both assuming the operational gains discussed in Section 4.5). As the IR rises the RTR has a compounding effect.

5 Advancing national service and capacity planning

Preparation and application of the Model as described in Section 4 has revealed a number of issues of relevance for future development of radiation oncology services in New Zealand. Section 5 considers these issues, and how they could be progressed at a national level by the Ministry, the Radiation Oncology Working Group, the regional DHB cancer networks, and the cancer centres.

5.1 Access to radiation therapy

5.1.1 Current variation

As discussed earlier in the Plan, two important indicators of access to radiation therapy[27] are:

- *Intervention rate* (IR): The proportion of all registered cancers that are treated with at least one course of radiation therapy.
- *Retreatment rate* (RTR): The proportion of all courses delivered to people with cancer who have already had at least one course for that cancer.

International analysis and discussions on appropriate levels of IR and RTR take an epidemiological approach in considering whole population coverage. The Model and this Plan follow that approach in including private sector activity (both privately funded and DHB funded).

There is considerable variation around the estimated national average IR of 37.4% (in 2012) by DHB of domicile (standard deviation +/- 5.5%), with the highest IR being in Capital and Coast DHB and Southern residents (45%) and lowest in Wairarapa (27%), and Nelson-Marlborough and West Coast (both 30%). There is also considerable variation in RTR by DHB (+/- 5.3%), ranging from 41% for South Canterbury DHB residents to 22% for Tairawhiti DHB. Figure 5 shows the current IR[28] and RTR by DHB of domicile (with these 2012 rates being used as the baseline in the Model).

The reasons for this variation in access to radiation therapy by DHB and the implications of it are not clear. Improved understanding of the underlying factors will be critical for identifying an acceptable level of variation, and designing remedial action where the variation is considered excessive.

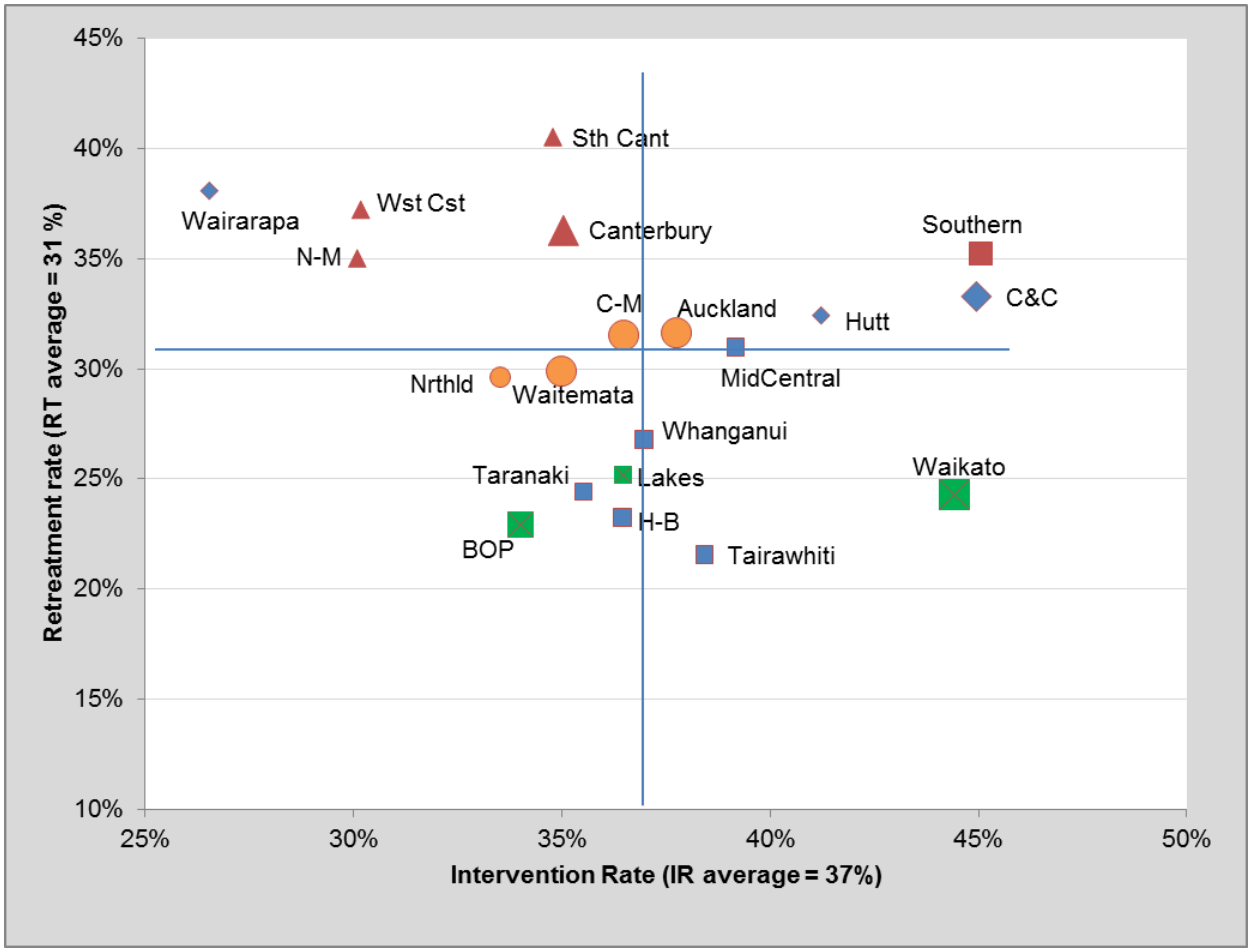
[27] Referral rate may also be a useful measure. Referral rate measures patient and clinician choices outside the cancer centre, while IR is a combination of referral choices, plus treatment choices by patients and clinicians within the cancer service.

[28] The current IR is based on 2012 courses of treatment, with modelled projected cancer registrations from a base of 2007–09 registration data as a denominator. The true IR for 2012 will not be known until all cancer registration data is compiled – likely to be around 2015.

Among the questions to be answered are the following:

- Is this variation in access rates to some extent an artefact created by differences in interpretation of KPI data definitions, and in DHB reporting practice? (This is discussed further in Section 5.2.)
- What patterns are present in current access rates by DHB and/or by cancer centre? Is distance from a cancer centre the significant factor in lower access rates in New Zealand than it is internationally? Are there variations in access by ethnic group, deprivation level, and/or tumour group? Is the variation a reflection of clinical practice by referrers, the radiation oncology service's model of care or patient choice, or a combination of these?
- Where a DHB has a lower access rate, what is the impact of this? Is there evidence of poorer cancer outcomes, and/or unmet need for radiation therapy in the resident population? Are other cancer treatment modalities being used instead?
- Are varying RTRs simply a reflection of differing approaches to palliative care around the country, or is radiation therapy not being offered as an option for some patients?

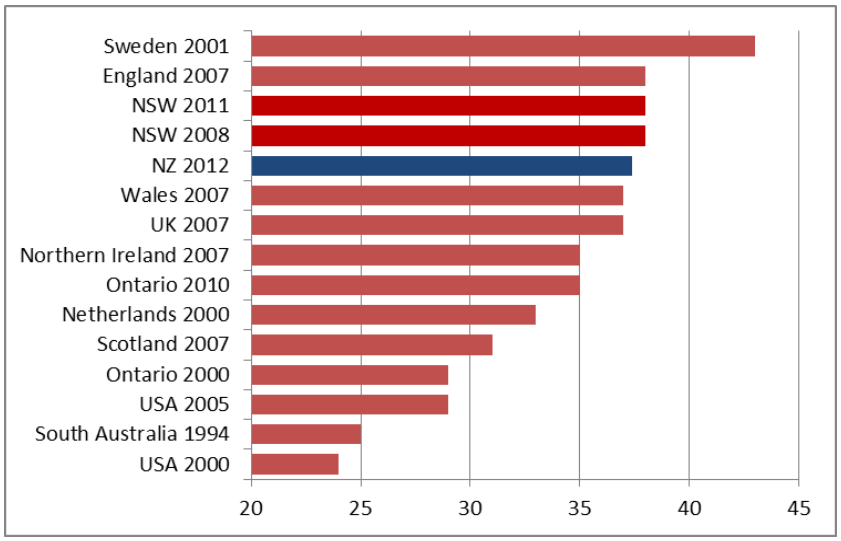
Figure 5: Radiation therapy intervention and retreatment rates in 2012 by DHB of domicile



Source: Health Partners estimate from cancer centre returns and estimated 2012 cancer registrations. Abbreviations: C&C = Capital and Coast DHB, C-M = Counties Manukau, N-M = Nelson-Marlborough, BOP = Bay of Plenty, H-B = Hawke's Bay.. Colour coding indicates the cancer regions for each DHB. Note that DHBs with small populations such as Tairawhiti, Wairarapa and West Coast will show significant variability from year to year. Actual values are shown in Table 4.

New Zealand's current IR of 37.4% is similar to those of other developed countries (Figure 6). The spread of IRs within Australia[29] and England[30] is also of a similar range to that seen across DHBs in New Zealand. As discussed below, both of these countries are seeking to lift their national average IR and reduce variation between cancer centres.

Figure 6: Selected international radiation therapy intervention rates (%)



Sources: Delaney et al 2005; Williams & Drinkwater 2009; IAEA 2007; Battista et al 2012; Barton et al 2011; Health Partners Consulting Group. NSW = New South Wales.

5.1.2 Barriers to access

There is no evidence of patients requiring radiation therapy being 'turned away' by a DHB cancer centre for reasons of workforce or linac capacity shortages, and all centres are meeting the national health target for radiation therapy wait times. The current variation in access is therefore unlikely to reflect deliberate setting of an IR by each DHB. A more likely explanation for the variation is a complex inter-play of factors associated with demand and supply of medical and surgical oncology, and patient and clinician decision-making.

In 2011 New South Wales Health published a report[31] on barriers to access to radiation therapy services, based upon a review of the international literature. The focus of the report is on referral barriers, and the evidence-based factors identified are listed in Table 15. Studies in Australia have suggested in particular that rural and remote populations have relatively poorer access compared with their urban counterparts, and this has led to a programme of investment in 'satellite' radiation therapy services in smaller cities.

[29] *Radiotherapy volumes report 2013*. NSW Health, 2013. Analysis by Health Partners Consulting Group.

[30] Williams MV, Drinkwater KJ. Geographical variation in radiotherapy services across the UK in 2007 and the effect of deprivation. *Clin Oncology* 2009; 21: 431–30.

[31] *Factors that impact on referral rates for radiotherapy*. NSW Health, 2011. Available at: http://www0.health.nsw.gov.au/resources/pdf/factors_impact_referral_r.pdf

The evidence underpinning Table 15 suggests that addressing these barriers will improve access, as measured by both intervention and referral rates.

Table 15: Factors affecting patient and referring clinician choice of radiation therapy

Factor	Description
Patient factors	
Proximity	Where the distance is significant, patients may choose another treatment option. Ease of transport factors also impact, such as availability of public transport and road quality.
Accommodation	Availability of affordable accommodation for the treatment period, given its protracted nature. Availability (and ease of access to) financial compensation may influence patient choice.
Patient perception	Perception of risk and benefit of radiotherapy versus other treatment options (another treatment, or no treatment).
Patient disruption	Degree of disruption that treatment causes to the patient and family/carers.
Family/carer support	Availability of family/carer support in the location of treatment.
Wait times	Perception of waiting times, based on media, service data or other sources.
Cultural sensitivity	Rates of cancer mortality are higher amongst the indigenous population in Australia (and New Zealand), with treatment disparity being responsible for most of the survival gap. Provider communication has been shown to be a significant factor in Aboriginal people's access to radiotherapy. Empathetic personal contact; and acknowledgement and respect for Aboriginal family structures, culture and life circumstances, and the importance of history, land and community are all considered important. Treatment remote from the spiritual link with home and community is also a barrier.
Financial impacts	Out-of-pocket costs or upfront payment.
Referring clinician factors	
Pathway	Understanding and knowledge of radiotherapy indications and treatment regimes. Involvement in an MDM may assist, as would access to online referral and treatment guidelines.
Specialty	Radiotherapy is often delivered in conjunction with surgery and chemotherapy. The use and order of the multiple treatment modalities may be influenced by the specialty of the referrer, or the preferences of the individual specialist. Use of MDMs, and availability of referral and treatment pathways and guidelines may improve access.
Outreach	Where there is no local radiotherapy service, outreach services can support referral for radiotherapy through effective communication with local GPs and specialists. 'Virtual' outreach through telehealth can also assist.
Wait time	Perception of lengthy waits may discourage referrals, whether or not that perception matches reality.
Financial impacts	Financial impacts of referral on an individual practitioner or on a service.

Based on NSW Health report, 2011.

5.1.3 International experience with optimal IRs

There is little evidence – either internationally or in New Zealand – to demonstrate that a higher radiation therapy IR results in better population cancer outcomes. However, it is apparent that health systems generally consider a higher rate to be an indicator of good access and performance, and a number of countries internationally (including Australia, and the various UK health jurisdictions) have set national target IRs to inform service and capacity development.

Where such a national target rate is set, this tends to be based on an 'optimal' IR which uses best available evidence or expert consensus to determine the proportion of cancer patients with an indication for radiation therapy. As discussed in Section 5.1.3, work in Australia based on detailed literature review and modelling defined radiotherapy to be a necessary component of treatment in 52.3% of all newly diagnosed cancers in Australia.[32] This figure has been accepted to apply more generally for developed countries and has been used as a reference for benchmarking actual radiation therapy utilisation across a range of health systems. In the UK, for example, highly variable access rates for radiotherapy, ranging between 25% and 49%, have been observed.[33] More recently the recommended Australian rate has been revised downwards to 48%, ranging from 46 to 50% for different Australian states.[34]

Australia,[35] Scotland[36] and England have all set national target IRs based on analysis of optimal radiation therapy treatment by cancer type. In England the NRAG model[37] uses information gathered from work in Canada, Australia and particularly Scotland to derive a radiation therapy rate for each cancer type, adjusted for English clinical practice. In all three cases the targets are positioned as aspirational goals rather than absolutes, and with the aims of:

- reducing variation in access across cancer centres and geographic populations
- ensuring access rates that encourage best clinical practice in use of radiation therapy
- supporting use of consistent assumptions to inform planning of future capacity requirements (including equipment and facilities, and education and training).

5.1.4 A preferred scenario for New Zealand

New Zealand does not have a national target IR. Nor has the analysis been undertaken here to determine an 'optimal' IR.[38] However, work within the Cancer Programme on tumour pathways will over time confirm the indications for radiation therapy and thereby contribute to such an analysis.

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[32] Delaney GP, Jacob S, Featherstone C, Barton MB. 2012 *Radiotherapy in cancer care: estimating optimal utilisation from a review of evidence-based clinical guidelines*. www.ncci.org.au. 2003.

[33] Williams MV, Drinkwater KJ. Geographical variation in radiotherapy services across the UK in 2007 and the effect of deprivation. *Clin Oncology* 2009; 21: 431–30.

[34] Barton M, Jacob S, Shafiq J, et al. 2013 *Review of Optimal Radiotherapy Utilisation Rates: Report for Department of Health and Ageing, Australia*. Sydney: Ingham Institute.

[35] *RANZCR. Planning for the Best: Tripartite National Strategic Plan for Radiation Oncology 2012–2022, version 1*. Sydney: RANZCR, 2012.

[36] *Cancer In Scotland: Radiotherapy Activity Planning for Scotland 2011–2015*. Scottish Executive Health Department, 2005.

[37] *NRAG. Radiotherapy Services in England 2012*. London: Department of Health, 2012.

[38] In 2010 the Northern Cancer Network applied the Scottish and Australian models to New Zealand cancer registrations, and found that these would set a New Zealand national rate of 52.3% (Australian), and 41.7% to 45.4% (Scottish).

Modelling undertaken by the four regions in developing their capacity forecasts (published in 2012) was not based on best clinical practice by tumour type, but rather consideration of radiation therapy use in aggregate across all cancers. The regional cancer networks all explored a range of IR scenarios, informed by advice from the Ministry that:

> *"An intervention rate of 45% is accepted as reasonable. However it is for each region to determine the time frame over which it would/could support capacity growth to achieve this intervention rate from the current regional baseline."*[39]

The regional capacity modelling reports indicate that the DHBs in all four regions intend lifting their IRs to reach the 45% in the next 5–8 years. The Ministry and DHBs did not intend these regional rates to reflect an absolute commitment to expand capacity and access to this level, but rather as a basis for future service and capacity planning and decision-making. They represent a potential outcome of the increased standardisation and consistency expected to occur over the next decade. As experience builds, the IR to use for planning purposes may be adjusted.

Using 45% IR is equivalent to the Growth scenario described in Section 4, and has been accepted as the preferred scenario for this Plan, and for future service and capacity planning. This 10-year scenario is for:

- an IR of 45%
- current RTR.

It would also seem prudent to assume that the operational gains and tipping point measures discussed in Section 4.5 are able to implemented. That is, 1% operational gain each year for 10 years in either treatments per course, or treatment times, or both, and measures such as outsourcing or increasing linac operating hours to postpone new linac builds.

As presented in Section 4, this suggests the need by 2022 for an additional:

- six linacs, with the first in 2016
- seven radiation oncologists, 30 medical physicists, and 25 radiation therapists over and above the current base and the current proportion of training output retained in the New Zealand health system
- $77 million pa operating costs (making $180 million total)
- $65 million capital (with a further $152 million in replacing and maintaining existing linear accelerators).

[39] Correspondence from Dr John Childs, at that time clinical director of the National Cancer Programme, quoted in *Central Cancer Network Linear Accelerator Modelling – 2012 to 2020.*

Pursuing this Growth scenario has significant implications for all DHBs, particularly when the increased activity is combined with the additional volumes that will be required by increased cancer incidence. Of the $77 million operating costs increase over the base, $41 million is growth due to demography and cancer incidence changes. Assuming that the PBFF demographic adjuster will cover that growth, then there will remain $36 million for DHBs to find. The different impacts on each DHB's operating expenditure on radiation therapy are shown in Figure 4 which uses the national DHB radiation therapy price applied to the required volume increase if each DHB were to individually reach a 45% IR.[40]

Volume growth of this magnitude will require resource reallocation by DHBs, and hence deliberate prioritisation processes in which radiation therapy will be competing with other possible investment and disinvestment options. Similar disciplined prioritisation processes will be required:

- by DHBs with cancer centres in allocating capital for linac and facility expansion (in addition to expenditure on linac replacement)
- by HWNZ and the Tertiary Education Commission in funding education and training for the expanded radiation oncology workforce.

These investment matters are discussed further in Section 5.5.

Increasing the IR will also require each regional cancer network to understand current access patterns, identify barriers, and devise local and regional solutions. Some degree of variation in access to radiation therapy between DHBs is to be expected, where alternate treatment pathways are available and patient needs are being met. Where variation exists, regional cancer networks should be expected to be able to explain why, and how overall cancer treatments are being managed.

Furthermore, movement to a consistent access rate across all the cancer centres will require greater alignment of clinical practice and models of care through increased collaboration to reduce variation. Historically the cancer centres have developed and worked in relative isolation from each other. Creation of the regional networks has contributed to improved linkages between referring DHBs and their cancer centre, and between cancer centres in the same region. National planning of radiation oncology will support the continued evolution of this collaboration in addressing issues of access, productivity improvement, best clinical practice, adoption of new techniques and technologies, workforce planning and value for money.

[40] In reality a national average of 45% will see DHBs in a range around that rate, so individual DHB expenditure will vary.

It is possible that actual volume growth will be slower than that assumed in the Growth scenario for a 45% IR by 2022. In that circumstance there will not be the demand to generate the need for expansion of linac capacity, so the modelled linac growth will not occur. In other words, linac capacity expansion should follow service demand, rather than leading it. With regard to workforce planning, aiming for sufficient personnel resources to cover 45% IR by 2022 is prudent, given the large outflows of the New Zealand workforce in the past, the stated aims of other jurisdictions to increase their IRs and thus staffing, and the possibility that increased treatment complexity could require additional staff (the impact of complexity was not specifically modelled). It is unlikely any new graduate would be long out of work.

5.1.5 The place of privately funded radiation therapy in IR calculation

Calculation of the IR in the Model includes privately funded radiation therapy volumes. There was a clear indication from the radiation oncologists on the Expert Advisory Group that any volumes carried out in private facilities would have been carried out in public centres had the person presented there. In other words, there was no sense of unnecessary or otherwise marginal treatments occurring. In addition, workforce planning must take account of both public and private centres in determining training needs as the radiation therapy workforce is sourced from the same pool of workers and new graduates.

Recommendations: Access to radiation therapy

4. A national radiation therapy IR goal and individual DHB IR targets for accountability purposes should not be set at this time because of uncertainty as to the reasons for and impact of current variation. However, a national IR should be confirmed by the Ministry and DHBs for service and capacity planning purposes.
5. The Growth scenario should be adopted by the Ministry and DHBs as the preferred scenario for planning purposes, meaning a potential national IR of 45% by 2022, and maintenance of current DHB retreatment volumes (national average 31% of treatments being retreatments).
6. The Ministry's Cancer Services Team should advise Health Workforce New Zealand of the Growth scenario's implications for workforce capacity requirements, and in particular the need to improve retention rates, and to urgently increase medical physicist training numbers and training places.
7. The Ministry's Cancer Services Team should advise the Capital Investment Committee of the Growth scenario's implications for capital expenditure – that is, an additional $64 million over and above the $152 million needed for existing equipment upgrades and replacement over the next 10 years.
8. DHB IRs and retreatment rates (RTRs) should be monitored nationally by the Radiation Oncology Work Group (ROWG), and by the regional cancer networks working with the DHBs and cancer centres. The regional networks should be required to report to the Cancer Programme Steering Group on the acceptability of the regional or DHB variation in IR and RTR where this is more than 5 percentage points above or below the national average prevailing at the time of measurement, and the reasons for the variation.

5.2 Performance improvement

5.2.1 Use of robust information

Since 2008 the Ministry has supported the cancer centres and private radiation therapy services to develop a consistent national radiation oncology KPI dataset for reporting and monitoring. Each radiation therapy service (including the two private services) reports voluntarily to a Ministry-funded third party that collates and feeds back the information to the centres and to ROWG. A data dictionary has been developed, and a full dataset has been in place and reported against since 2009.

As discussed in Section 3, development of the Model associated with this Plan showed measures with significant variation between DHBs and centres including:

- intervention rates (IR)
- retreatment rate (RTR)
- complexity.

The ratio of palliative to curative treatments also showed significant variation, but the Expert Advisory Group considered the data to not be sufficiently robust for use in capacity modelling. (Other radiation therapy KPIs may also show significant variation; however only those relevant for Model development were considered in the current assessment.)

Some variation in clinical practice is to be expected, given that New Zealand best clinical practice has not been defined for all cancers, with alternate treatments (surgery, chemotherapy) available for some, and different linac techniques being used (eg, hypofractionation) across the cancer centres. However, variation in performance of the type and scale suggested in KPI reporting impacts on patients from both the host and referring DHBs, and has implications for both patient access and resource use.

The evidence provided in KPI reporting may indicate real variation in clinical practice or patient choices; or it may equally be the appearance of variation as an artefact arising from differences in interpretation of the data elements, or inconsistency in data collection and/or reporting. The balance of these two possibilities is not known at present. Audit of underlying data may also be useful. For example, if people in rural areas gave a local address when staying over for a radiation therapy course and their home DHB was not accurately recorded, this might lead to DHBs with cancer centres appearing to have a slightly inflated IR, while the rural DHBs would appear to have a lower IR.

Accurate information is of fundamental importance for performance improvement, capacity and service planning, evaluation and research. It is clear that the radiation oncology KPI dataset is not sufficiently robust, and should be strengthened so that it can serve a useful purpose at local, regional and national levels.

For example, improving access to radiation therapy by reducing variation and lifting the overall IR requires analysis to identify the reasons for the current state. Reliable data on radiation therapy activity is required to do this. Information on pathways of care and patient outcomes will

also be important, as will information on the different technologies and techniques in use. Improved ethnicity data collection is needed.

In addition, the cancer centres and networks should consider whether the KPIs selected represent the most relevant and useful measures. This is likely to depend on the purpose of each indicator – in other words, why is the measure being used, what information does it provide, and what action can it trigger? For example, treatment time will be a more relevant metric than complexity for capacity modelling, while the latter will be an important consideration in workforce and service planning.

Recommendations: Use of robust information

9. An end-to-end review of the national radiation oncology KPIs should be undertaken by the Ministry, including:
    - purpose of the collection
    - confirmation that the KPIs are fit-for-purpose
    - barriers to accurate reporting
    - how use of the information for performance improvement and planning can be strengthened at local, regional and national levels.

5.2.2 A high quality service

International and New Zealand experience has identified key elements of high quality radiation oncology services. Prioritised aspects are discussed below.

Multidisciplinary meetings

The optimal care of cancer patients is a multidisciplinary effort that may combine three or more disciplines (eg, surgery, radiation oncology, medical oncology, and haematology). Multidisciplinary care will support the achievement of improved outcomes, increase utilisation of treatment, and promote efficiency.[41] Tumour site oriented multidisciplinary meetings (MDMs) are valuable for evaluation of patients before treatment, and guiding the subsequent steps of treatment and follow-up.

Tumour standards

As part of the Faster Cancer Treatment Programme (section 2.4.4), the Ministry and clinical working groups have developed 10 national tumour standards (in addition to the already published tumour standard for lung cancer). The tumour standards[42] set out best practice management of specific tumour types. They enable a nationally coordinated and consistent

[41] *Guidance for Implementing High-quality Multidisciplinary Meetings: Achieving best practice cancer care*. Ministry of Health, 2012.

[42] Available on the Ministry of Health website at: http://www.health.govt.nz/our-work/diseases-and-conditions/cancer-programme/faster-cancer-treatment-programme/tumour-standards

approach to service provision that is specific to different types of tumours, and reduce the risk of patients receiving poor quality care. The tumour standards cover investigation, diagnosis, treatment and other points that relate to a patient's pathway. As the standards develop, the Model might be extended to detail the major tumour streams.

Radiation oncology service standards

New Zealand radiation oncology services do not currently have an agreed set of standards that they can measure themselves against (or be measured). In Australia, Radiation Oncology Practice Standards outline the components of a quality radiation therapy service in three domains: facility management; treatment planning and delivery; and safety and quality management. ROWG has made significant progress in adapting these Australian standards for New Zealand circumstances, but the localised version is yet to be formally considered, and the implications of adoption have yet to be scoped. (The need for cancer centres to carry out research and for the workforce to have time to do this would be included in the service standards.)

Recommendations: A high quality service

10. A set of radiation oncology service standards should be considered by the Ministry and DHBs for adoption in New Zealand, including identification of their cost implications related to promulgation, compliance and accreditation.
11. The Ministry and DHBs should encourage increased standardisation of clinical practice, with a focus on the treatment course for common tumour sites.

5.3 Evaluation of new techniques and technologies

Whilst linacs are a mature technology, new techniques have emerged, and will continue to do so. The two most notable of recent developments have been intensity modulated radiation therapy (IMRT) and image guided radiation therapy (IGRT), both of which allow better targeting of the radiation to the tumour, thereby sparing normal tissue from radiation effects. These and other emerging technologies and techniques are described briefly in Table 16.

ROWG maintains a horizon scan[43] examining three areas – techniques, technologies and related innovations. The 2012 scan listed 44 separate items, and described their current use and potential applicability to New Zealand. This horizon scan is currently being updated.

In the future, newer modalities have the potential to significantly change the treatment of specific cancers (eg, IntraBeam for breast cancer). To date new technologies and techniques have been introduced to the New Zealand health system in a relatively ad hoc and unplanned manner. There has been no deliberate and transparent evaluation of the costs and benefits of the new techniques, and identification of the patient and tumour groups in whom they offer

[43] The horizon scan is based on work by the Faculty of Radiation Oncology of the Royal Australian and New Zealand College of Radiologists.

greatest benefits. Similarly, there has been limited progress[44] in determining the core technologies and techniques that should be offered at all six DHB cancer centres, and which centres should develop a specialisation in treating particular tumour types. The absence of a deliberate assessment and planning process carries the risk of perpetuating variation in access to effective new techniques, and inefficient use of them.

A coordinated approach is being used in other countries. For example, in the UK the Radiotherapy Development Board is working on a strategy for the implementation of IMRT and IGRT. This will include the evaluation of existing practice in their cancer centres, preparation of guidelines for implementation, and the identification of workforce and skills issues. Implementation guidelines are likely to included targets for treatment mix (eg, the percentage of radiation oncology patients who should access IMRT).

Similarly, in recognition of the need for prioritisation of investment in health technology, the Australian Government has contracted the Trans Tasman Radiation Oncology Group (TROG) to establish a generic research framework for the evaluation of new technologies and treatment in radiation oncology, and to test the framework on IMRT and IGRT.

In New Zealand, the National Health Committee (NHC) has a focus on health technology assessment. There is an opportunity for ROWG to link with the NHC to ensure that radiation therapy techniques become the focus of joint evaluation, building on international assessments.

Recommendations: Technology assessment

12. The Ministry's Cancer Services Team should discuss annually with the National Health Committee and National Health Board how a national approach to evaluation and implementation of new radiation therapy technologies and techniques could be maintained. The approach should be established for 2014/15.

Changing approaches to new technologies and techniques will then feed through into the annual updating of the Plan as per Recommendations 1 and 15. The Ministry's Cancer Services team should continue to work closely with ROWG on this. Highly specialised therapies may never be feasible to supply in New Zealand – in that circumstance, cases would continue to be assessed for funding on an individual basis for overseas treatment.

[44] Areas of consensus include paediatric cancers and stereotactic treatment for benign intracranial tumours. Some progress has also been made with HDR brachytherapy.

Table 16: Emerging technologies and techniques in radiation therapy

Radiation therapy process	Radiation therapy technique	Definition	Technologies to deliver	Currently used in NZ
Treatment delivery	Intensity modulated radiation therapy (IMRT)	Radiation therapy that conforms the radiation dose closely to the shape of the tumour by changing the intensity of the radiation beam. This enables sharp dose gradients adjacent to both targets and organs at risk.	Linac based IMRT Linac based volumetric arc therapy (VMAT) Helical based IMRT	Yes Yes No
Treatment delivery verification	Image guided radiation therapy (IGRT)	Image-guided radiation therapy is two and three-dimensional imaging captured as close as possible to the time of treatment. Positioning correction based on these images is done before treatment delivery.	2D IGRT 3D IGRT MRI Guided IGRT	Yes Yes No
Treatment delivery	Stereotactic radiation treatment Stereotactic radiosurgery (SRS) Stereotactic radiation therapy (SRT)	Highly conformal radiation volumes targeted accurately to small volumes. Permits delivery of single doses to brain lesions (SRS) or fractionated doses (SRT) to small brain lesions.	Linac based SRS Cobalt based SRS (Gamma Knife) Helical based SRS (Tomotherapy) Robotic SRS (Cyber knife)	Yes No No No
Treatment planning	Advanced imaging for radiation therapy planning	Computed tomography (CT) scans acquired in the radiation therapy treatment position are the basic imaging modality for contouring tumour target volumes and normal tissues for dose calculation in radiation therapy planning. PET scans show functional information, 4DCT shows the motion of tumours and/or organs at risk and MRI shows additional anatomical detail not visualised on conventional CT.	4DCT PET CT fusion MRI CT fusion	Yes Yes Yes

Source: Summarised from 2012 Radiation Oncology Horizon Scan. ROWG, 2012.

5.4 Procurement

A number of national health agencies in addition to the NHC are likely to have an interest in any significant expansion of linac capacity:

- the National Health Board (NHB) promotes collaborative service and capacity planning and decision-making by DHBs
- the Capital Investment Committee (CIC) supports effective capital planning and decision-making by DHBs, including at regional and national levels where the investment meets predetermined thresholds[45]
- cost-effective DHB procurement of equipment and supplies is of interest to both Health Benefits Ltd (HBL) and PHARMAC, with the latters' brief being expanded to include medical devices from July 2015.[46]

The opportunity for gains through collaborative procurement of linac hardware and software have been explored in the past, and most recently in 2012 by HBL at the request of the Cancer Programme Steering Group. HBL's advice at that time considered the DHB cancer centres' linac replacement schedule, but did not factor in the capacity expansion required through increased cancer incidence and a lift in the IR to 45% by 2022.

5.5 Securing investment

The New Zealand health system is operating in an environment of resource constraint that can be expected to continue for the foreseeable future. Service sustainability has become the focus of longer term service and capacity planning. Sustainability has both clinical and financial dimensions, and relates to the ability of a health service to provide ongoing access to high quality care in an efficient and effective manner in a changing environment.

The focus of this Plan and associated Model is on future demand for radiation oncology services, and the service capacity required to meet that demand. Expansion of service capacity will be required to not only meet the 'organic' demand growth associated with increased cancer incidence, but also a further lift towards an IR of 45%. The scale of the potential investment is discussed in Section 4.3.3.

Given the structure of the New Zealand health system, consideration of whether and how to make such an investment will occur at local, regional and national levels.

[45] CIC needs to approve any capital investment over $10 million. Individual linac capital costs tend to be in the $4–6 million range, depending on the extent of facility development required.

[46] PHARMAC has consulted DHBs on the priorities for the initial phase of work on medical devices over the next 12–18 months. The DHBs were also asked to identify any other categories that they considered of importance that they would like PHARMAC to work on. Linacs have not been identified at this stage, with the categories selected being a mixture of consumables and some smaller capital hardware, but not more specialised and higher cost capital equipment such as linacs.

- **Local**: Each DHB funds access for its population to radiation therapy, either as a direct cost in the case of the six DHBs with cancer centres, or as an IDF paid for at the national price in the case of the other 14 DHBs. All DHBs will need to allocate additional funds to radiation therapy treatments to match the increased incidence of cancer, and an increase in the proportion of those cancers being treated with radiation therapy. The cancer centres will also need to develop and support capital business cases for linac replacement and capacity expansion, and cater for increased operational costs in their annual planning.
- **Regional**: The capacity modelling done by each regional cancer network suggests all are aiming for a consistent and increased IR of 45% by 2020, in line with the Growth scenario. This will require collective regional commitments by the constituent DHBs to allocate additional operating funds, and approval by the regional capital committees of capital investment by the cancer centres.
- **National**: Ongoing development of the Plan and Model will create a supportive national context for development of radiation oncology services, with engagement of national health agencies as described in Sections 5.3 and 5.4.

At all three levels, radiation therapy will be competing for investment against other services in prioritisation processes that will require evidence of value for money. Questions such as the following are likely to be asked:

- How efficient are radiation therapy services? Could their productivity be improved to make better use of existing resources?
- How effective are radiation therapy services? Do they produce positive health outcomes for the tumour groups and population groups that access them?
- Will additional funding to increase radiation therapy capacity and access provide a better return on investment than other spending options?

The cancer centres' immediate focus should be on improvement of operational performance. The Model assumes a relatively modest 1% operational gain per year. This had the effect of reducing two to three linac builds in each scenario, up to six in the Growth scenario. When coupled with a 'tipping point' extra use of linacs (eg, up to 10-hour days in the maximal months of the year) this has a significant impact on the required linac capacity, as shown in the contrast between the Base and operational gain scenarios (Table 10). The significant variation in total minutes of treatment per course across the centres highlights the possibilities for benchmarking and productivity gains. In the constrained funding environment service funders will be looking for improved financial performance.

Cost information from the four DHB cancer centres submitting data for national pricing purposes suggests considerable variation. Collaboration between centres should include shared learning from the model of care and cost structures of the apparently more efficient radiation therapy providers including understanding of work patterns in the private cancer centres.

An example of a potential focus area for performance improvement is the impact of model of care options on access and productivity, and could include:

- whether follow-ups are best done at the cancer centre by a specialist, or locally by GPs
- whether 'virtual' follow-ups via telemedicine are a viable option to specialist or patient travel
- whether palliative treatments should be given as single or multiple fractions.

International experience may also prove useful. For example, extending the hours of operation of existing linacs is the most obvious area to investigate for operational improvement, and delay of capital expansion. A 2007 analysis of extended working hours in radiation therapy in the UK concluded that two shifts covering an 11.5-hour working day was a sound alternative to the normal working day. This took into account efficient use of radiation therapists, and some patients' preferences for out-of-hours appointments.

Analysis in Scotland concluded that equitable access at a higher intervention rate could best be achieved through service redesign together with a modest increase in the number of linacs. The initial service changes recommended were:

- increase the core clinical service to a 10-hour day, 5-day week
- reduce the days lost as a result of closure for public holidays and routine maintenance to achieve 257 clinical days per annum
- review workforce shift patterns, working practices, skill mix, new roles, and additional staff requirements to meet the new service model
- optimise the capacity of all linacs in Scotland and redistribute workloads, including changes to referral practices and further development of collaborative working.

An increased focus on analysis, research and evaluation of radiation therapy will be required to provide the information needed to support further investment. This will apply not only to new techniques and technologies as described in Section 5.3, but also the impact of existing services on clinical and patient-reported outcomes from both radical and palliative use of radiation therapy. As noted in Section 2.2, ROWG's defined role encompasses consideration of the information base required to support the future investment in radiation therapy capacity.

Recommendations: Securing investment

13. The Ministry and DHBs should use the Model to inform local, regional and national planning and business case development. Consistent assumptions and metrics should be used in planning, based on the national KPI dataset and Model standardisation.
14. The Ministry and DHBs should place greater emphasis on benchmarking of radiation therapy services to inform identification at regional and national levels of opportunities for improved access and productivity.

5.6 National planning and action

The terms of reference for ROWG (Section 2.2) place it in a key national expert advisory role within the radiation oncology sector, and wider cancer services. This role should include providing the Ministry (and DHBs) with advice in key action areas arising from this Plan:

- reduction of variation in patient access and clinical practice, as reflected in the radiation oncology KPIs. In this area, ROWG should link with the Health Quality and Safety Commission, to understand how it is approaching its role in reducing unwarranted clinical variation
- evaluation of new technologies and techniques, and advice on the managed implementation of those deemed effective. This should include consideration of indications for their cost-effective use, and their distribution across New Zealand. In this area, ROWG should link with the National Health Committee as noted above
- support for use of KPI information to understand comparative cancer centre performance, IR monitoring, and encourage spread of effective innovation to improve access and operational efficiency and effectiveness
- workforce planning and development, including education and training, and opportunities to explore new models of care and workforce roles. In this area, ROWG should link with Health Workforce New Zealand
- capacity and service planning, including advising the Ministry on updating and enhancement of the Model and Plan
- capacity and service planning for sub-specialised services such as child cancer treatment
- consideration of the information base required to support future investment in radiation therapy capacity.

The advent of the Plan and Model should allow ROWG to develop and deliver a more structured work programme that is agreed with the Ministry annually. This work programme should be linked to an annual radiation oncology national implementation plan, as part of the Cancer Programme.

Recommendations: National planning and action

15. The Ministry should produce an annual radiation oncology national implementation plan, as part of the Cancer Programme.

Appendix 1: Members of the Steering Group and Expert Advisory Group

Steering Group

Andrew Simpson (Chair) – National Clinical Director, Cancer, Ministry of Health
Jo Anson – Central Cancer Network Manager, MidCentral DHB
Kate Garland – Senior Advisor, Cancer Services, Ministry of Health
Charles De Groot – Radiation Oncologist, Waikato DHB
Emmanuel Jo – Principal Technical Specialist, Health Workforce New Zealand, Ministry of Health
Chris Lowry – Chief Operating Officer, Capital and Coast DHB
Mhairi McHugh – Team Leader, DHB Performance, National Health Board, Ministry of Health
Robert Taylor – Group Chief Financial Officer, Mercy Ascot
Ricarda Vandervorst – Manager, Cancer Services, Ministry of Health

Expert Advisory Group

Carol Johnson (Chair) – Clinical Leader, Capital and Coast DHB
Vivienne Ali – Radiation Therapist Clinical Manager/Practice Manager, St Georges Cancer Care Centre
John Childs – Radiation Oncologist, Auckland DHB
Shaun Costello – Radiation Oncologist, Director Southern Cancer Network, Southern DHB
Shelley Donnell – Unit Manager, Oncology, Waikato DHB
Lynne Greig – Chief Medical Physicist, Capital and Coast DHB
Rob Hallinan – Clinical Manager Radiation Therapy, Canterbury DHB
Cushla Lucas – Service Manager, Regional Cancer Treatment Service, MidCentral DHB
Neil McKelvie – Service Manager, Bay of Plenty DHB
Isla Nixon – Principal Physicist, Cancer & Blood Services, Auckland DHB
Denise Redwood – Radiation Therapy Manager, Auckland Radiation Oncology
Giuseppe Sasso – Radiation Oncologist, Auckland DHB
Iain Ward – Clinical Director, Radiation Oncology, Canterbury DHB

Appendix 2: Consultation programme

Specific feedback was received from:

- Australasian College of Physical Scientists & Engineers in Medicine (ACPSEM)
- Bay of Plenty DHB
- Cancer Control New Zealand (CCNZ)
- CCNZ – John Waldon separate comment
- Central Cancer Network
- Tania Ferguson, Specialist Radiation Therapist AHDB
- Rob Hallinan, Clinical Manager Radiation Therapy, Canterbury Regional Cancer and Blood Service
- Dr David Hamilton, Oncologist, Wellington
- Midland Cancer Network Executive Group and Midland Radiation Oncology Work Group
- National Cancer Consumer Representative Advisory Group
- National Child Cancer Network (NCCN)
- New Zealand Radiation Oncology Executive Committee (NZROEC)
- New Zealand Regional Cancer Networks (NZRCN)
- Northern Cancer Network
- Otago University – Director & Head of Department Radiation Therapy Department
- Radiation Oncology Work Group
- Radiation Therapy Advisory Panel
- Royal Australian and NZ College of Radiologists (RANZCR)
- Southern DHB, Deputy CEO, Director of Patient Services

Appendix 3: Links of the Plan with the roles of central agencies

Agency	Role	Nature of link
National Health Board	Funding and monitoring of DHBs, as well as promoting long term service and capacity planning at national and regional levels	The Plan builds on regional radiation therapy capacity planning; provides a model to support local, regional and national planning; and initiates alignment of service and capacity planning
Health Quality & Safety Commission	Leading and coordinating quality and safety improvement initiatives across public and private sector health and disability providers. Includes focus on reduction in unwarranted clinical variation	The Plan makes transparent the current variation in access to radiation therapy across New Zealand, and promotes increase collaboration between radiation oncology services to foster quality improvement. National standards are also considered
Health Workforce New Zealand	Planning and development of the health workforce to ensure that staffing capacity is aligned with service plans, and that the healthcare workforce is fit for purpose	The Plan and associated Model identify future workforce requirements for the three core work groups associated with radiation therapy
Pharmaceutical Management Agency (PHARMAC)	Management of community and hospital pharmaceuticals, and moving into procurement of some medical devices	Yet to be determined whether PHARMAC's role will encompass more specialised and high cost capital equipment such as linacs
National Health Committee	Prioritising new diagnostic and treatment services, and significant expansions of existing services; also advice on what technologies are obsolete or no longer providing value for money	The Plan recommends a nationally led process to consider the place of new radiation therapy technologies and techniques
Capital Investment Committee (CIC)	National prioritisation and allocation of health capital funding	Radiation therapy is highly capital intensive, through both new and replacement linacs, and the requirement for dedicated bunker facilities. CIC needs to approve any capital investment over $10 million, while individual linac capital costs tend to be in the $4–6 million range, depending on the extent of facility development required. The magnitude of total forecast capital expenditure on linac replacement and capacity expansion may prompt CIC interest

Appendix 4: Cancer registration growth

Aim: To re-base the current Ministry of Health (MOH) projections[47] and re-project to 2022 by DHB.

Background: The current MOH projections are based on 2004 to 2008 cancer registrations (mid-point 2006). 2009 data is now available.[48] The modelling for medical oncology excluded child and haematological cancers, which need to be included for radiation oncology. Revised population projections carried out for the Ministry by Statistics New Zealand[49] have seen population projections reduce slightly.

Method: All cancers excluding myelodysplastic disorders are included. The Ministry projections per main cancer type were re-based on a 2007–09 average registration rate (mid-point 2008), and projected through to 2022 by DHB using the October 2012 revised population projections. Variables used were cancer type, DHB of domicile, age group, and gender.

Results: Results of the re-basing by cancer type are shown in Table 17, and by DHB of domicile in Table 18. Overall numbers are slightly lower than previous work due to the re-basing and the lower population projections.

47 *Cancer Projections: Incidence 2004–08 to 2014–18*. Wellington: Ministry of Health, 2010.

48 2010 registration data arrived too late for inclusion. The overall total for 2010 was within 50 cases of the projected total, so updating is unlikely to be discernable in the Model. More recent provisional data is available for some cancers, but these are not considered complete, so are less useful for IR calculations and demand projections.

49 Population projections commissioned from Statistics New Zealand. Unpublished Excel spreadsheet. Ministry of Health, 2012.

Table 17: Projected cancer registrations by type, Ministry projections re-based to 2007–2009

	Actual average registrations 2007–09	Projected to 2012	Projected to 2022	Growth over 10 years	10 year growth %	Growth % pa
Brain cancer	264	263	303	40	15%	1.4%
Colorectal cancer	2,816	2,961	3,563	602	20%	1.9%
Lung cancer	1,898	1,965	2,201	236	12%	1.1%
NH Lymphoma	747	831	1,132	301	36%	3.1%
Leukaemia	576	580	752	172	30%	2.6%
Myeloma	270	288	342	54	19%	1.7%
Melanoma	2,214	2,442	3,215	773	32%	2.8%
Oesophageal cancer	275	303	402	99	33%	2.9%
Pancreas cancer	442	474	584	110	23%	2.1%
Stomach cancer	371	379	404	25	7%	0.6%
Breast	2,679	2,887	3,472	584	20%	1.9%
Cervical	158	143	112	-31	-22%	-2.4%
Prostate	**3,087**	**3,882**	**6,604**	**2,721**	**70%**	**5.5%**
Testis	153	151	169	18	12%	1.1%
All other adult cancers	4,003	4,266	5,084	818	19%	1.8%
Child cancer	121	119	120	1	1%	0.1%
Total	**20,074**	**21,934**	**28,458**	**6,524**	**30%**	**2.6%**

Source: HPCG; method as described in text above.

Prostate cancer has shown apparent high growth in the recent past due to diagnostic changes, and has a significant impact on the total cancer growth. The original Ministry projections had difficulties with the prostate growth, and revised the figures based on the ‘PSA effect’. The potential for actual growth to be lower than the projections is tested in the sensitivity analyses (Section 4.6).

Table 18: Projected cancer registrations by DHB

Centre	DHB	Actual average 2007–09	Projected cancer registrations					Average % pa
			2010	2011	2012	2017	2022	
Auckland	Northland	868	905	923	943	1,055	1,198	2.4%
Auckland	Waitemata	2,276	2,412	2,482	2,555	2,988	3,552	3.4%
Auckland	Auckland	1,690	1,757	1,791	1,826	2,059	2,397	2.8%
Auckland	Counties Manukau	1,742	1,855	1,913	1,974	2,316	2,729	3.3%
Hamilton	Waikato	1,651	1,726	1,765	1,805	2,029	2,299	2.4%
Hamilton	Lakes	487	503	512	521	577	654	2.3%
Hamilton	Bay of Plenty	1,202	1,257	1,286	1,315	1,482	1,687	2.5%
Hamilton	Tairawhiti	223	230	233	237	263	302	2.5%
Palmerston North	Hawkes Bay	809	839	854	870	963	1,083	2.2%
Palmerston North	Taranaki	604	624	634	645	706	782	2.0%
Palmerston North	MidCentral	856	888	905	922	1,024	1,159	2.3%
Palmerston North	Whanganui	368	376	380	384	414	458	1.8%
Wellington	Capital & Coast	1,093	1,149	1,178	1,208	1,369	1,552	2.5%
Wellington	Hutt Valley	620	643	655	667	739	831	2.2%
Wellington	Wairarapa	225	235	240	245	275	310	2.4%
Christchurch	Nelson Marlborough	763	806	828	851	975	1,118	2.8%
Christchurch	West Coast	180	188	191	196	218	246	2.3%
Christchurch	Canterbury	2,596	2,708	2,766	2,826	3,208	3,746	2.9%
Christchurch	South Canterbury	353	366	373	379	417	462	2.0%
Dunedin	Southern – Otago	936	973	992	1,011	1,115	1,234	2.0%
Dunedin	Southern – Southland	489	502	509	516	560	619	1.8%
Total New Zealand		20,073	20,983	21,453	21,934	24,791	28,458	2.6%

Source: HPCG; method as described in text above.

The DHBs with the fastest growing and ageing populations have the highest projected cancer registration growth as expected, with Counties Manukau and Waitemata growing at over 3% per annum. Over the next 10 years there is expected to be a growth of 6,524 cancer registrations for New Zealand, 2.6% per annum growth, or 30% from 2012 to 2022.

Appendix 5: Linear accelerator location and timings

The following tables show possible configurations for new linacs suggested by the Model, in the same format as Table 14. Note that locations and timing are indicative only – actual build locations and timing will be dependent on DHB business cases and actual service demand in the time leading up to said business cases. Only new linacs are shown in the first three tables – an indicative replacement schedule is shown in the last table. No assumption is made as to whether the new builds will be in the private or public sector (or indeed some mixture of the two). The Model uses current operating arrangements to project forward, but these arrangements may change in the future – all suggestions are indicative only.

The tables are by cancer centre, arranged by region:

- ADHB = Auckland DHB, Auckland
- ARO = Auckland Radiation Oncology
- WDHB =Waikato DHB, Hamilton
- KKC = Kathleen Kilgour Centre, Tauranga
- MDHB = MidCentral DHB, Palmerston North
- CCDHB = Capital and Coast DHB, Wellington
- CDHB = Canterbury DHB, Christchurch
- SGC = St Georges Centre, Christchurch
- SDHB = Southern DHB, Dunedin

A. Linear accelerator additions suggested by the Model – Base

Region	Centre	2014	2015	2016	2017	2018	2019	2020	2021	2022
Northern	ADHB	+1						+1		
	ARO			+1						
Midland	WDHB									
	KKC	S								
Central	MDHB	+1						+1		
	CCDHB	+1								
South Island	CDHB		+1							
	SGC									
	SDHB						+1			
Cumulative total NZ		**+3**	**+4**	**+5**			**+6**	**+8**		

Key:

Within 95% of capacity
Model suggests new linac may be needed

Assumes Base scenario – demographic and cancer incidence changes only, with all centres working at current operating parameters and no change in IR.

S = KKC (Tauranga) starts mid-2014.

B. Linear accelerator additions suggested by the Model – 40% IR

Region	Centre	2014	2015	2016	2017	2018	2019	2020	2021	2022
Northern	ADHB	+1				+1			+1	
	ARO			+1						
Midland	WDHB									
	KKC	S								
Central	MDHB	+1				+1				
	CCDHB	+1								
South Island	CDHB	+1							+1	
	SGC									
	SDHB								+1	
Cumulative total NZ		**+4**		**+5**		**+7**			**+10**	

Key:

Within 95% of capacity
Model suggests new linac may be needed

Assumes all centres working at current operating parameters and all DHBs moving to a 40% IR. Suggested locations and timing only; actual build locations and timing will be dependent on DHB business cases and actual service demand.

S= KKC (Tauranga) starts mid-2014.

C. Linear accelerator additions suggested by the Model – 45% IR

Region	Centre	2014	2015	2016	2017	2018	2019	2020	2021	2022
Northern	ADHB	+1			+1		+1		+1	
	ARO		+1						+1	
Midland	WDHB									
	KKC	S								+1
Central	MDHB	+1		+1					+1	
	CCDHB	+1						+1		
South Island	CDHB	+1					+1			+1
	SGC									+1
	SDHB						+1			
Cumulative total NZ		**+4**	**+5**	**+6**	**+7**		**+10**	**+11**	**+14**	**+17**

Key:

Within 95% of capacity
Model suggests new linac may be needed

Assumes Growth scenario (45% IR), with all centres working at current operating parameters (for table with tipping point and operational gains included, see Table 14. Suggested locations and timing only; actual build locations and timing will be dependent on DHB business cases and actual service demand.

S = KKC (Tauranga) starts mid-2014.

D. Linear accelerator replacements as per HBL schedule

Region	Centre	2014	2015	2016	2017	2018	2019	2020	2021	2022
Northern	ADHB	+1			+1	+1	+1	+1	+1	
	ARO					+2		+1		
Midland	WDHB		+1			+1		+1		
	KKC									
Central	MDHB		+1				+1	+1		+1
	CCDHB	+1					+1		+1	
South Island	CDHB		+1					+1	+2	
	SGC	+1			+1					+1
	SDHB							+2		
Cumulative total NZ		+3	+6		+8	+12	+15	+22	+26	+28