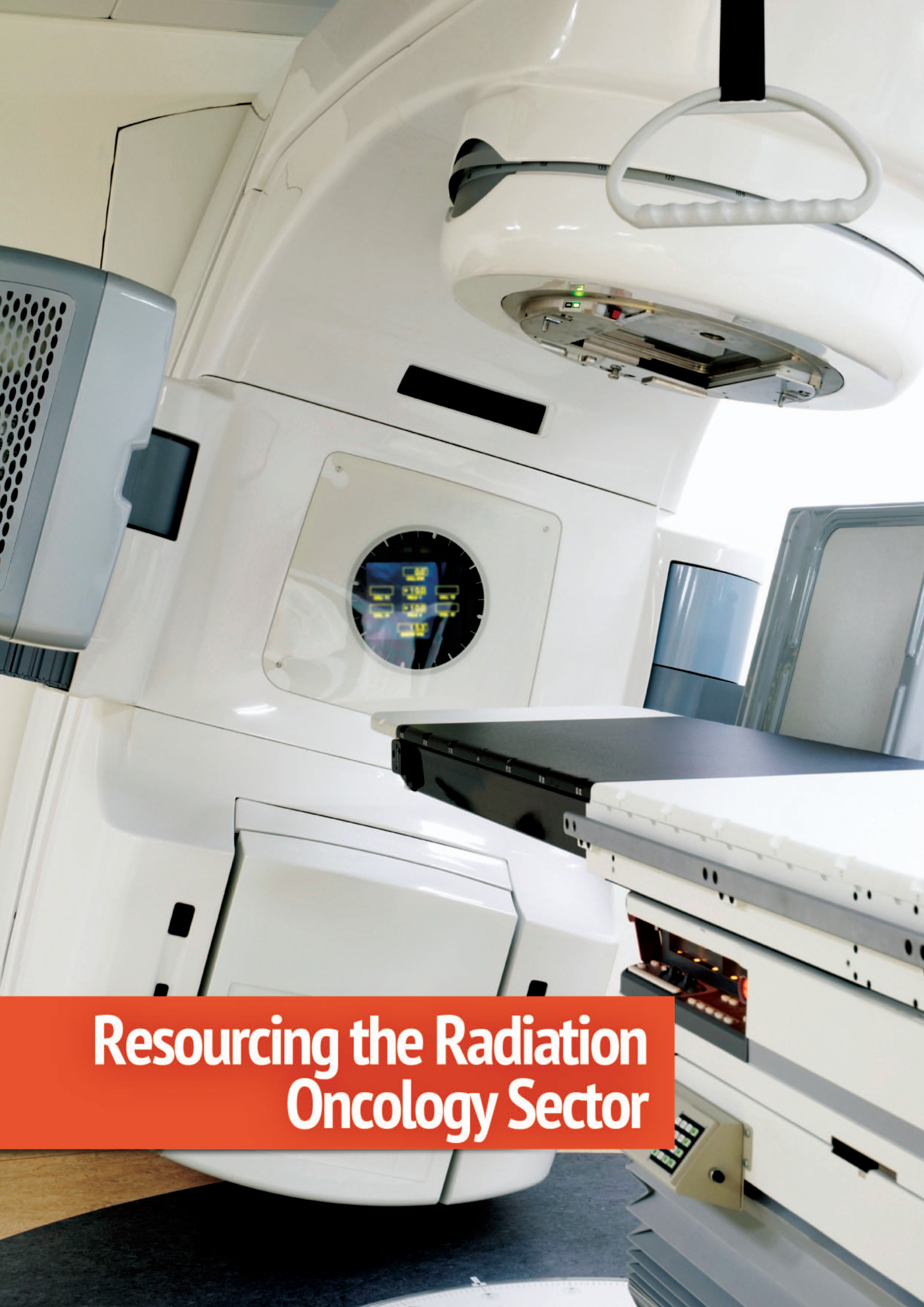


Resourcing the Radiation Oncology Sector

In this section

Key Issues

Delivery of a quality radiation oncology service for cancer treatment relies on the availability of specialised workforce and infrastructure. The situation across the Australian radiation oncology sector is such that:

- The current numbers and trends in the availability of workforce and linear accelerators (linacs) are not sufficient to meet the target optimal utilisation rate of 52.3% of new cancer patients either in 2012 or in 2022;
- There is a lack of effective coordination between bodies responsible for workforce, resources and infrastructure planning;
- A critical barrier for patients to access radiotherapy is their proximity to radiation oncology facilities;
- Appropriate imaging and specialised radiotherapy techniques (such as IMRT) are not cohesively incorporated into service plans and infrastructure planning;
- Ongoing resourcing for the national program of equipment replacement within agreed lifespans is essential to ensure that radiotherapy equipment is kept current.

Objective

The radiation oncology workforce and infrastructure are appropriate to meet current and future cancer incidence.

Defining Success

A prospectively planned and nationally coordinated radiation oncology service across Australia, which includes the following:

- Cancer incidence is the basis for planning;
- Workforce and infrastructure are planned together in a coordinated way;
- Workforce training is aligned with service demand projections and supported appropriately;
- A National Cancer Action Plan which includes radiation oncology is adopted;
- Jurisdictional radiation oncology action plans are developed, maintained and integrated with the National Cancer Action Plan;
- Closer consultative collaboration between governments, policy-makers, service providers, patients and the professions to ensure most effective use of resources;
- Innovative models of quality service provision are developed to improve efficiencies.

Calculating Demand for Radiation Oncology Services

Calculations of the demand for radiation oncology service that underpin this section of the Plan are based on the following model.

Number of new cancer cases	x	Radiotherapy utilisation rate	=	New cases requiring radiotherapy	+	Re-treatment cases and treatment of non-notifiable disease	=	**Total number of cases requiring radiotherapy**

The Australian Institute of Health and Welfare (AIHW)[1] projected cancer incidence data was used (all cancers excluding basal and squamous cell carcinomas of the skin). The target radiotherapy utilisation rate for new cancer cases was the clinically-appropriate benchmark of 52.3% for notifiable cancers[2]. For each year between 2012 and 2022, the utilisation rate was applied to the projected incidence of new cancer cases to obtain the number of new cases to receive radiotherapy. This result is increased by 25% to account for retreatments, and by 10 % to account for treatment of non-notifiable disease[3]. In this way the total number of cases requiring services is obtained.

Workforce

Introduction

Radiation oncology is a complex multidisciplinary service and requires interaction between a range of professionals. Workforce has historically been a rate-limiting step in radiation oncology. At facility level, workforce profile is considered in terms of risk management as it can be a causal factor in adverse patient care incidents. Specific emphasis is needed to match workforce strategies to service expansion plans to provide a quality service, ensure that investment in workforce is used effectively and to grow the facilities infrastructure sustainably.

The specialist workforce

Radiation oncology treatment is delivered by three core professional groups: Radiation Oncologists (RO), Radiation Therapists (RT) and Radiation Oncology Medical Physicists (ROMP). This essential team must be supported by a broader inter-professional team which include: engineers, IT support, data managers, oncology nurses, social workers, dietitians and other allied health professionals. Although detailed workforce analysis for the broader team supporting cancer care is outside the scope of this plan, these groups are essential to optimising outcomes for patients and the access to allied health staff is explored in the section on Rural and Regional Access (on page 96).

Radiation Oncologists

Radiation Oncologists (ROs) are the medical specialists responsible for the treatment of patients with cancer through the use of ionizing radiation. A Radiation Oncologist is a medical specialist who has specific postgraduate training in management of patients with cancer, in particular, involving the use of radiation therapy. They are responsible for assessing the patient by clinical evaluation, and organising imaging and other tests, in order to establish and implement a management plan for an individual. Patient management may include assessment, treatment, follow-up, and psychosocial and physical care coordination.

Radiation Therapists

Radiation Therapists (RTs) are responsible for working with patients throughout their treatment course, to localise the area to be treated, develop dosimetry and accurately deliver radiation therapy, as prescribed. In conjunction with the Radiation Oncologists they are responsible for the design, accurate calculation and delivery of a prescribed radiation dose over a course of treatment to the patient.

Radiation Oncology Medical Physicists

A Radiation Oncology Medical Physicists (ROMPs) are medical physicists who establish, implement and monitor processes which allow optimal treatment using radiation, taking account of the protection and safety of patients and others involved in the treatment process. In their role, a ROMP:

- Consults on optimisation of medical exposures;
- Performs or supervises radiotherapy calibration, dosimetry and quality assurance; and
- Gives advice on matters relating to radiation protection[4].

Estimating workforce requirements and projecting future need

The Tripartite Committee has commissioned the Allen Consulting Group to develop an analysis of the medical radiation workforce and projections covering the next ten years. This work covers three professional groups:

- Radiation Oncologists;
- Radiation Therapists; and
- Radiation Oncology Medical Physicists (ROMPs).

Previous studies have been conducted on radiotherapy workforce, in particular, the 2009 Health Consult for the Department of Health and Ageing. However, the Tripartite Committee did not find that previous work provided the answers to the key questions underpinning the Plan. Therefore, the Allen Consulting Group was commissioned to work on updated data and makes more variables available for analysis. Workforce and linac projections in this section of the Plan are based on the Allen Consulting Group work.

In order to estimate potential workforce shortfalls for each occupation into the future, demand for, and supply of, full-time equivalent (FTE) professionals has been estimated over the period 2012 to 2022. The base year is 2011 and projections start from 2012 and extend through to 2022. Projections of the medical radiation workforce rely on assumptions regarding supply and demand.

Factors that influence workforce demand

A number of factors influence the medical radiation workforce demand. These include:

- Incidence of cancer;
- Availability of linacs;
- Availability of clinical training positions;
- Actual and optimal radiotherapy utilisation rates;
- Relevant State/Territory and Commonwealth government policies.

Projections are further based on the number of linacs required to service patients, which are calculated based on the industry accepted average number of courses of treatment (414) each linac can accommodate per year.

Target utilisation for radiation oncology- closing the gap in patient access

The demand projections in the Plan factor in the increasing incidence of cancer and the utilisation rate. Target utilisation was set to 45.2% in 2017 and 52.3% in 2022. A utilisation rate of 52.3% is estimated to be the optimal rate, and 45.2% was taken as the mid-point between the target rate and the current under-utilisation rate of 38.1%[4-6].

Factors that influence workforce supply

Factors which influence the supply of this workforce include:

- The supply of newly qualified personnel;
- Participation rates;
- Flexible work arrangements;
- Work practices, including use of time for different purposes;
- Retirements from the existing workforce; and
- Relevant government policies.

Baseline workforce supply – business as usual

The projections calculate the supply of FTE professionals from which it is possible to derive headcount numbers. The baseline supply estimates the supply of professional FTEs into the future assuming that current entrant and attrition trends continue. The projections build on the base year's supply of professional FTEs, with inflows into the occupation due to trainees, immigration and re-entry added each year, and outflows due to retirement and other factors such as emigration and career change removed each year. The inflow due to trainees is the intake of trainees each year minus the average loss rate from the trainee program. The entry and attrition inputs have been determined based on historical data sources. They are held constant across future years, but the calculations are conducted year on year.

This gap between the current rate of radiotherapy under-utilisation (38.1%) and the target rate (52.3%) represents the magnitude of the unmet need for radiation oncology services in Australia. To close this gap, appropriate radiation oncology infrastructure and workforce are required. Assuming that appropriate facilities were to be put in place, the table below summarises the number of radiation oncology professionals required in 2012.

Current workforce and required workforce: 2012

Profession	*Available workforce 2012*	*Workforce required to meet target utilisation rate of 52.3% (FTE)*	*Shortfall*
Radiation Oncologists	259	415	156
Radiation Therapists	1447	2073	626
Radiation Oncology Medical Physicists	203	415	212

Issues impacting on the workforce

Stakeholder consultation identified a number of factors that impact on the radiation oncology workforce, these include:

- Uncertain funding mix and regulatory environments for both senior and trainee workforces;
- The ageing of the workforce;
- Increasing trend towards part-time work; and flexible work hours;
- Perceived issues of early retirement or exit of experienced professionals from the workforce;
- Perceived declining attraction of the professions;
- Increasing dependence on overseas recruitment;
- Increased training requirements necessitating more volunteer time from supervisors;
- Difficulty for existing accredited training facilities to balance the increasing demand for training positions and provision of clinical services;
- Reported difficulties for jurisdictional health departments to maintain staff salary increases and competition between jurisdictions and facilities for skilled workforce;
- Challenges in funding the difference between the actual salary for training positions and the Commonwealth funding received;
- Increasing demand and changes to the workforce mix due to the opening of regional cancer centres.

There are also a number of issues specific to the each individual profession in radiation oncology sector:

- Some jurisdictions have reported they have half the number of radiation oncologists they require now;
- Widely reported deficiencies in the number of training positions for ROMPs;
- The status of Commonwealth funding for ROMP and RT training positions is uncertain;
- There is a significant disparity in remuneration for ROMPs across the Australia, creating a system where graduates flock to states with higher remuneration;
- Radiation Therapists post National Professional Development Programme (NPDP) often exit the profession because positions are not available. Although some hope this will be remedied when the new regional radiation oncology treatment centres open, the problem may remain because some graduates may not wish to relocate for work.

Projecting the 2022 Workforce Requirements

Assuming the achievement of the target utilisation rate of 52.3% in 2022, significant workforce shortfalls would occur by 2022. These are summarised in the table below. Significant action coordinated nationally would be required to meet these shortfalls, including implications for the funding of additional linacs and clinical training positions.

*Estimated workforce and required workforce: 2022**

Profession	Estimated workforce 2022 (current trends)	Workforce required to meet target utilisation rate of 52.3% (FTE)	Projected short
Radiation oncologists	499	535	36
Radiation Therapists	2135	2673	538
Radiation Oncology Medical Physicists	327	535	208

Source: The Allen Consulting Group, 2012[7]

Appendix I provides these projections for each jurisdiction across Australia.

** These projections of radiation oncology workforce are an extrapolation of past trends, assuming that the same trend will continue into the future, and are intended to illustrate future changes that may reasonably be expected if the assumptions underpinning the model were to apply over the projection period. These projections are not forecasts and do not allow for future changes in cancer incidence, treatments, risk factors or other factors. No liability will be accepted by the Tripartite Committee or its member organisations for any damages arising from decision or actions based upon these projections.*

Radiation Oncologist Workforce

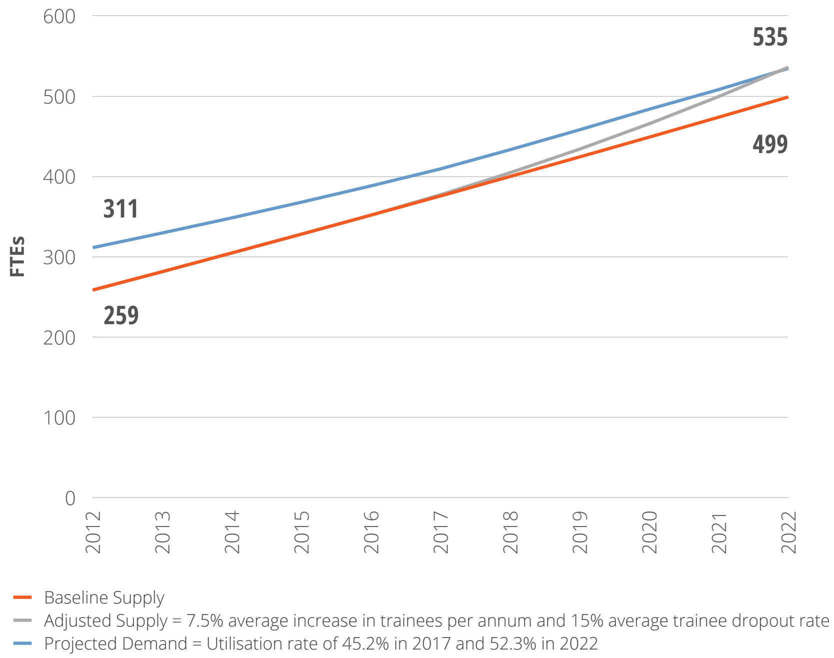
Baseline workforce supply – business as usual

Starting from a base supply of 235.8 FTE professionals in 2011, the Ra diation Oncologist baseline supply model, which assumes current entry and attrition trends will continue, projects a supply of 376 FTE professionals in 2017 and 499 FTE professionals in 2022. The precise difference between supply and demand depends, in large part, upon the utilisation rate that will be achieved in 2017 and 2022.

Target utilisation for radiation oncology- closing the gap in patient access

In 2017, with an utilisation rate of 45.2%, 410 FTEs would be required, resulting in a shortfall of 34 FTEs. If the target utilisation rate of 52.3% is to be achieved by 2022, the model projects that 535 FTEs would be required in 2022, resulting in a workforce shortfall of 36 FTEs (see Figure).

Radiation oncology workforce in 2022 target utilisation scenario



Source: The Allen Consulting Group, 2012[7]

What needs to be done

In order for supply to meet target utilisation in 2022, the intake of trainees over the years 2012 to 2017 needs to increase, on average, by around 7.5% each year (resulting in an inflow of 31 FTE trainees into the occupation in 2022, assuming the dropout rate from the trainee program remains at 15%). Historical data indicates that the intake of trainees has been increasing at a rate of only 2% per annum over the last 10 years.

Radiation Therapist Workforce

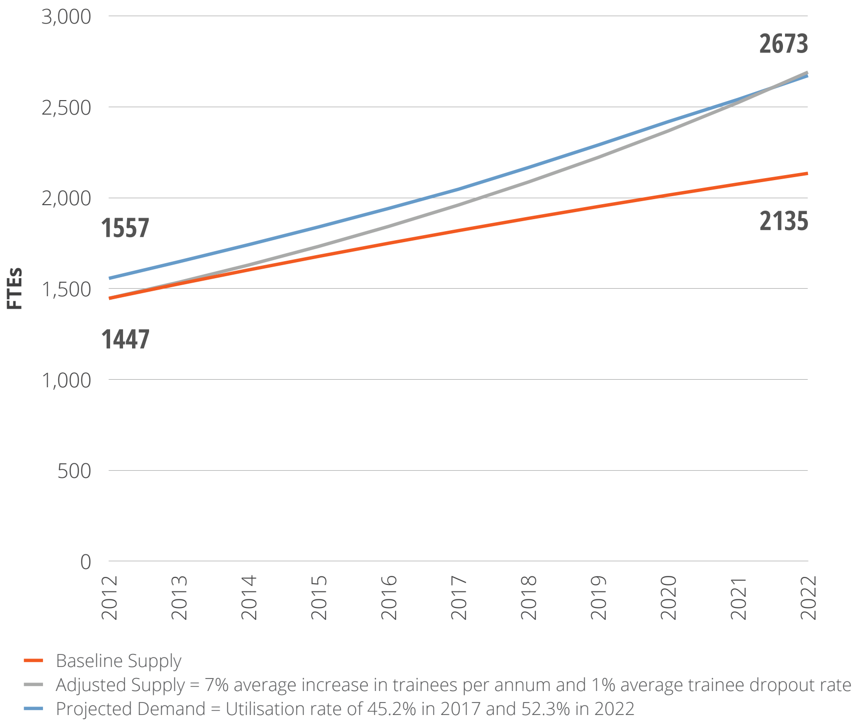
Baseline workforce supply – business as usual

Starting from a base supply of 1364.4 FTE professionals in 2011, the Radiation Therapist baseline model projects a supply of 1726 FTE professionals in 2017 and 1947 in 2022.

Target utilisation for radiation oncology- closing the gap in patient access

In 2017, with an utilisation rate of 45.2%, 2047 FTEs would be required, resulting in a shortfall of 228 FTEs. If the target utilisation rate of 52.3% is to be achieved by 2022, the model projects that 2673 FTEs would be required in 2022, resulting in a workforce shortfall of 538 FTEs (see Figure).

Radiation therapist workforce in 2022 target utilisation scenario



Source: The Allen Consulting Group, 2012[7]

What needs to be done

In order for supply to meet target utilisation in 2022, the intake of trainees over the years 2012 to 2021 needs to increase, on average, by around 7% each year (resulting in an inflow of 292 FTE trainees into the occupation in 2022, assuming the dropout rate from the clinical trainee program remains at 1%).

Radiation Oncology Medical Physicist Workforce

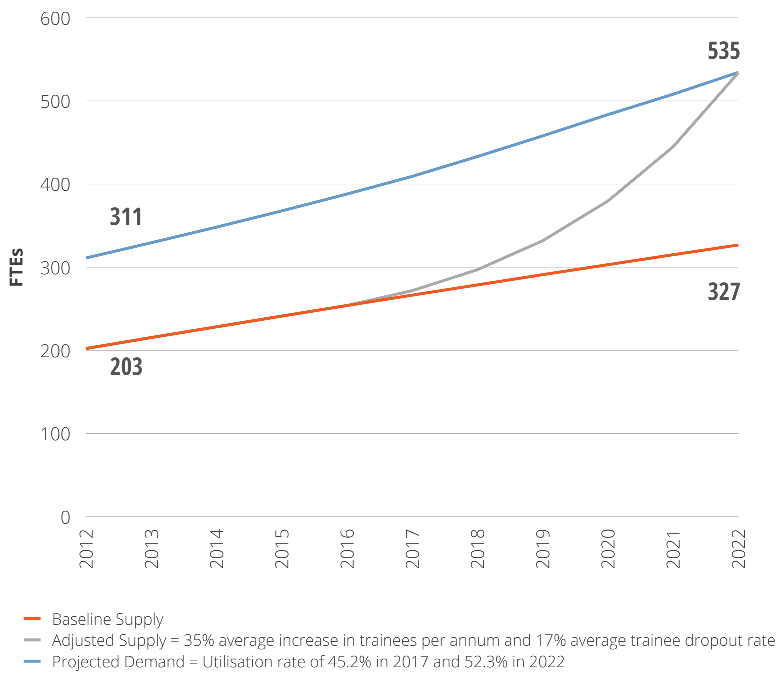
Baseline workforce supply – business as usual

Starting from a base supply of 189.2 FTE professionals in 2011, the ROMP baseline model projects a supply of 267 FTE professionals in 2017 and 327 in 2022.

Target utilisation for radiation oncology- closing the gap in patient access

In 2017, with an utilisation rate of 45.2%, 410 FTEs would be required, resulting in a shortfall of 143 FTEs. If the target utilisation rate of 52.3% is to be achieved by 2022, the model projects that 535 FTEs would be required in 2022, resulting in a workforce shortfall of 208 FTEs (see Figure).

Radiation oncology medical physicist workforce 2022 target utilisation scenario



Source: The Allen Consulting Group, 2012[7]

What needs to be done

In order for supply to meet target utilisation in 2022, the intake of trainees over the years 2012 to 2017 needs to increase, on average, by around 35% each year (resulting in an inflow of 94 FTE trainees into the occupation in 2022, assuming the dropout rate from the trainee program remains at 17%). Historical data indicates that the intake of trainees has been increasing at a rate of only 6% per annum over the last seven years.

Interpreting the results

The estimates are conservative and likely under represent the demand for the workforce.

The projections of radiation oncology workforce numbers are conservative estimates for a number of reasons:

- Linac throughput of 414 is used as a planning parameter, however, data from hospitals across Australia indicates that the actual throughput may be lower than that;
- Trends towards more complex and time-consuming treatments may negate efficiency gains in other areas;
- Generational changes that affect the Australian society generally are likely to also have an impact on the radiation oncology workforce. The most likely implication may be the increase in professionals working part time;
- The increasing number of regional cancer centres may result in a misdistribution of the workforce, with an over-supply in metropolitan and an under-supply in regional areas.
- Conversion of FTE projection into headcount (i.e. people) is likely to increase the numbers required.

The workforce projections are entirely contingent on the availability of the appropriate radiation oncology infrastructure.

In the absence of appropriate infrastructure, including facilities and equipment, the radiation oncology workforce will not be able to deliver radiotherapy services. This will result in unhealthy workforce dynamics and is likely to impact on the future ability of the sector to recruit top quality graduates into the professions.

The workforce projections cannot be viewed in isolation from each other.

The three radiation oncology professions are interdependent in the delivery of quality radiotherapy treatments. Significant shortage of any profession inhibits the provision of services by the others. This is over and above the link between the professions and the infrastructure availability.

Implications for the training programs

There are limits to the capacity of each training program to expand with the requisite urgency to achieve the target utilisation of 52.3%. Growth in training programs needs to be planned carefully to acknowledge the challenges the workforce is currently facing. Planning needs to recognise the need for sustainable growth in training programs and cannot be done independently of facility planning.

Impact on clinical supervisors and examiners

With training program expansion, the professions need to ensure that there are enough clinical supervisors to train trainees effectively, while effectively managing their clinical workload. The need to accommodate further increases in trainee numbers will challenge all three professions, because there are limited numbers of supervisors and examiners available.

Availability of educational resources

Many radiotherapy centres are already under considerable clinical training strain. Training and education are currently provided in addition to the normal duties of clinicians. There are limited education resources available that take advantage of improved technologies to reduce the burden on clinicians of providing didactic lectures.

Need for nationally coordinated training networks

Regional and rural training must be considered as an integral part of training. The allocation of training positions often depends on the individual facility's capacity to provide comprehensive training. A pilot project for supported training networks for radiation oncology trainees is underway with funding from the Commonwealth Department of Health and Ageing. A nationally coordinated training network approach will enable provision of adequate breadth of training for trainees and would include new and established centres.

Specific issues – Radiation Oncologists

There is a greater need for Fellowship positions (with related funding required), to provide a post graduate training pathway for radiation oncologists.

Fellowship positions in this context refer to positions filled by recently graduated specialist Radiation Oncologists following their Registrar (vocational) training, undertaken as a transition to specialist level employment. These positions are usually filled for one year, although are of no defined duration. The positions can include any mix of clinical and research-based work and can involve the integration of other post-graduate qualifications. Fellowship positions can be undertaken locally or internationally with many Fellows using the role as an opportunity to practice in a different centre to the one in which they completed their specialist training, thus broadening their training experience.

Fellowships are a highly desirable component of post-graduate training through which Radiation Oncologists develop important clinical and research skills that allow them to remain at the forefront of cancer management and research, thereby ensuring that Australian and New Zealand cancer patients receive the best possible care.

Specific issues – Radiation Therapists

For service and workforce planning reasons, the radiation oncology sector clearly has a vested interest in student numbers entering medical radiation science courses In Australia. Effective workforce planning must also involves consideration of the need for clinical service providers to accommodate clinical education and training for students, an essential component of entry level training. Service providers themselves however exert only some influence over student numbers. Governments, universities themselves and educational, vocational and economic market forces arguably have far greater influence on total numbers in the available workforce.

Balancing student numbers with the number of available clinical placements will be an increasingly important issue in workforce planning. Wide and coordinated consultation between governments, universities, clinical services and those responsible for workforce planning will be necessary. This is particularly so given the workforce projections to 2022 prepared as part of this Tripartite National Strategic Plan and anecdotal evidence that suggests clinical centres are already under significant student training stress.

An example of the problems that result from ineffective consultation is a unilateral decision by a university in recent years to cease its undergraduate radiation therapy course and only offer a post graduate entry level course. Anecdotally, the graduate output from this school now appears to be declining and the viability of the course threatened whilst at the same time state RT workforce needs are increasing. The radiation oncology sector can ill afford such examples to be repeated and the matching of students with clinical placements and workforce needs will be critical to success.

The other priority issues for RT training are:

- Further support and development of virtual learning environments base on the need to ease the burden on clinical services to provide for clinical placements and training;
- For education and training to focus on supporting advanced and extended scopes of practice as a means of establishing enhanced and robust career pathways in the profession and a more skilled and knowledgeable workforce[8];
- Academic courses to include more emphasis on quality management and research;
- Developing where applicable and appropriate assistant roles as is happening in other allied health professions and for which implementation frameworks are already in place in some jurisdictions[9] with a view to: providing the space for RTs to develop into more value added advanced practice roles; and to provide a feeder for the profession for assistants to go on to undertake further training;
- Development of strategies to attract more Indigenous and regional students into radiation therapy and tailor education and training to their needs;
- Re-design the RT staffing model to ensure educational roles in staffing profiles are better matched to clinical training needs for both learners and qualified staff (re-design of the staffing model is underway).

Specific issues – Radiation Oncology Medical Physicists

The major workforce issue for ROMP's is ensuring adequate postgraduate clinical and academic education and training. There is no specific undergraduate degree for ROMP's and a career in Medical Physics relies on the completion of both an undergraduate (in physics or engineering) and a postgraduate degree with a major in medical physics. The post-graduate Training Education and Assessment Program (TEAP) generally takes three to five years to complete.

There are several challenges inhibiting the increases in the number of ROMPs:

- Declining attractiveness of undergraduate science degrees majoring in physics[10];
- Lack of funding for ROMP registrar positions;
- Lack of senior ROMP positions to appropriately supervise registrars;

Hospitals are increasingly concerned about rejecting funding for registrar positions, despite not having the supervisory capacity in place. This funding is often tied to clinical outcomes, diminishing the focus on training and education.

Some centres find it difficult to recruit senior medical physicists, even with the recent initiatives for experienced certification and certification of overseas-trained medical physicists. Medical Physics is likely to remain on the Australian Department of Immigration's Skilled Occupation List.

As part of meeting the need for senior ROMPs to train ROMP registrars, the option of employing dedicated training preceptors has proven beneficial to improve the quality and governance of the TEAP. Where these preceptor positions provide support to a network of training sites, the ROMP registrars are able to access to a wide variety of training opportunities enabling the quality of the TEAP graduates to be more consistent. If the preceptor support were to include regional centres then additional resources are required to allow movement of preceptor and registrars between centres.

Infrastructure

Introduction

In comparison with other branches of medicine, radiation oncology is highly dependent on physical infrastructure and equipment. Most people in Australia who have radiotherapy are treated with megavoltage X-rays produced by a linear accelerators (linacs).

The Tripartite National Strategic Plan utilised linacs as a basic unit of resource availability and projected the numbers of linacs required to meet the increase in cancer incidence numbers.

The importance of imaging in the delivery of quality radiotherapy and a range of essential radiotherapy techniques has also been considered.

Linacs require a number of important accompanying resources, which are not specifically assessed in the Plan, including:

- Radiation-proof bunkers
- Expansion pathways
- IT infrastructure and information systems
- Access to imaging modalities and other cancer treatments

Linear Accelerator Fleet in 2012

As of December 2011, there were 168 linear accelerators installed in Radiation Oncology centres throughout Australia, 108 (74%) were in the public sector and 60 (36%) in the private sector. Table one shows the number of linear accelerators by state and territory.

Linear accelerators in Australia 2011

State/territory	*Public*	*Private*	*Total*	*Population Sep 2011 '000*[16]	*Population per linac '000*
ACT	4	0	4	367	91.8
NSW	41	13	54	7,318	135.5
NT	2	0	2	231	115.5
QLD	17	16	33	4,599	139.4
SA	5	8	13	1,660	127.7
TAS	5	0	5	511	102.2
VIC	28	16	44	5,641	128.2
WA	6	7	13	2,367	182.1
Australia	*108*	*60*	*168*	*22,696*	*135.1*

Currency of radiotherapy equipment is maintained though the Australian Government Department of Health and Ageing program – Radiation Oncology Health Program Grants, which reimburses the cost of expensive eligible radiation oncology equipment to facilities. A profile of the linear accelerators in Australia is provided in Appendix II and demonstrates that government support has resulted in a reduction in the average age of linear accelerators.

Baseline linac supply – business as usual

In 2011 there were 168 linacs nationally. At current utilisation and throughput levels, the gap between the availability of, and requirements for, linear accelerators would be 5 nationally in 2022.

Target utilisation for radiation oncology- matching linacs to workforce

The table below summarises the workforce and linac requirements for reaching target utilisation of radiotherapy. The number of linacs needed in the table below does not take into account machine retirements.

2011 numbers of workforce and linacs, compared to projected requirements to meet target utilisation rate.

	Actual numbers	*Estimated numbers required to meet target utilisation rate of 52.3%*	
Year	*2011*	*2017*	*2022*
Linacs	168	208	267
ROs (FTE)	235.8	410	535
RTs (FTE)	1364.4	2047	2673
ROMPs (FTE)	189.2	410	535

Source: The Allen Consulting Group, 2012[7]

Projecting required linac numbers

The number of linacs that will be available and the number that will be required over the years 2012 to 2022 was projected. Each year of projections of the number of linacs that will be available adds the average number of linacs installed per year over the last five years, and removes those that should be retired. The 2011 data on existing linacs was broken down into year of installation.

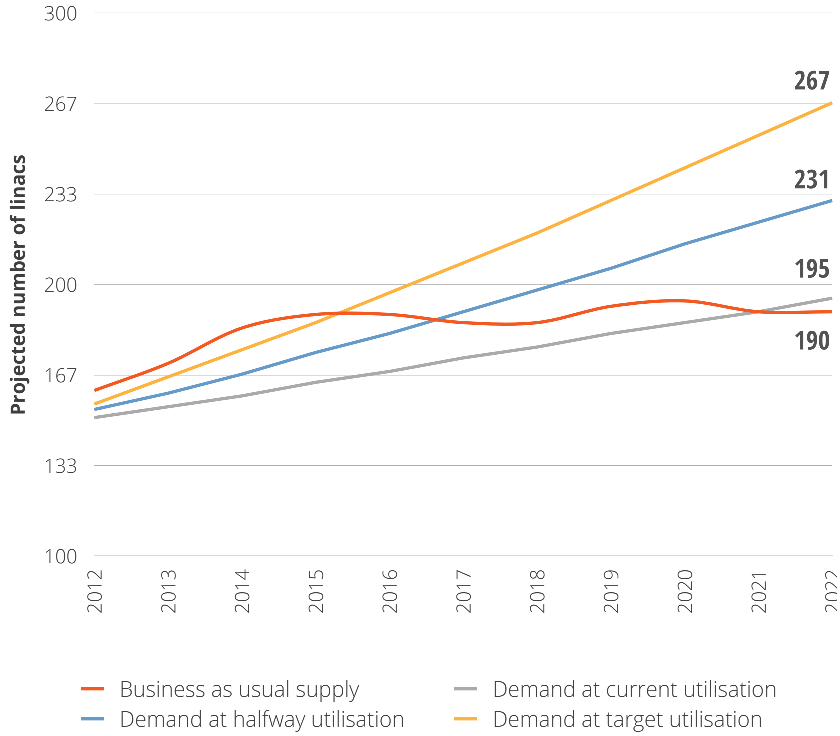
Projections are further based on the number of linacs required to service patients, which are calculated based on the industry accepted average number of courses of treatment (414) each linac can accommodate per year. It is acknowledged that linac throughput can vary based on the case mix of patients and service-related factors. The useful life of a linac was assumed to be 10 years.

Projected linac availability over the next 10 years, at the national level, was compared with 3 scenarios based on the utilisation:

- target – optimal rate of 52.3% by 2022
- halfway rate of 45.2% by 2022
- maintenance of current under-utilisation rate 38.1%.

The first year of projections (2012) removes all linacs in the current stock that was installed in 2002 or prior (15% of current stock), as it is assumed they will not be in service in the projected period. In the subsequent years, the linacs that were installed in the year that was 10 years prior are removed from the projections. The average number of linac installations per year, over the years 2007 to 2011 years, was calculated. Each year of projections adds this number to the previous year's stock.

Projected linear accelerator requirements 2012-2022



Source: The Allen Consulting Group, 2012[7]

Implications of Projections for Infrastructure Planning

Interpreting the results

The projections should be treated as baseline numbers rather than as the maximum linac numbers required.

The model developed by the Allen Consulting Group to predict the number of linacs required across Australia assumes that capacity needs equal demand. However, queuing theory (mathematical study of waiting times) proves that capacity needs to exceed mean demand to avoid the build-up of waiting times, including in radiotherapy[11]. Research into the required percentage of spare capacity needed to keep radiotherapy waiting times to treatment short found that about 10% spare capacity is required to ensure that 86% of patients are able to start radiotherapy within a week of completing the treatment planning process[12].

Meeting the target utilisation rate should therefore incorporate an additional 10% capacity in linear accelerator numbers to negate increases in the waiting times for treatment. This would mean that to meet the 52.3% target utilisation rate in 2022, at least 27 additional linacs would be needed extra to the projected number of 267 linacs to create this needed spare capacity.

It is possible that the lack of spare capacity allocation in previous calculations of linac requirements by service planners has resulted in unrealistic expectations regarding throughput and waiting times.

Linac requirements in each jurisdiction

Projected linac requirements for each State and Territory are not included in the Plan. There are two key reasons for this:

- Some jurisdictions have very low linac numbers and therefore the model is of limited use;
- While the national linac projections are robust, linac numbers at jurisdiction level should be based on local population characteristics and numbers.

There are existing benchmarks for planning radiotherapy services on a population basis2. For every 1,000 cases of cancer in a population, 523 patients would need radiation as an optimal part of their management. Considering the average linac throughput (patients that can be treated in a year), for every 600 new cases of cancer, a linac is required.

Imaging in radiation oncology

The success of radiotherapy as a treatment modality is intimately related to the ability to accurately define, plan and deliver radiation treatment to the tumour whilst limiting dose to normal tissue. The confluence of technological advances in both imaging techniques and the way radiotherapy is being delivered has fostered even closer relationships between radiologists, radiation oncologists (RO), radiation therapists (RT), and radiation oncology medical physicists (ROMP). At the same time, the capital and human resource costs associated with these advances challenges the management of modern radiotherapy centres.

Advances in imaging technologies have supported improved treatment delivery and the development of new techniques in radiation oncology such as stereotactic body radiotherapy. Increased accuracy has led to improved tumour control rates and a reduction in treatment-related toxicities with resultant improved quality of life for cancer patients.

The imaging phases of the best practice radiotherapy process

Diagnosis & Staging	Treatment Simulation	Treatment Planning	Treatment Localistation (IGRT)	Treatment Delivery (IGRT)	Response Assessment
• CT • MRI • PET • SPECT	• CT + optical lasers • 4D CT	• CT • MRI - MRS • PET • SPECT	• CBCT or CT • kV \MV Images	• Optical lasers • 4D CT • Fluoroscopy	• CT • MRI • PET • SPECT

The increasing use and complexity throughout the best practice radiotherapy process is demonstrated in the figure above.

Diagnosis and staging

There is now a large body of evidence showing that more accurate staging in cancer is associated with better patient selection onto treatment pathways.

The imaging used for diagnosing and staging the disease should have quantitative capabilities allowing for longitudinal studies to be performed. During treatment and for follow up on completion of treatment, the quantitative capability of the imaging system must be verifiable and maintained to allow accurate and precise evaluation of treatment outcomes in a quantitative manner. This requires the imaging systems to be adequately calibrated and maintained which requires consultation with Diagnostic Imaging Medical Physicists. The increasing reliance of complex imaging systems is increasing the interaction and collaboration between diagnostic imaging and radiation oncology modalities.

Treatment simulation and treatment planning

Computed tomography (CT) scans acquired in the radiotherapy treatment position before the start of radiotherapy remain the basic imaging modality for contouring tumour target volumes and defining dose-limiting normal body structures known as "organs at risk". A CT scan is mandatory for accurate calculation of dose using a treatment planning computer. 4D CT can be utilised to capture the motion of the tumour volume and the surrounding organs at risk to allow for dose escalation and dose hypo fractionation. Tumour motion can also be managed or reduced, for example, by using respiratory gating technology to deliver the treatment only at a certain phase of the breathing cycle. This enables improved tumour control and reduction in the toxicity from treatment. Advances in the software, computing power and data storage capabilities of treatment planning systems have enabled multiple image sets to be overlayed or "fused" with the planning CT scan to further improve accuracy of delineation of tumour and normal tissue. There is reasonable evidence from lung, oesophageal and head and neck cancers that fusion of PET images to the planning CT can result in significant changes to the target volumes delineated.

Treatment delivery and localisation (IGRT)

The problem of motion of tumour volumes within organs as well as adjacent healthy organs, for example motion of the prostate due to bladder and rectal filling and of lung tumour movement within the breathing cycle, has been addressed by the implementation of image-guided radiotherapy (IGRT). Whereas previously only bony structures could be visualized on the treatment couch of the linear accelerator at the time of each radiotherapy fraction, the integration of computed tomography into linear accelerator technology ("cone-beam CT") as well as the option to introduce radio-opaque fiducial markers into tumours, such as the prostate, made possible the correction of the patient position based on this information at each treatment session. This same principle of IGRT is used in delivery of brachytherapy of gynaecological cancers where MRI is used; as well in high-dose rate brachytherapy of prostate cancer where implanted fiducial markers are used. This not only ensures that the tumour volume is being treated accurately each day but gives the potential to reduce 'error margins' in radiotherapy delivery thereby significantly reducing side effects of treatment.

A good understanding of the dosimetric impact of the increased imaging requires access to Diagnostic Imaging Medical Physics expertise. If daily cone beam CT imaging is used, then a significant proportion of the radiation dose could be delivered by the imaging system requiring the two sources of radiation dose to be combined for planning purposes. This challenge is yet to be faced in most centres, however it will become increasingly important that the diagnostic imaging modalities used during treatment are well understood.

Evolution of new techniques

Extremely precise delivery of high radiation doses to small volumes was already technically possible in the 1990s but this was limited to intracranial stereotactic radiotherapy ("radiosurgery"). The brain is ideal for this procedure, as tumour or organ motion is practically non-existent within the bony cranium.

However, with the ability to accurately image patients while lying in the treatment position on the linear accelerator, new ablative treatments have become available for treating extracranial sites, particularly in the lung, liver and spine. Although these procedures have only recently become available the emerging literature suggests that they are more efficacious and well tolerated compared to previous 'non-stereotactic' treatments. These new evolving techniques depend on a combination of immobilisation devices integral to the linear accelerators and on-board, in treatment room, real-time imaging that allow for online correction of minute displacements of the target from the idealised treatment position. This technology has started to become available in the modern radiotherapy department with sophisticated equipment that requires additional investment in capital and human resources. The actual delivery of such complex treatment that requires additional quality assurance steps, and time, also impacts on the throughput of patients within a radiotherapy department. These new techniques of treatment allow an additional spectrum of patients to be referred for radiotherapy; including those who are considered inoperable and otherwise would be considered "untreatable". These non-invasive techniques enhance the armamentarium of the radiation oncologist and offer additional hope to such patients.

Response assessment

After receiving radiotherapy, particularly for radical (curative) radiotherapy it is important to be able to decide if a patient is in remission or if there is still evidence of active disease that may require further treatment. Many patients will have residual abnormalities on standard imaging (CT or MRI) following treatment that has previously been difficult to define as residual active tumour, necrotic (dead) tumour/tissue or post-radiotherapy fibrosis and oedema. There is no doubt that before the evolution of improved imaging techniques like functional MRI and PET /CT there were a large number of patients that underwent unnecessary treatments based on anatomical information alone.

There is now good evidence in head and neck cancer and in lung cancer that the use of post-treatment PET scanning to assess treatment response is not only an accurate predictor of outcome but has significantly reduced the rate of unnecessary salvage surgery offered to patients that have an anatomical abnormality which is composed of dead/dying tumour. Likewise in brain tumours, functional MRI and PET imaging may reduce the rate of unnecessary salvage surgery offered to patients, who appear to have disease progression on routine imaging, by more accurately delineating those with treatment related changes from those with true progression. This approach is being extended to other sites including lung cancer, gastrointestinal tumours and melanoma.

These new approaches to the use of functional and targeted imaging will allow the evaluation of changing treatment regimens, including in clinical trials, to determine the most appropriate clinical programmes are offered to patients. Integration of such technologies into routine clinical practice remains a challenge as a result of difficulties providing access and limited expertise.

Essential Radiotherapy Techniques – Intensity Modulated Radiation Therapy (IMRT)

What is Intensity Modulated Radiation Therapy (IMRT)

Intensity modulated radiation therapy is a radiotherapy technique that allows radiation to be more closely shaped to fit the tumour and spare nearby critical normal tissue.

Use of IMRT

The decision to use IMRT would depend on the clinical circumstances and the intent of the treatment. Not all patients will require IMRT; however there are circumstances where IMRT is increasingly the standard of care. When the radiation doses required to control the cancer are close to normal tissue radiation tolerance levels IMRT is indicated.

Consideration should be given to the impact on the quality of life, technical implementation and anatomical complexity.

The sparing of normal tissue achieved by IMRT results in fewer treatment-related toxicities and side effects. In addition, comparable or higher doses to the tumour with IMRT would result in equivalent or better tumour control and disease free intervals.

IMRT is also indicated where previous radiotherapy has been given to nearby tissues and conventional techniques of radiotherapy would result in unacceptable toxicities.

IMRT-capable equipment distribution across Australia[14]

C-arm linac: IMRT

IMRT is traditionally delivered by a C-arm Linac, with a number of static modulated beam positions around the tumour volume. According to the Faculty of Radiation Oncology facilities census, 85% of all linear accelerators in Australia are IMRT-capable and 97% of Australian radiotherapy centres have at least one IMRT –capable linac.

C-arm linac: Volumetric Modulated Arc Therapy (VMAT)

VMAT is a newer type of IMRT technique that uses the same hardware but delivers the radiotherapy using a rotational or arc geometry rather than static beams. Of the current linear accelerator pool 25% of machines are VMAT-capable. Arc techniques enable an improvement in the beam delivery time and may result in overall reduction in the treatment time.

Helical IMRT

Helical IMRT combines a 'CT-like' physical configuration with a radiotherapy delivery system (linac). One Helical IMRT linac is currently operating in Australia.

IMRT services across Australia in 2010 [14]

Although IMRT-capable equipment is available in 49 centres (97%) nationally, in many centres the IMRT service is not offered. In 2010 Australian Capital Territory and Northern Territory did not offer any IMRT services. They both have since introduced the service, but the data on IMRT utilisation is not available. In South Australia IMRT is only available through a private service provider.

Although the majority of Australian centres have IMRT capability, 14 centres (29%) of those with IMRT capability do not deliver any IMRT treatments.

Of the 35 centres (71%) that deliver IMRT treatments in 2010:

- 12% treated 10 of fewer patients with IMRT
- 20% treated between 11 and 50 patients with IMRT
- 25% treated between 51 and 150 patients with IMRT
- 14% treated more than 151 patients with IMRT

Overall, out of the total new radiotherapy treatments delivered nationally, IMRT treatment courses comprised only 6.5%.

Total National IMRT courses delivered (2010)

State	Percentage by state
ACT	0%[14]
NSW	44%
QLD	23%
SA	1%
TAS	3%
VIC	29%
WA[14]	0.1%
NT	0%

Trends and issues arising

IMRT should be available in all centres that offer radiation therapy including rural, metropolitan, and in both public and private facilities. All patients who have radiation therapy should have access to IMRT where clinically appropriate.

Given that the equipment base to deliver IMRT in Australia already exists and that the sector is becoming more experienced in the use of this technique, it is estimated that between 30% and 50% of all radiation therapy patients will be treated with IMRT going forward. The fact that the IMRT potential of existing technology is not being used to benefit patients should be a significant concern to patients and service providers.

There are a number of barriers to IMRT uptake at present, these include:

- Professional – lack of capacity to undertake the training and learning required as most radiotherapy teams are devoted to meeting the existing patient load;
- Professional – lack of capacity to undertake the necessary Quality Assurance which is essential for this technique;
- Resourcing – lack of an appropriate Medicare rebate which would resource and encourage timely implementation.

IMRT treatment planning and delivery requires significantly longer preparation time and physics QA and therefore is more resource-intensive. As such, the cost of delivering IMRT treatment is higher than 3D conformal therapy. In the absence of appropriate public funding, patient access to IMRT is limited by the capacity of the radiotherapy departments to absorb the financial cost.

Delivering IMRT requires precise imaging to guide clinical decision-making. Image Guided Radiation Therapy (IGRT) is an essential component of delivering IMRT. The rapid evolution of IGRT technologies offers a high level of reassurance that IMRT cases can be done with high quality[15].

Essential Radiotherapy Techniques – Stereotactic Radiotherapy

What is a stereotactic treatment?

A highly specialised and complex delivery of external beam radiation therapy called stereotactic radiation uses focused radiation beams targeting a well-defined tumour, relying on detailed imaging, computerized three-dimensional treatment planning and precise treatment set-up to deliver a much higher radiation dose than standard radiotherapy with extreme accuracy.

There are two types of stereotactic radiation

- Stereotactic radiosurgery (SRS) refers to a single or several stereotactic radiation treatments of the brain or spine. Dedicated equipment is required, which could be either a CyberKnife or Linac that has been specially modified with small sized collimators. Specific planning systems are required for this treatment delivery in all such cases.
- Stereotactic body radiation therapy (SBRT) refers to one or several stereotactic radiation treatments with the body, excluding the brain or spine.

Conditions treated with stereotactic radiation

Stereotactic radiosurgery (SRS) is used to treat conditions involving the brain or spine including:

- Primary brain tumours
- Brain metastases
- Benign tumours arising from the membranes covering the brain (meningiomas)
- Benign tumours of the inner ear (acoustic neuromas)
- Abnormal blood vessels in the brain (arteriovenous malformations)

Stereotactic body radiation therapy (SBRT) is used to treat small tumours in the chest, abdomen or pelvis that cannot be removed surgically or treated with conventional radiation therapy, including:

- Small lung cancers
- Lung metastases
- Liver metastases

These lists cover commonly treated conditions but cannot include every possibility.

Stereotactic services across Australia[14]

Stereotactic radiotherapy is offered in 11 centres (21%) nationally. 82% of stereotactic equipment is located in the public sector, while the remaining 18% is located at privately owned facilities. Australian Capital Territory, Northern Territory and Tasmania do not offer any stereotactic services.

Stereotactic equipment distribution

State	*Percentage of total machines*
ACT	0%
NSW	45%
QLD	18%
SA	9%
TAS	0%
VIC	18%
WA	9%
NT	0%

Trends and issues arising

Demand for stereotactic services is difficult to measure because in the absence of stereotactic radiotherapy treatment patients receive alternative treatments such as surgery for acoustic neuromas and whole brain radiotherapy for solitary brain metastasis. For this reason an increase in stereotactic service provision is important for patient choice and appropriate clinical decision-making. The likelihood of SRS usage will increase from increased patient and referrer demand as the more consistent utilisation of SRS in other countries will resonate with cancer managers and patients here. This will be compounded as oligometastases are increasingly more aggressively managed overseas.

Continued evolution of stereotactic techniques broadens applicability of stereotactic treatments to extra-cranial sites. This activity is referred to as stereotactic body radiation therapy (SBRT) and this is a fast-developing area, particularly in Europe and North America. SBRT has potential for reduced morbidity, an example being SBRT to liver metastasis as an alternative to surgery. SBRT also holds a promise for durable local control and even cure for patients with solitary (or oligo) metastatic disease.

The capability of linear accelerators to deliver stereotactic radiotherapy is increasing and it is expected that this technique will be applied more widely in the next decade. Highly specialised techniques, such as SRS and SBRT must be provided by centres which have specialist multidisciplinary clinical teams with expertise in the delivery of the stereotactic technique.

The current single fraction Medicare rebate grossly under-reimburses the cost of providing stereotactic radiosurgery, when considered in terms of cost in capital outlays and time taken for planning and treatment. The rebate is based on a single fraction (i.e. one big dose of radiation delivered in one treatment). All stereotactic radiotherapy regardless of its mode of delivery should carry a Medicare rebate that is appropriate for the complexity of planning and delivery. Fractionated delivery of stereotactic radiotherapy (i.e. delivered over multiple treatments) is expected to increase. Research into the radiobiology of cancer supports increased fractionation to allow normal tissue cells time to repair and recover between treatments.

Essential Radiotherapy Techniques – Brachytherapy

What is brachytherapy?

Brachytherapy is a highly specialised and resource intensive radiotherapy technique. Brachytherapy involves the placement of radioactive sources in, or just next to, a cancer. Unlike external beam radiotherapy, brachytherapy may be invasive. During brachytherapy, the radioactive sources may be left in place permanently or only temporarily, depending upon the radioactive isotope employed. Brachytherapy may be used alone or in conjunction with external radiation treatments.

Two types of brachytherapy

- High-dose-rate (HDR) brachytherapy involves the remote placement of the powerful radiation source into the tumour for several minutes through a catheter. It is usually given in multiple doses once or twice daily or once or twice weekly.
- Low-dose-rate (LDR) brachytherapy involves the longer placement of the temporary (several days) or permanent radiation source into the tumour area.

Conditions treated with brachytherapy

- Prostate cancer
- Gynaecological cancers
- Breast cancers
- Cancers of the eye

This list covers commonly treated conditions but cannot include every possibility.

Brachytherapy services across Australia[14]

Less than half of all radiation oncology centres in Australia offer some form of brachytherapy service (45%). Northern Territory is the only Australian State or Territory that does not currently have any brachytherapy services.

High-dose-rate brachytherapy (HDR BT) is offered in 22 centres (42 %) nationally and in all jurisdictions excluding Northern Territory. 70% of HDR BT equipment is located in the public sector, while the remaining 30% is located at privately owned facilities.

HDR BT equipment distribution

State	*Percentage of total machines*
ACT	5%
NSW	32%
QLD	19%
SA	14%
TAS	3%
VIC	19%
WA	8%
NT	0%

Low-dose-rate brachytherapy (LDR BT) is offered in only 14 centres nationally (27%). In 2010 Australian Capital Territory, Northern Territory and Tasmania did not offer any LDR BT services. This has since changed for ACT and Tasmania. In Queensland, LDR BT services are not available in the public hospital system.

LDR BT service volume

State	Percentage of total LDR BT courses delivered
ACT	0%
NSW	24%
QLD	15%
SA	23%
TAS	0%
VIC	32%
WA	6%
NT	0%

Trends and issues arising

Brachytherapy services are changing and developing along with other oncological and radiotherapy services. The screening and vaccination programs across Australia should ultimately result in reduced referrals for gynaecological brachytherapy overall. This, however, is anticipated to be offset to some extent by the increasing complexity of the gynaecological cases requiring brachytherapy, as these cases are often late stage disease.

Significant growth is expected to continue in the demand for prostate cancer brachytherapy. Current evidence-based reports suggest brachytherapy has a favourable cost-effectiveness compared with other active treatments for prostate cancer. Prostate cancer is the most common internal cancer, and increasing rapidly in incidence with population growth and aging. These factors are likely to lead to a demand for brachytherapy services. The potential introduction of prostate cancer screening services is likely to increase the demand for early brachytherapy (low-dose-rate) in particular.

Essential Radiotherapy Techniques – Superficial and Orthovoltage

What are superficial and orthovoltage treatments?

Superficial (SXT) and Orthovoltage (DXT) radiotherapy utilise low energy ionizing radiation to treat cancer and other conditions that occur either on or close to the skin surface. SXT utilises x-ray energies of between 50 and 200 kV, having a treatment range of up to 5mm, and DXT utilises 200 to 500 kV x-rays penetrating to a useful depth of 4 – 6cm.

The shallow penetrating power of both SXT and DXT means that they are often superior to megavoltage external beam radiation for the treatment of superficial lesions. Orthovoltage and superficial treatment machines are becoming less common, with much of the treatment that was previously delivered with them now being delivered using linear accelerators.

Conditions treated with superficial and orthovoltage radiotherapy

Superficial and orthovoltage radiotherapy are used for the treatment of skin lesions such as melanoma, squamous cell carcinoma (SCC) and basal cell carcinoma (BCC) as well as non-malignant skin conditions such as keloids. Relatively high absorption of these low energy x-rays in bone also means that orthovoltage treatment is well suited to the palliative treatment of painful bony metastases in shallow regions such as the ribs and sternum.

These above mentioned conditions are those commonly treated with these techniques but do not constitute an exhaustive list.

Superficial and orthovoltage services across Australia[14]

Superficial and orthovoltage radiotherapy are offered in 28 centres (55%) nationally. 86% of the relevant equipment is located in the public sector, while the remaining 14% is located at privately owned facilities. Northern Territory is the only jurisdiction which does not offer Superficial and orthovoltage radiotherapy.

SXT and DXT equipment distribution

State	Percentage of total machines
ACT	4%
NSW	46%
QLD	14%
SA	7%
TAS	4%
VIC	21%
WA	4%
NT	0%

Trends and issues arising

Superficial and orthovoltage radiotherapy will remain a useful technique for treating skin cancer and a number of other conditions. It is likely that the caseload for these treatments will increase due to the ageing population and the consequent rise in the incidence of cancer. However, this trend may be offset by:

- Impact of the prevention campaigns (such as 'sun-smart' strategies);
- Better management prior to the condition turning into a malignancy;
- More effective management of early skin cancer;
- Use of alternative methods of treatment (such as Moh's surgery and laser surgery or ablation).

Equipment availability

- It is anticipated that superficial treatments will move solely to the domain of radiotherapy departments as anecdotal evidence suggests this equipment is being phased out in the private dermatology practices.
- Some radiotherapy departments and centres will choose not to install superficial and orthovoltage machine units. This is because most of the applications can also be delivered by appropriately configured linear accelerators.

There still are some specific clinical situations where the unique characteristics and physical properties of superficial radiotherapy remain compelling, one example being treatments around the eye, such as skin cancers on the eye.

Recommendations

Cancer incidence is the basis for planning

26. The nationally coordinated radiation oncology planning must consider:
    - 26.1. Projected cancer incidence;
    - 26.2. Target optimal utilisation rate;
    - 26.3. Regional and rural service access;
    - 26.4. Projected changes in demographics.

Workforce and infrastructure are planned together in a coordinated way

27. Establish a system for facilities to regularly report on their activities to inform coordinated planning.
28. Implementation of new technology must consider workforce implications.
29. Overcapitalized radiotherapy services, such as brachytherapy and radiosurgery, should be rationalised.
30. New facilities should be planned with the capacity to allow expansion and service continuity.
31. All facilities must have adequate information and communication technology infrastructure and expertise.
32. Workforce planning should consider the need for multidisciplinary care and adequate supply of allied health and support services.
33. Australia needs 267 linacs by 2022 to achieve the optimal utilisation rate of 52.3% (approximately an extra 100, in addition to the replacement of current fleet).
34. Governments must have a plan for the number of new linacs that will come into use over the next ten years.
    - 34.1. Coordinated across the public and private sectors;
    - 34.2. Aligned with workforce training and development;
    - 34.3. Developed in close consultation with the professions and consumers;
    - 34.4. Taking into account the lead time of 2-5 years for starting an operational service.
35. Services should be planned to operate with 10% additional capacity such that surges in demand can be met without increasing the waiting times for treatment.
36. Development of sustainable fellowship programs for Radiation Oncologists must be a key priority to ensure the development of important clinical and research skills.
37. Develop workforce strategies offering enhanced career pathways for Radiation Therapists (RT):
    - 37.1. Support advanced practice and role evolution for RTs;
    - 37.2. Explore assistant roles in radiotherapy.
38. The Radiation Oncology Medical Physicists (ROMP) workforce crisis requires an urgent and multi-faceted response:
    - 38.1. Australia must have a nationally self-sufficient ROMP workforce by 2022;
    - 38.2. support promotion of a physics career to school students and undergraduates;
    - 38.3. increase and streamline funding for TEAP positions, and embed into the radiation oncology workforce profile;
    - 38.4. strengthen recruitment strategies to attract and retain the ROMP workforce;
    - 38.5. urgently develop innovative models of service provision that do not compromise quality;
    - 38.6. a national workforce summit must be held by June 2013 to get consensus on the implementation of workforce solutions.
39. Develop plans to support professionals returning to full-time and part-time work.

Workforce training is aligned with service demand projections and supported appropriately

40. Governments to match the funding contracts for training positions in both public and private accredited facilities to the length of the training programs.
41. Accreditation and training processes that allow for:
    - 41.1. Increased trainee numbers in the three key professional areas i.e. Radiation Oncology, Radiation Therapy and Radiation Oncology Medical Physicists;
    - 41.2. Embedded funding for clinical supervisors, preceptors and training network coordinators to adequately support the training programs; and
    - 41.3. Continued professional education and development for those in the workforce;
    - 41.4. Support of training in rural and regional areas.
42. To establish innovative models of training such as:
    - 42.1. Virtual and simulated learning programs;
    - 42.2. Nationally coordinated training networks to enable optimal utilisation of resources.

A National Cancer Action Plan which includes radiation oncology is adopted

43. There needs to be a National Cancer Action Plan developed, implemented and maintained for Australia:
    - 43.1. In consultation with the professions and consumers;
    - 43.2. Encompassing radiation oncology as a core element of quality cancer care.

Jurisdictional radiation oncology action plans are developed, maintained and integrated with the National Cancer Action Plan

44. Jurisdictions must develop, regularly review, evaluate and update 5-year action plans for radiation oncology and these must be coordinated nationally.
45. Financing options for establishing and resourcing services should be explored and must ensure access to radiation oncology services is safeguarded;
46. To ensure that infrastructure is used efficiently:
    - 46.1. Business process review must be undertaken regularly;
    - 46.2. Business process improvement must be part of standard practice;

Closer consultative collaboration between governments, policy-makers, service providers, patients and the professions to ensure most effective use of resources

47. Establish and strengthen radiation oncology networks where smaller centres are linked to major centres.
48. The existing national ROHPG capital replacement program must be maintained and regularly updated to reflect changes in radiation oncology practice.

Innovative models of quality service provision are developed to improve efficiencies

49. There should be ongoing horizon scanning for new radiotherapy techniques and technologies, to inform facilities planning;
50. Essential role of imaging in radiation oncology must be acknowledged:
    - 50.1. Regulatory constraints such as licensing must be remedied;
    - 50.2. Training and expertise of professionals must be enhanced;
    - 50.3. Funding for planning and treatment of patients must support evidence-based practice;
    - 50.4. The role of the Diagnostic Imaging Medical Physicists needs to be recognised and supported.
51. The use of essential radiotherapy techniques must align with best practice:
    - 51.1. At least 30% of radiotherapy patients should receive IMRT treatments;
    - 51.2. Benchmarks for other essential radiotherapy techniques should be developed and services should publicly report against these.

Appendix I – Workforce Projections by Jurisdiction

Radiation oncologist workforce

	2012			2017			2022		
	supply	demand	shortfall	supply	demand	shortfall	supply	demand	shortfall
NSW	85.4	98.1	12.7	124.3	139.7	15.4	165.2	182.3	17.2
VIC	79.0	79.7	0.7	114.9	99.3	-15.6	152.7	129.6	-23.1
QLD	51.0	58.4	7.4	74.2	80.8	6.6	98.6	105.4	6.8
SA	17.0	25.6	8.6	24.7	33.8	9.0	32.8	44.1	11.2
WA	9.4	35.6	26.2	13.7	37.7	23.9	18.2	49.2	30.9
TAS	6.6	8.1	1.5	9.6	10.9	1.4	12.7	14.3	1.5
NT	1.5	0.3	-1.2	2.2	2.1	-0.1	3.0	2.8	-0.2
ACT	7.7	6.6	-1.1	11.2	5.3	-5.9	14.8	6.9	-7.9
AUS	*258.6*	*311.4*	*52.8*	*375.8*	*409.5*	*33.6*	*499.0*	*534.6*	*35.5*

Radiation Therapist workforce

	2012			2017			2022		
	supply	demand	shortfall	supply	demand	shortfall	supply	demand	shortfall
NSW	476.3	490.5	14.2	599.1	698.3	99.2	702.9	911.7	208.8
VIC	380.6	398.3	17.7	478.6	496.4	17.7	561.6	648.0	86.4
QLD	317.6	292.1	-25.5	399.4	403.8	4.4	468.6	527.2	58.5
SA	99.8	128.1	28.3	125.5	168.8	43.3	147.2	220.3	73.1
WA	74.7	178.1	103.5	93.9	188.3	94.4	110.2	245.8	135.6
TAS	50.6	40.3	-10.3	63.6	54.7	-9.0	74.6	71.4	-3.3
NT	8.5	1.6	-6.9	10.7	10.7	0.0	12.5	13.9	1.4
ACT	38.8	33.0	-5.8	48.8	26.4	-22.4	57.3	34.5	-22.8
AUS	*1446.8*	*1556.9*	*110.1*	*1819.6*	*2047.3*	*227.7*	*2134.9*	*2672.8*	*537.9*

Radiation Oncology Medical Physicist workforce

	2012			2017			2022		
	supply	demand	shortfall	supply	demand	shortfall	supply	demand	shortfall
NSW	95.4	98.1	2.7	125.6	139.7	14.1	154.0	182.3	28.3
VIC	42.9	79.7	36.7	56.5	99.3	42.8	69.3	129.6	60.3
QLD	25.7	58.4	32.7	33.8	80.8	46.9	41.5	105.4	63.9
SA	17.7	25.6	8.0	23.3	33.8	10.5	28.5	44.1	15.5
WA	8.0	35.6	27.6	10.6	37.7	27.1	13.0	49.2	36.2
TAS	5.4	8.1	2.7	7.0	10.9	3.9	8.6	14.3	5.6
NT	3.2	0.3	-2.9	4.2	2.1	-2.1	5.2	2.8	-2.4
ACT	4.3	6.6	2.3	5.6	5.3	-0.4	6.9	6.9	0.0
AUS	*202.5*	*311.4*	*108.9*	*266.7*	*409.5*	*142.8*	*327.0*	*534.6*	*207.5*

The supply is based on existing workforce with current entrant and attrition trends. The demand is based on radiotherapy utilisation rate of 39.3% in 2012, 45.2% in 2017 and 52.3% in 2022.

Source: The Allen Consulting Group, 2012[7]

***Note regarding the WA data:** An adjustment was made to reflect the 2012 actual data from Western Australia in the above table to account for the one non-responded WA facility in the original data collection process. The Australian total does not reflect the adjusted WA figures to maintain consistency of the data set.*

***Cautionary note about small numbers:** The workforce numbers in some jurisdictions can be very small. Due to a large degree of year-to-year statistical fluctuation in these small numbers, great care should be taken when assessing apparent differences involving small numbers and measures based on small numbers.*

Appendix II – Linacs Age and Features

Linear accelerators across Australia in 2000 and 2010: age and features

	2000[13]	2010[14]
Characteristics	*Percentage*	
By Year of Installation		
>10 years	14.0%	9.0%
>5 to 10 years	39.0%	28.3%
0 to 5 years	40.0%	60.7%
In the survey years	7.0%	2.1%
X-ray Energy		
Dual		88.3%
Single		11.7%
MLC (Multileaf collimation)		
Yes	74.2%	97.2%
No	25.8%	2.1%
No response		0.7%
EPI (Electronic Portal Imaging)		
Yes	79.6%	92.4%
No	20.4%	5.5%
No response		2.1%
R&V (Record and Verify)		
Yes	91.4%	94.5%
No	8.6%	2.8%
No response		2.8%
IMRT Capable (Intensity Modulated Radiation Therapy)		
Yes		84.8%
No		15.2%
Cone Beam CT		
Yes		39.3%
No		58.6%
No response		2.1%
Tertiary Imaging/online correction		
Yes		63.4%
No		29.0%
No response		7.6%
VMAT Capable (Volumetric Modulation Arc Therapy)		
Yes		24.1%
No		73.8%
No response		2.1%

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