The Royal Australian
and New Zealand
College of Radiologists®

The Faculty of Radiation Oncology

FACILITIES SURVEY REPORT: INSIGHTS AND TRENDS FROM 2010-2020

AUSTRALIA

FACULTY OF RADIATION ONCOLOGY

KEY TRENDS

1 INCREASINGLY COMPLEX TREATMENT

30%

Radiation therapy treatments have become more complex with the use of IMRT and stereotactic treatments increasing by around 30% per year (*figure 20, table 1*). In 2010 these treatments made up 7.2% of courses, in 2020 it was 72%.

2 SHORTER COURSE LENGTH

In keeping with changing evidence-based practice in delivering shorter courses (hypofractionation), as well as the uptake in stereotactic treatments – it is not surprising that there has been a reduction in the length of the average course of treatment. What is perhaps surprising is that this was relatively modest falling 18.1 to 15.5 (*figure 18*).

3 CHANGING LOCATION OF TREATMENT

2.3 VS 2.8

LINACS PER FACILITY

In 2020 compared to 2010, the average facility was smaller (2.3 vs 2.8 linacs per facility) and more likely to be privately operated (60% vs < 40%). There was also an increasing proportion of treatment delivered outside of major cities (21% vs 16%) (*figures 8 and 16*).

4 MORE (BUT AGEING) TREATMENT EQUIPMENT

7 LINACS PER MILLION POPULATION

There has been a steady and appropriate increase in the number of linacs in all states and nationally. The disparity between states in 2011 has largely disappeared and all states now have at least 7 linacs per million population (*figure 9 and or 10*) which is similar to most western European countries. However the age profile of machines has deteriorated slightly with the proportion of older machines higher than ideal in 2020 (*figure 11*).[4]

5 WORKLOAD INCREASING FASTER THAN WORKFORCE

INCREASED BY 55% OVER THE 10 YEAR PERIOD

The total number of courses delivered increased by 55% over the 10 year period (*figure 14*). Taking into account population changes all states (except Tasmania) increased courses of treatment with less variation between states (*figure 15*). However the rise in full time equivalent radiation oncologists was much smaller in this time frame – with an absolute reduction between 2019 and 2021 (*figure 26*) meaning an increase in average annual caseload of 23.5% (237.1 to 293).

6 REDUCING USE OF BRACHYTHERAPY

In contrast to external beam radiation therapy use of brachytherapy has fallen. This is true with brachytherapy for both gynaecological (*figure 22*) and prostate (*figure 23*) cancers – and is not easily explained by changes in evidence based practice.

RANZCR RECOMMENDATIONS

1. Create a working group to investigate the collapse of brachytherapy in Australia with a view to suggesting strategies to reverse or at least mitigate this trend.

2. Use this data to advocate for a funding model that reflects the changing delivery patterns of radiation therapy in both complexity and course length to ensure that they both value the work required to deliver treatment and do not inadvertently disincentivise modern evidence-based approaches.

3. Ensure that both providers and funders recognise the need to maintain a funding stream that enables and encourages timely replacement of ageing equipment as well as necessary expansion in numbers.

4. Monitor the trends in course complexity and course numbers with respect to staff levels in various craft groups to ensure that staffing levels keep up with ever increasing workload demands.

5. Encourage involvement in education and research in the increasing number of private, regional and smaller treatment centres.

FOREWORD AND ACKNOWLEDGEMENTS

The Faculty of Radiation Oncology's (FRO) Economics and Workforce Committee (EWC) are delighted to present the **Facilities Survey Report: Insight and Trends from 2010-2020, Australia.**

The Facilities Survey is a biennial survey designed to assess the resources available at radiation therapy facilities, with the aim of ensuring that high-quality radiation oncology services can be provided. This report analyses and presents the findings from the 2021 Facilities Survey with reference to data from all surveys since 2011.

The College sets, promotes and continuously improves the standards of training and practice in radiation oncology and clinical radiology for the betterment of the people of Australia and New Zealand. The College aims to influence policy and promote appropriate economic conditions and workforce supply, to encourage and support excellence in practice and patient care.

Data from these surveys provide an understanding of existing services and trends and enable benchmarking. This data is important to FRO's planning and advocacy initiatives which are aimed at ensuring there are adequate resources for the provision of high-quality radiation oncology services.

Acknowledgements

The EWC is grateful to Dr Sarat Chander under whose Chairmanship of the EWC, most of the work on this survey took place. All past and current members of the EWC and its predecessors have made contributions to the data and knowledge base. In particular, a special thank you is extended to A/Prof Hien Le, for his work on the initial draft of this report. Special acknowledgement is given to Ms Natalia Vukolova, Ms Sonja Cronjé, Ms Legend Lee, Mr Phil Munro, Ms Sandra Keogh, and Mr Tan Nguyen for their work on the Facilities Survey over the years. We are particularly grateful for the assistance of Dr Gerry Adams, Dean, Faculty of Radiation Oncology, Mr Nishant Gupta, Economics and Workforce Analyst at RANZCR, Ms Sara Hughes, Manager, Policy Development and other RANZCR staff; particularly Dr Brendan Grabau, General Manager, Specialty Training Unit and Ms Melissa Doyle, General Manager, Policy, Advocacy and Faculties for their supervisory support.

We are thankful for the unwavering support of the staff at radiation therapy treatment centres in New Zealand and Australia who played an indispensable role in making this Facilities Survey report: Insights and Trends from 2010-2020 possible.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

This report provides a comprehensive analysis of the current state of radiation oncology, identifying several key trends and challenges in the field.

One of the most significant trends observed in the radiation oncology facilities survey is the stagnation in brachytherapy services which are vital for effective cancer treatment. While external beam radiation therapy (EBRT) has grown, brachytherapy usage has dropped. Notably, prostate brachytherapy has experienced a decline which has worsened since 2017. This fall is unlikely to be due to changes in evidence-based practice alone. Reasons are likely to be complex and beyond the scope of this document. However, the rise in popularity in stereotactic treatments as well as changes in funding models such as the removal of brachytherapy from Radiation Oncology Health Program Grant (ROHPG) scheme could well be factors. This report suggests that further analysis is needed to understand the causes and implications of this trend. In response, a brachytherapy working group to investigate this trend further and determine appropriate interventions has been commissioned by EWC.

The report highlights the growing number of radiation therapy facilities and linear accelerators (LINACs), which has led to improved patient access to treatment. It is noteworthy that the data indicates a significantly higher growth rate in privately owned radiation therapy facilities in Australia, which increased from 18 to 60 facilities since 2011. In contrast, the publicly owned facilities witnessed a slower growth from 31 to 40 facilities during the same period.

The growth in number of radiation therapy facilities and LINACs has been more pronounced in metropolitan areas. While there has been some redistribution – with 21% of courses being delivered in non-urban locations in 2020 compared to only 16% in 2010 (*figure 16*) the fact that 30% of the Australian population live outside major urban (MM1[*]) locations means that gaps persist.[1, 2]

This growth in radiation therapy facilities and LINACs is also reflected by the increase in number of new and retreatment courses as indicated in *Figure 1*.

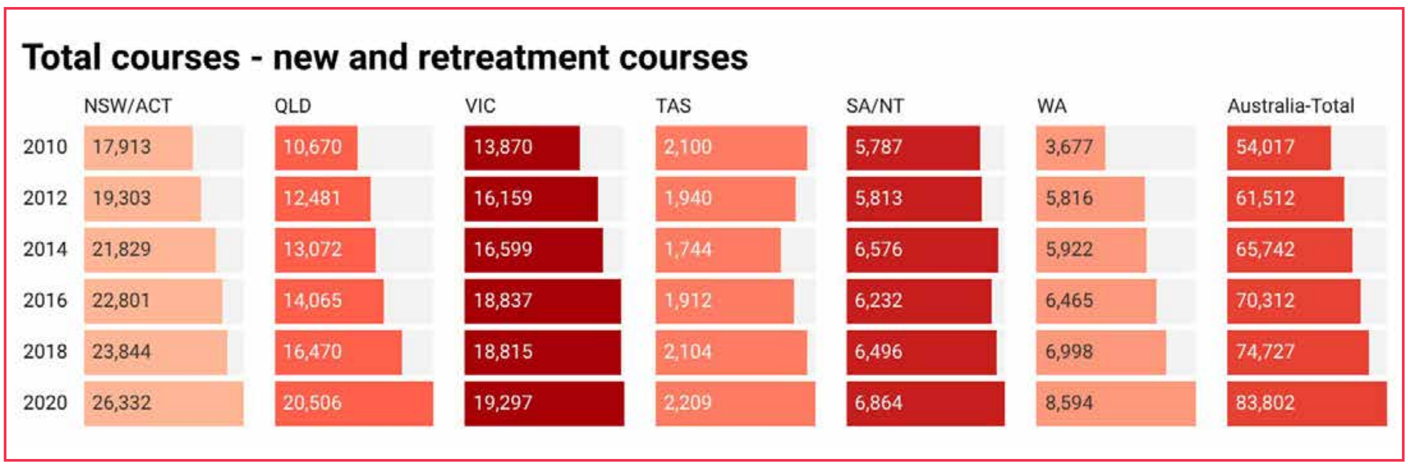

Figure 1: Total Courses- New and Retreatment in Australia

The data presented in *Figure 2* indicates a remarkable increase in the use of intensity-modulated radiation therapy (IMRT) across Australia with a compound annual growth rate (CAGR) of 31.5%. A similar trend was also observed with stereotactic radiosurgery (SRS), stereotactical ablative body radiation therapy (SABR), and stereotactic body radiation therapy (SBRT) collectively, while other megavoltage (such as 3D conformal and electron therapy) treatment took a dip by 7.5% CAGR.

[*] The Modified Monash Model (MMM) categorises locations on a scale from MM1 (major metropolitan city) to MM7 (very remote) based on remoteness and population size.[22]

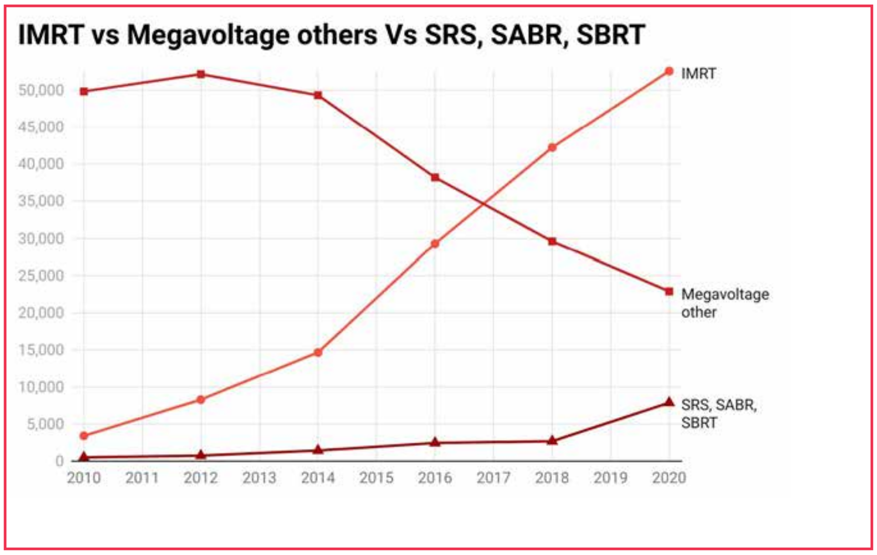

Figure 2: Trends in reported number of different Treatment Types

The report also presents data on LINAC density in 2011 and 2021 as shown in *Figures 3, 4* and *5*, providing valuable insights into the availability of equipment for radiation therapy. The past decade saw a significant increase in both the number of LINACs and radiation therapy facilities across Australia from 145 to 233 and 51 to 100 respectively. The average LINAC per facility decreased from 2.8 in 2011 to 2.3 in 2021.

The 2021 survey data shows that around 43% of LINACs in Australia will need to be replaced shortly. The percentage of newer equipment has declined from 72% in 2011 to 57% in 2021, however it is still within the ideal percentage for newer machines.

Given the current data it can be said that the last decade has shown a great increase in the amount of equipment available to treat patients however in the near future it is important to ensure that adequate funding is available to replace a significant proportion of the fleet.

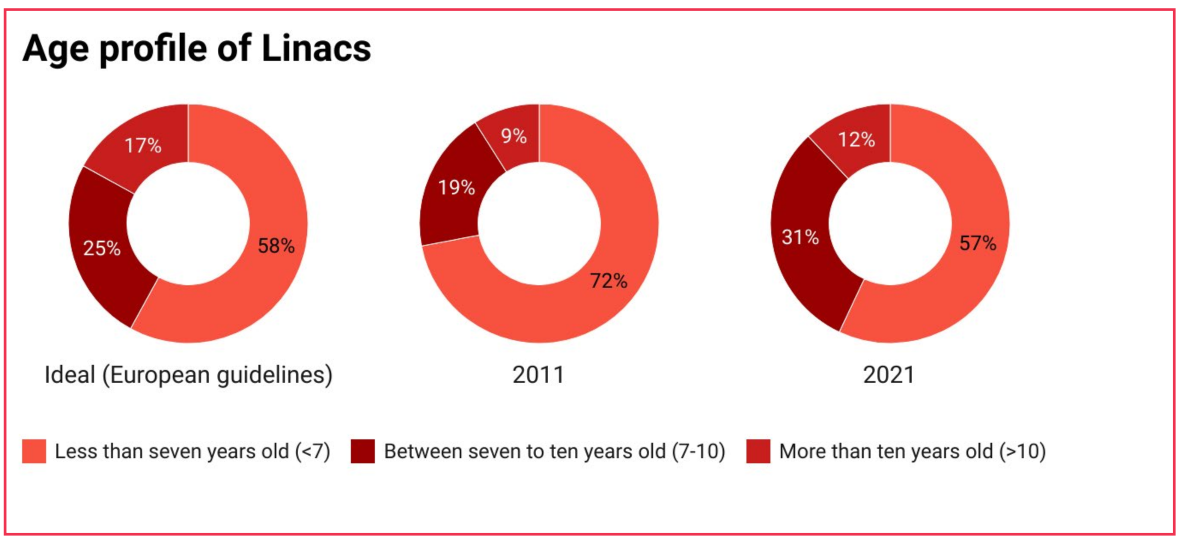

Figure 3: Comparison of LINACs in 2011 and 2021 based on COCIR recommendation for ideal age profile of LINAC[4]

Total courses per 100,000 population

	NSW/ACT	QLD	VIC	TAS	SA/NT	WA	AUS
2010	234.6	234.6	248.3	412.3	307.8	158.7	240.3
2020	308.5	395	294	390.6	335.5	314.6	326.9

Figure 4: Comparison of recorded total courses per 100,000 population in 2010 and 2020[5]

Linac per million population

	NSW/ACT	QLD	VIC	TAS	SA/NT	WA	AUS
2011	6.8	6.0	6.6	9.8	8.5	3.4	6.4
2021	9.4	10.1	8.2	14.0	8.3	7.6	9.0

Figure 5: Comparison of recorded LINAC per million population in 2010 and 2021[4]

In keeping with the historical format of the survey, treatment data for the 2021 survey reflects treatments from January to December 2020 while equipment and staffing data were as of 31 March 2021. Despite minimal impact on treatment numbers in calendar year 2020 compared to 2018, there was a noticeable decrease in staffing between March 2019 and March 2021, which may be attributed to temporal variations. Notably, there was a clear decline in the number of radiation oncologist full-time equivalents (FTEs), marking the first instance of such a trend. This decline is likely influenced by expected retirement, early retirement in the Covid-19 peak, limited new entries due to cancelled exams, and the potential exit of international medical graduates (IMGs) from the workforce. If so, these trends may well course correct in the 2023 survey. However other cultural trends such as a general desire for a better work life balance with more less than full time workers and a trend to exit the workforce at an earlier age may also be true. To address the situation effectively, it is essential to closely monitor the responses to the 2022 Workforce Census and the 2023 Facilities Survey. Failure to rebound from the net workforce loss between 2019 and 2021 may lead to an increased risk of burnout among radiation oncologists as there is no doubt treatment rates will continue to rise. If the 2021 workforce trends persist we will need to analyse more closely as this may need to alter how we train (and how many we train) for the next generation.

Radiation oncology relies on the contributions of new generation workforce participants across all disciplines, so patients can access new and improved methods of treatment. As more patients receive treatment in smaller suburban, regional, and rural centres, this lack of growth in staffing poses risks to quality and safety, and highlights workforce pressures. While the change in rural and regional access may be beneficial for patients, it presents a novel challenge to training and research that reflects the realities of the field. With the changing complexity and fast-paced nature of the industry, investment in training and research is critical to address these issues.

Additionally, the increasing complexity of radiation oncology demands advanced training and education for practitioners to ensure they are well-equipped to provide the best possible care to patients. Prioritising training and research opportunities remains critical to prepare future generations of the workforce to meet the evolving demands of the field.

INTRODUCTION AND BACKGROUND

In 1986, the Royal Australian and New Zealand College of Radiologists (RANZCR) conducted national surveys of radiation oncology units in Australia to gather data on the facilities and workforce [3]. The surveys were carried out again in 1999, and since 2011, the RANZCR Faculty of Radiation Oncology (FRO) has been conducting biennial surveys that also include New Zealand. Apart from one small centre that failed to return data in 2021, there has been a 100% response rate from facilities since 2013. These surveys aim to provide insights into radiation facilities, equipment, workforce, and treatment activities at each site and help set criteria to improve the delivery of radiation oncology services in both countries.

The FRO Economics and Workforce Committee (EWC) designs the survey questions. The principle has been to maintain a consistent set of questions over time which allows comparison of data, but also allows for slight adjustment by the EWC through each survey to ensure their continuing relevance. We aim to return to 100% response rates with the next survey in 2023, with thanks to the continuing support of all centres and FRO members.

It is inevitable that terminology changes over time. For the purpose of analysis SRS (stereotactic radiosurgery) represents single fraction treatments as well as fractionated intracranial treatment that have become more prevalent over the decade. Similarly, the terms stereotactic body radiation therapy (SBRT) and stereotactic ablative body radiation therapy (SABR) have both been used. Given that these are all advanced techniques of similar complexity we have analaysed as one group (SRS, SABR, SBRT).

The data collected by the survey is critical to the FRO's advocacy efforts and helps the Faculty develop a comprehensive database of physical and human resources available in Australia and New Zealand, as well as trends in treatment activities. Aggregated data from these surveys have informed key FRO projects, including the development of the Tripartite National Strategic Plan for Radiation Oncology 2012-2022, workforce and infrastructure projections, radiation therapy techniques and technologies Horizon Scan development, and the Faculty's advocacy work around the Medicare Benefits Schedule (MBS) review and the New Zealand Health and Disability system review. We also welcome its use in any other forms of scientific research.

RESULTS AND ANALYSIS

The biennial Facilities Survey serves as a snapshot of equipment, treatment, and workforce of all radiation therapy facilities in Australia and New Zealand. The survey is reviewed and developed by the Faculty of Radiation Oncology Economics and Workforce Committee. This paper reports on trends within the Australian radiation oncology sector, particularly regarding facilities, equipment, treatment, and workforce.

The survey is divided into six separate parts, each dealing with a different aspect of the radiation oncology facility. Please refer to Appendix B for the 2021 Facilities Survey template. The six parts are:

1) Details of megavoltage equipment
2) Details of other equipment
3) Megavoltage treatment activity
4) Other treatment activity
5) Staffing – Radiation Oncologists
6) Staffing - Other

Data collected for Equipment and Workforce were as of 31 March of the survey year (e.g. 2021) and treatment data were by the whole of the previous calendar year (e.g. 2020). The survey data presented in this report was for years 2011 to 2021. To ensure confidentiality of facilities providing data, some jurisdictions have been combined: New South Wales (NSW) and the Australian Capital Territory (ACT); and South Australia (SA) and the Northern Territory (NT). Because of this requirement for centre confidentiality some subgroup analysis such as public/private make up by state or metro vs regional make up per state is not possible. Appendix A covers the detailed methodology that goes towards designing the Facilities Survey. It should be noted that due to the rounding of data, some percentages may not sum to exactly 100%.

The results are divided into 4 sections with preliminary analysis in each section for ease of reading. The sections are:

1. Facilities
2. Equipment
3. Treatment
4. Staffing

1. FACILITIES

Based on *Figure 6*, there has been a significant expansion in the number of radiation therapy facilities in Australia since 2011. The data indicates a 98% increase from 51 facilities in 2011 to 101 facilities in 2021. Notably, the most rapid growth occurred between 2013 and 2015, when the number of facilities rose from 57 to 74 and continued to increase to 94 in 2019. Please note that nonresponding facilities are not reported in the data. As stated previously from our various sources we are confident that the only missing facility is one small centre that declined to return data in 2021 – which we believe will have little impact on the described data and trends.

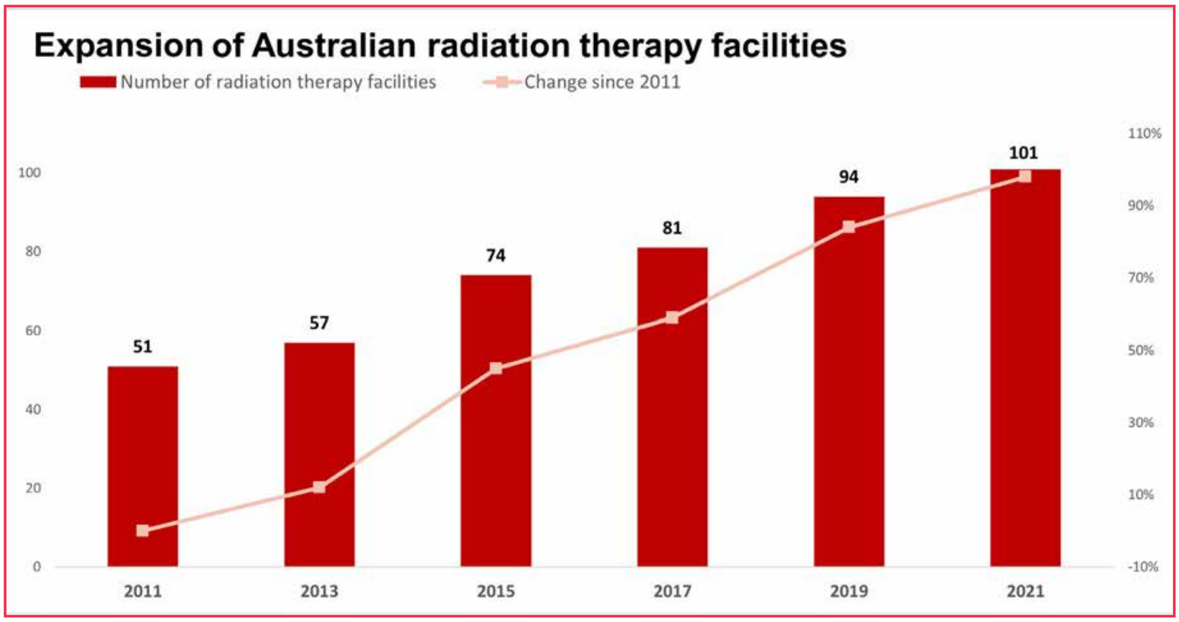

Figure 6: Expansion of Australian radiation therapy facilities

Figure 7 highlights the state-level trends in the number of radiation therapy facilities across Australia since 2011. The data reveals that WA and QLD experienced the most significant growth in the number of facilities over the 10-year period (2011-2021). WA saw a notable increase from 2 facilities in 2011 to 9 facilities in 2021, representing a CAGR of 16%. QLD also demonstrated significant growth, with the number of facilities rising from 7 in 2011 to 24 in 2021, representing a CAGR of 13%. In contrast, NSW (including the ACT) had the smallest growth over the 10-year period with an increase of 10 facilities, representing a CAGR of approximately 4%.

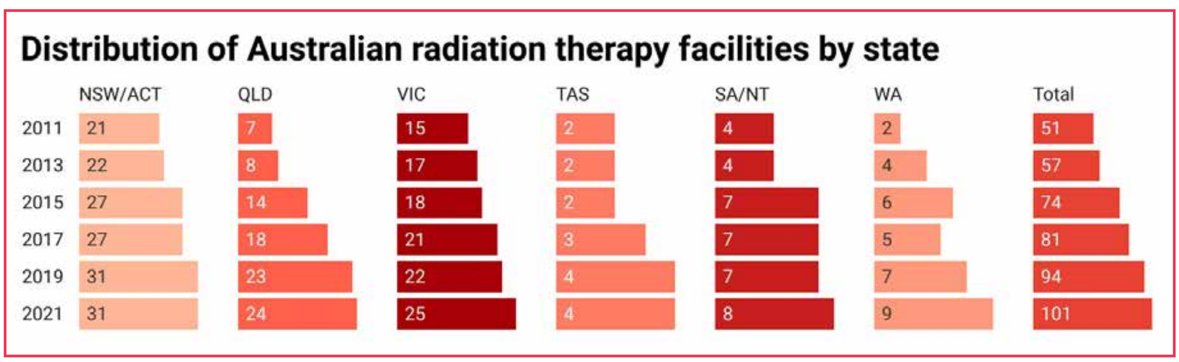

Figure 7: Distribution of Australian radiation therapy facilities by State

As depicted in *Figure 8*, analysis indicates a greater rate of increase in the number of privately owned radiation therapy facilities in Australia since 2011 (CAGR 13% over the 10-year period, from 18 to 60) compared to a 3% increase in public ownership (31 to 40 facilities). It is important to note that in 2011 two (4%) of the radiation therapy facilities were under a third category of 'Public/Private' which does not exist as an option in the recent surveys.

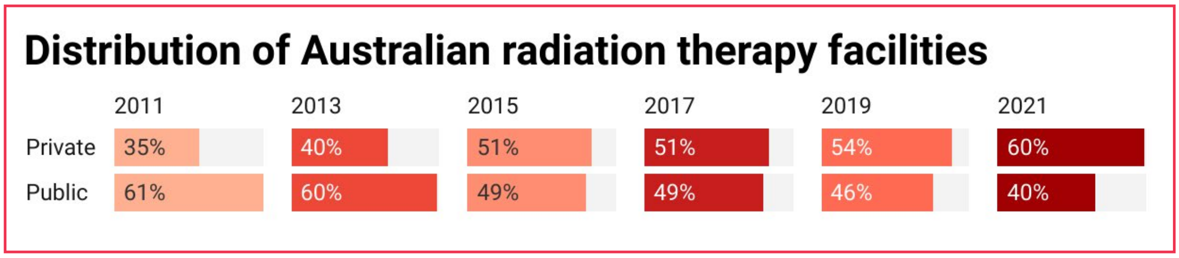

Figure 8: Distribution of Australian radiation therapy facilities by ownership

The data also explored the growth of radiation therapy facilities under different Modified Monash (MM) Models area of classifications. While locations are classified MM1-7 in reality only MM1 (major cities) MM2 (locations within 20km of towns with populations of 50,000) and MM3 (within 15km of populations 15,000-50,000) are relevant as there are currently no facilities in smaller communities. There was a significant increase in the number of facilities across all MM areas with a CAGR of 7% over the 10-year period in MM1, and 5.9% and 8.2% in MM2 and MM3 respectively.

2. EQUIPMENT

In the past decade, there has been a significant increase in both the number of LINACs and radiation therapy facilities across Australia. The number of LINACs has grown by a CAGR of 5% between 2011 and 2021, with the largest growth occurring in WA (10%) and QLD (7%). There has been minimal change in the absolute number of LINACs in SA/NT despite the increased number of facilities. As indicated in *Figure 10*, when the LINAC number is analysed relative to population these different patterns of change in number in different states reflect different baselines and population shifts. So while SA/NT is the only region where the LINAC density fell this was from a higher base line than most and in 2021 there was a much more even distribution with all regions having more than 7.1 LINACs per million population which was the western European average in 2019[4].

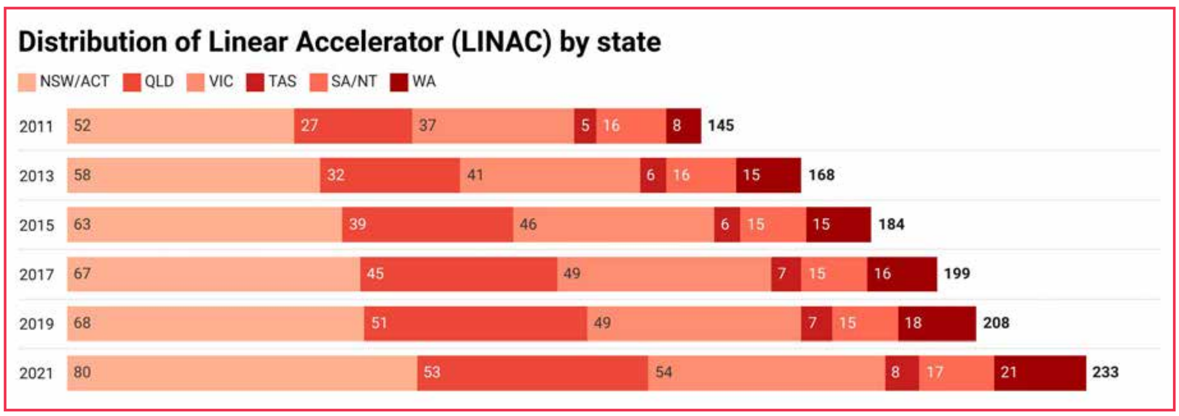

Figure 9: Distribution of Linear Accelerator (LINAC) in Australia

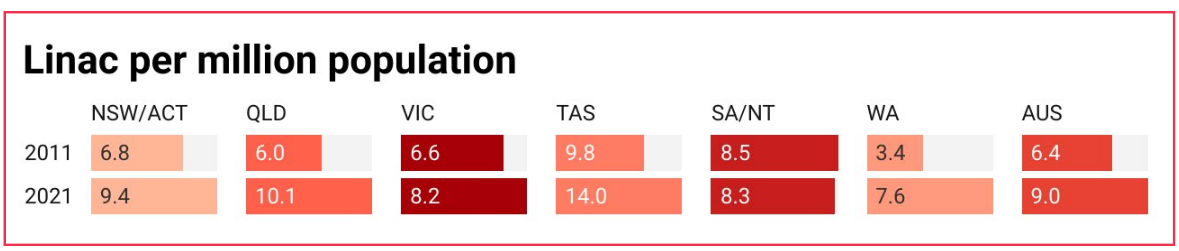

Figure 10: Comparison of recorded LINAC per million population in 2010 and 2020[4]

The 2021 survey data shows that a significant number of LINACs (around 43%) in Australia have reached or will shortly reach an age where they should ideally be replaced[4]. Although still a reasonable age profile, this has deteriorated over the decade and should be monitored.

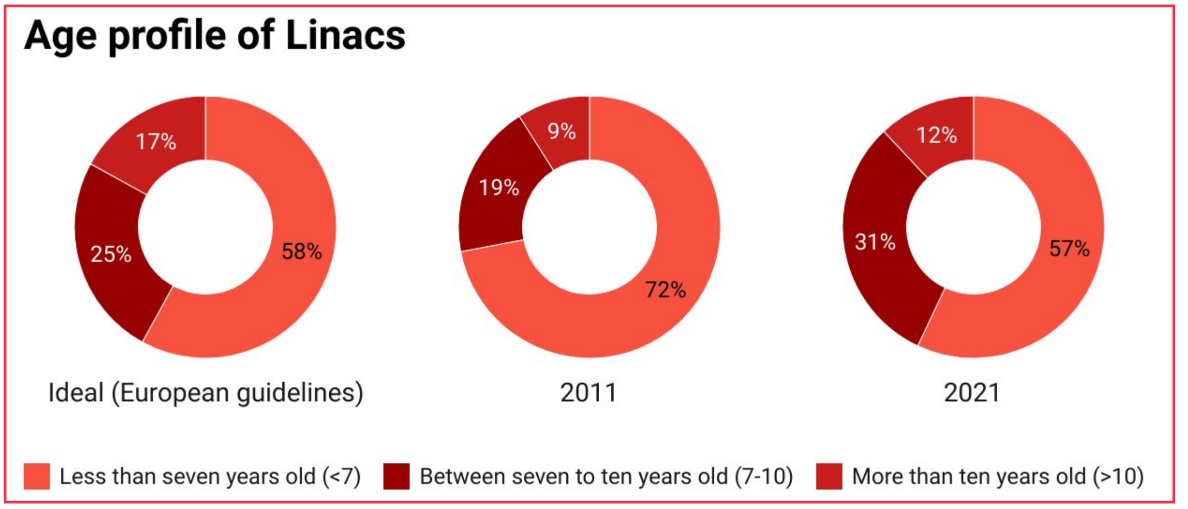

Figure 11: Comparison of LINACs in 2011 and 2021 based on COCIR recommendation for ideal age profile of LINAC[4]

The data reveals that in 2011 seven (14%) surveyed facilities had five or more LINACs, whereas 61% had two or fewer. In 2021, while the absolute number of centres with five or more LINACs had increased to nine (9%) facilities reported having five or more LINACs, while 69% reported having two or fewer. This change in the pattern of facility size means that on an average, each radiation therapy facility has 2.3 LINACs which is a decrease from an average of 2.8 per facility in 2011.

Figure 12 highlights the growth in number of LINACs across Australia under different population areas, accounting to CAGRs of 5% (MM1), 4% (MM2) and 8% (MM3). Although there has been an increase in regional areas, the growth is still less than metropolitan areas.

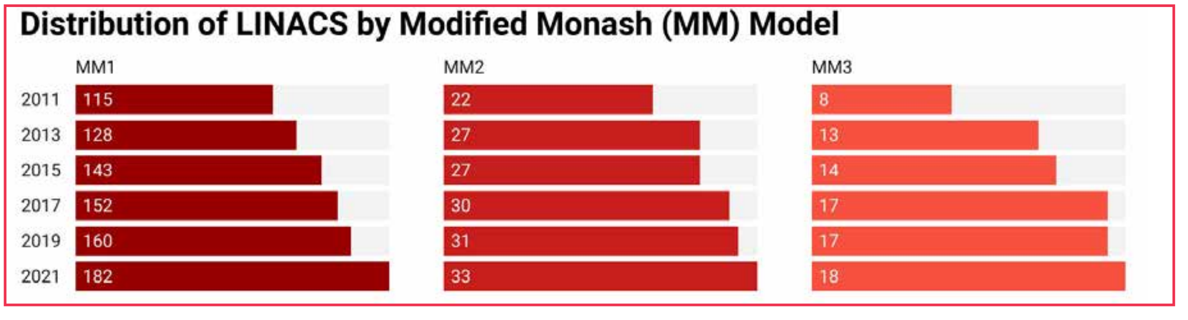

Figure 12: Distribution of Linear Accelerator (LINAC) by Modified Monash Models

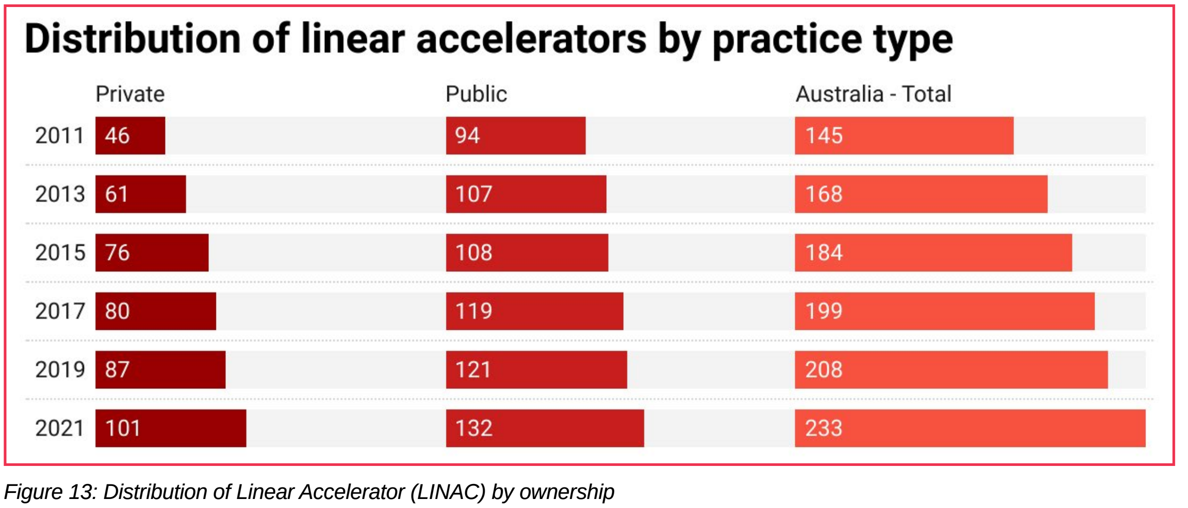

Figure 13: Distribution of Linear Accelerator (LINAC) by ownership
**The total Australia LINAC in 2011 includes 5 LINAC of Public/Private type.*

Figure 13 provides an overview of the ownership distribution of LINACs. Since 2011, there has been a significant increase in the number of LINACs under both private and public ownership. While the CAGR of LINACs under private ownership has been higher (8%), the public sector still has more LINACs with a CAGR of 3%.

Since 2017, survey recipients have been asked to provide information on the status of bunkers, including the number of currently unoccupied bunkers and the anticipated installation year. In 2017, the survey reported a total of 36 unoccupied bunkers, 10 of which specified a planned installation year. In 2019, the number of unoccupied bunkers rose to 54, with 19 specifying a designated installation year. By 2021, the count of unoccupied bunkers decreased to 17, and all of them had a planned installation year specified.

3. TREATMENT

a. External Beam Radiation Therapy

The data from *Figure 14* shows that between 2010 and 2020, there was an increase in the number of treatment courses across all jurisdictions in Australia, denoting a CAGR of 4%. Nationally, the number of treatment courses increased to 83,802 courses which includes new treatments and retreatments. The most significant changes were observed in WA (9% CAGR) and QLD (7% CAGR) which reflects the increases in facilities and LINACs. However, Tasmania (TAS) had only a slight increase accounting to 1% CAGR.

Total courses - new and retreatment courses

	NSW/ACT	QLD	VIC	TAS	SA/NT	WA	Australia-Total
2010	17,913	10,670	13,870	2,100	5,787	3,677	54,017
2012	19,303	12,481	16,159	1,940	5,813	5,816	61,512
2014	21,829	13,072	16,599	1,744	6,576	5,922	65,742
2016	22,801	14,065	18,837	1,912	6,232	6,465	70,312
2018	23,844	16,470	18,815	2,104	6,496	6,998	74,727
2020	26,332	20,506	19,297	2,209	6,864	8,594	83,802

Figure 14: Total courses - new and retreatment in Australia by State

Figure 15 further emphasises the increase in the number of treatment courses across Australia. The recorded total courses per 100,000 population have increased from 240.3 to 326.9 in the past decade[5]. The Australian Institute of Health and Welfare (AIHW) reportable cancer incidence data[6] from 2010 to 2020 reveals a significant increase in the number of cancer incidence across the population. In 2010, there were 119,674 reported cases, with 54,017 courses available, resulting in a rate of 451.4 courses per 1,000 cancer incidences. However, by 2020, the number of reported cancer cases rose to 148,468, and the courses offered increased to 83,802, leading to a rate of 564.4 courses per 1,000 cancer incidences. While this data clearly demonstrates increasing use of radiation in absolute and in population terms – they cannot be used to infer that historical gaps in optimal utility of radiation therapy are closing (see discussion for details , page 23)

Total courses per 100,000 population

	NSW/ACT	QLD	VIC	TAS	SA/NT	WA	AUS
2010	234.6	234.6	248.3	412.3	307.8	158.7	240.3
2020	308.5	395	294	390.6	335.5	314.6	326.9

Figure 15: Comparison of recorded total courses per 100,000 population in 2010 and 2020[5]

The data in *Figure 16* shows that while there was an increase in the proportion of courses delivered in regional areas, there is still likely to be a significant service gap as approximately 70% of the population live in MM1 areas. Out of the 83,802 total courses in 2020, 80% were delivered in MM1 regions, while only 13% and 8% were delivered in MM2 and MM3 respectively.

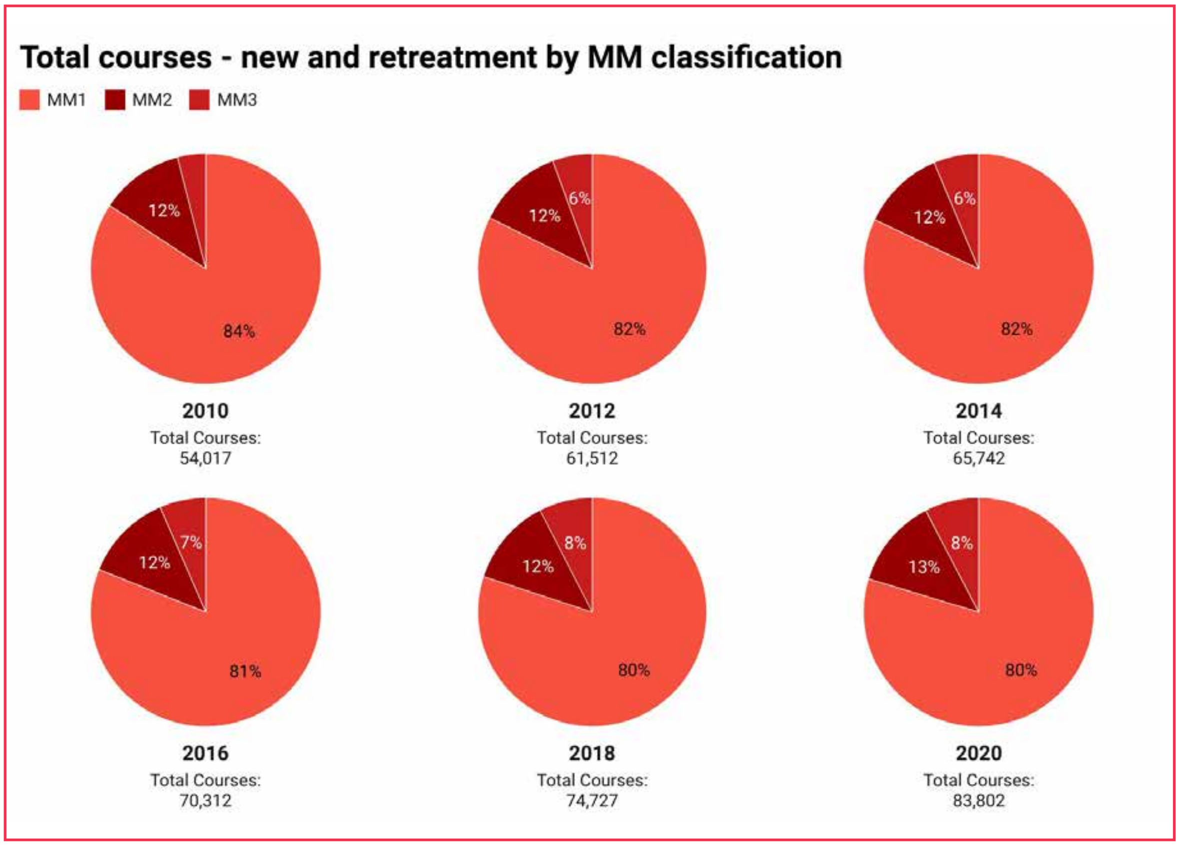

Figure 16: Total courses - new and retreatment by Modified Monash Models
**Note that some percentages may not sum to exactly 100% due to rounding.*

As observed with the number of courses, a similar trend was observed nationally in the case of fractions. There was a rise in the number of fractions (3% CAGR) from 977,858 in 2010 to 1,300,159 in 2020, as shown in *Figure 17*, with WA experiencing the highest growth (7% CAGR). However, Victoria (VIC) and NSW/ACT reported a slight decrease in the number of fractions since 2018, despite reporting an increase in the total number of courses in Australia.

Reported number of fractions

	NSW/ACT	QLD	VIC	TAS	SA/NT	WA	Total fractions
2010	328,478	203,325	252,303	35,563	85,411	72,778	977,858
2012	349,662	225,698	271,631	38,695	102,315	115,429	1,103,430
2014	411,601	245,677	276,976	35,775	106,176	118,069	1,194,274
2016	390,257	249,550	277,770	36,884	136,634	126,481	1,217,576
2018	397,925	282,261	300,221	41,263	107,741	133,245	1,262,656
2020	394,671	313,287	290,706	43,186	109,029	149,280	1,300,159

Figure 17: Total reported number of fractions in Australia by State

The average number of fractions per course in Australia in the last decade has declined from 18.1 to 15.5, according to *Figure 18*. QLD experienced the greatest decrease from 19.1 to 15.3, while WA saw the smallest decrease from 19.8 to 17.4. On the other hand, SA/NT and TAS recorded an increase from 14.8 to 15.9 and 16.9 to 19.6 respectively.

Figure 18 also represents the average number of fractions per course under different MMs. In both MM1 and MM3 the number of fractions decreased by 2.9, while the average number in MM2 dipped – however not as significantly when compared to MM1 or MM3.

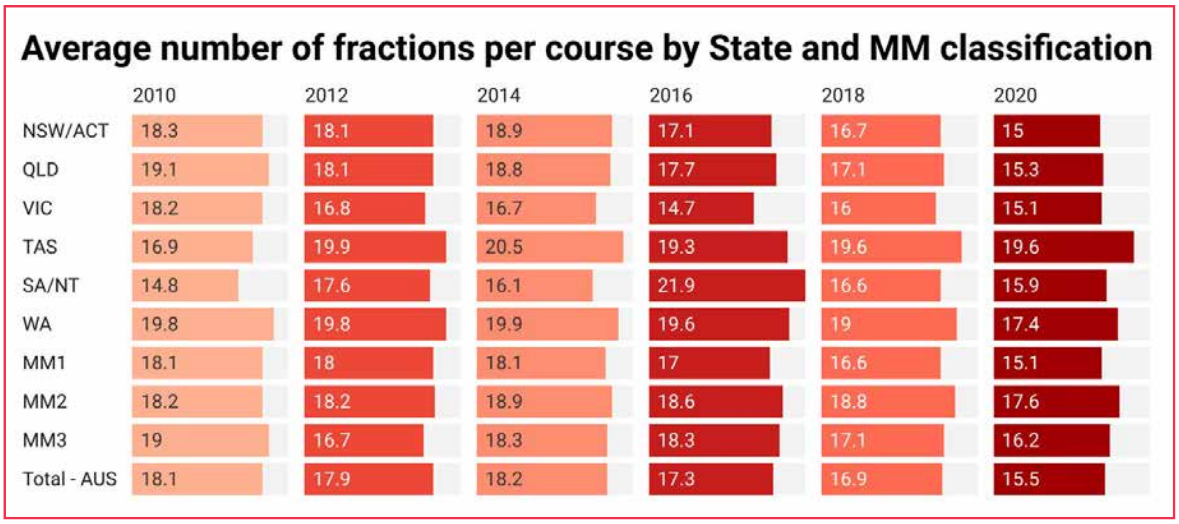

Figure 18: Average number of fractions per course by State and Modified Monash Models

As indicated in *Figure 19*, the workload of LINACs decreased by 2% between 2010 and 2020 despite the increase in LINAC numbers. The average number of courses per LINAC in 2010 was 380.4 compared to 374.1 in 2020.

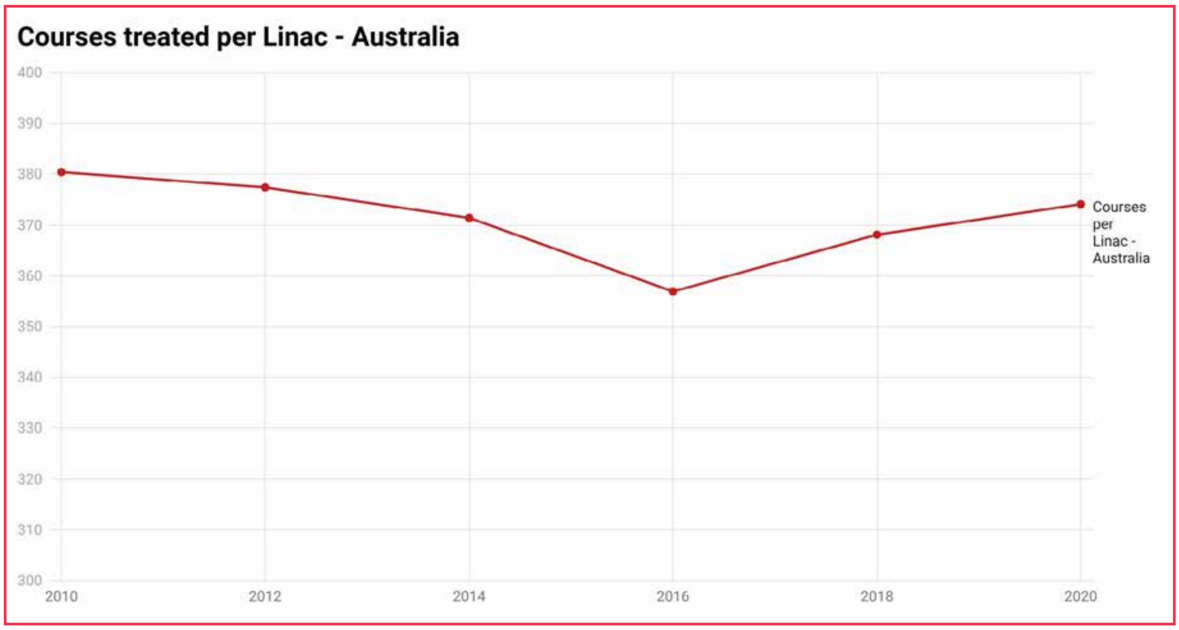

Figure 19: Average number of courses treated per LINAC

The rate of increase in courses and fractions over the past 10 years in regional centres has been greater than the rate of increase in LINACs, while the opposite can be said for metropolitan centres. The number of courses per LINAC has increased in regional centres by 33% (289 to 322 in MM2) and 87.4% (267.3 to 354.6 in MM3) decreasing by 28.8% from 395.8 to 367 in metropolitan centres.

Private centres have experienced a slight increase in workload with the number of courses per LINAC rising from 349.7 to 365.1, while there has been a decrease of 22.3 (from 377.8 to 355.5) in public centres. Variation on case mix (e.g. percentage of stereotactic courses) make detailed analysis of these patterns difficult.

As indicated in *Figure 20* and *Table 1*, there was a significant increase in the use of intensity-modulated radiation therapy (IMRT) across Australia between 2010 and 2020, with a CAGR of 31.5%. A similar trend was also observed with stereotactic radiosurgery (SRS), stereotactical ablative body radiation therapy (SABR), and stereotactic body radiation therapy (SBRT) collectively increased from 508 to 7851, while other megavoltage treatment decreased by 7.5% CAGR.

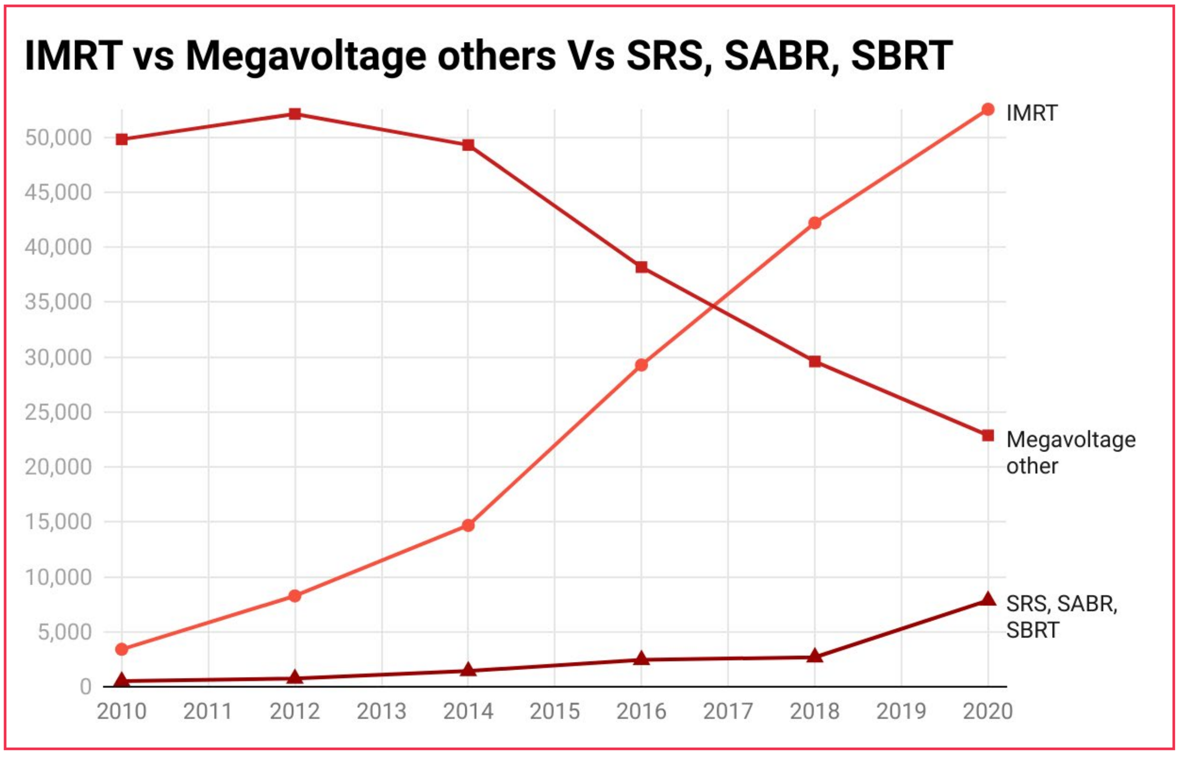

Figure 20: Trends in Reported number of Treatment Types

	Megavoltage						
Australia	**IMRT**	**SRS, SABR, SBRT**	**Megavoltage other**	**Total**	**Superficial**	**Orthovoltage**	**Paediatric**
2010	3,404	508	49,804	54,017	1,628	599	301
2012	8,266	743	52,116	61,512	2,604	816	387
2014	14,687	1,434	49,289	65,742	2,376	1,411	332
2016	29,282	2,450	38,178	70,312	2,047	902	402
2018	42,205	2,683	29,593	74,727	2,283	344	246
2020	52,542	7,851	22,872	83,802	2,379	373	537
10 yrs CAGR	31.50%	31.50%	-7.50%	4.50%	3.90%	-4.60%	6.00%

Table 1: Reported number of treatment types - Australia

b. Brachytherapy

Brachytherapy Courses

Between 2010 and 2016, the number of brachytherapy courses increased from 1,832 to 1,920 across all specialties. However, as depicted in *Figure 21*, brachytherapy numbers have been decreasing since 2018, with the total number of courses decreasing to 1,395 in 2020.

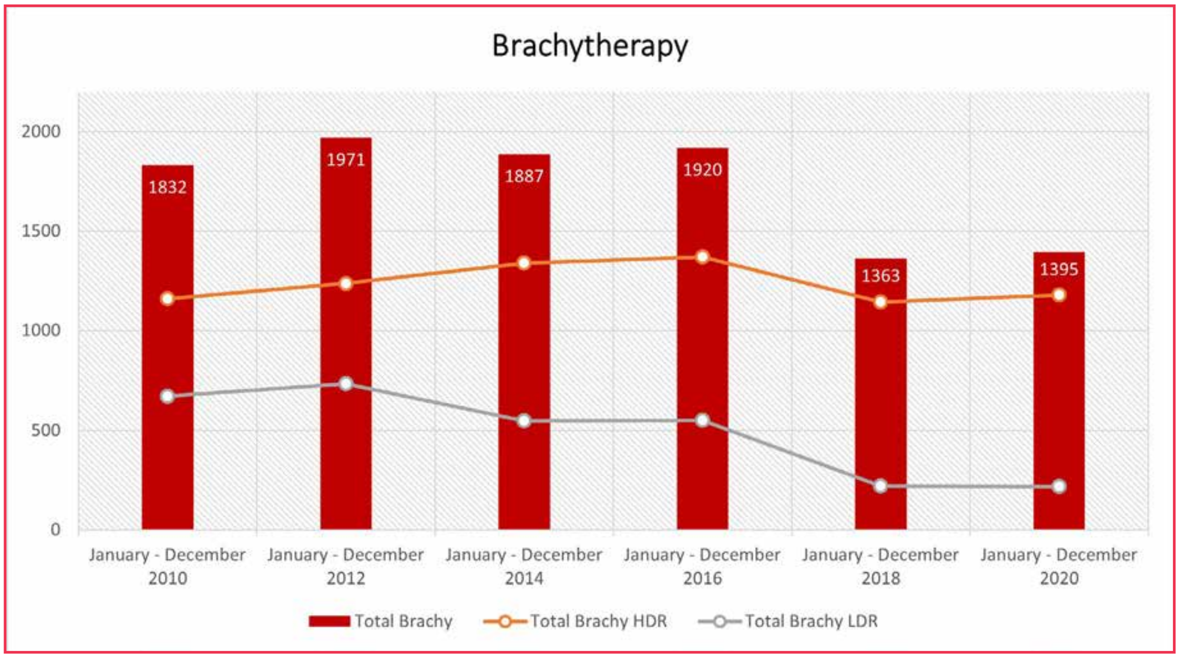

Figure 21: Total Brachytherapy courses in Australia between 2010 and 2020

Table 2 tracks the use of brachytherapy courses across different specialties. Overall, the data indicates a decline in the use of brachytherapy courses in Australia, and particularly highlights the decline in use of brachytherapy to treat prostate cancer.

		PROSTATE				
Year	**Total Brachy**	**HDR**	**LDR**	**GYN**	**GI**	**OTHER**
2010	1,832	450	554	583	24	71
2012	1,971	409	691	725	29	117
2014	1,887	255	517	832	19	182
2016	1,920	381	478	911	21	120
2018	1,363	258	216	785	11	137
2020	1,395	156	165	739	13	250
10 yrs CAGR	-2.7%	-10.1%	-11.4%	2.4%	-5.9%	13.4%

Table 2: Brachytherapy courses across different specialities between 2010 and 2020

As depicted in *Figure 22*, an initial upward trend with a later small decline is observed with brachytherapy courses in gynaecology, amounting to a CAGR of 2.4% (from 583 to 739). However, both HDR and LDR brachytherapy for prostate recorded a dramatic decrease of -10% CAGR and -11% CAGR respectively, as highlighted in *Figure 23*.

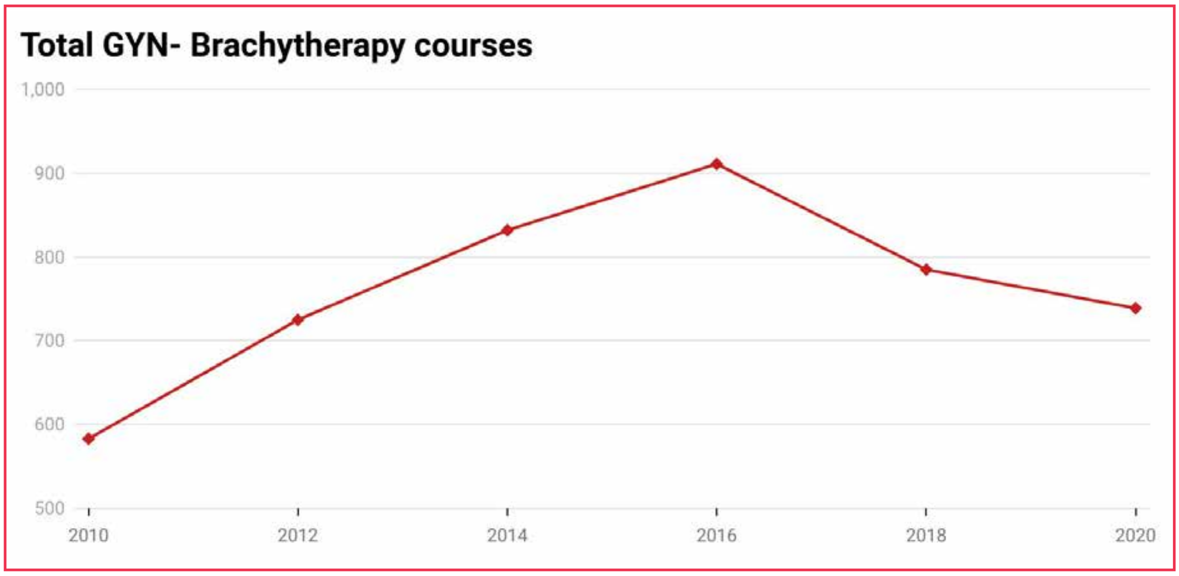

Figure 22: Total Brachytherapy courses in Gynaecology between 2010 and 2020

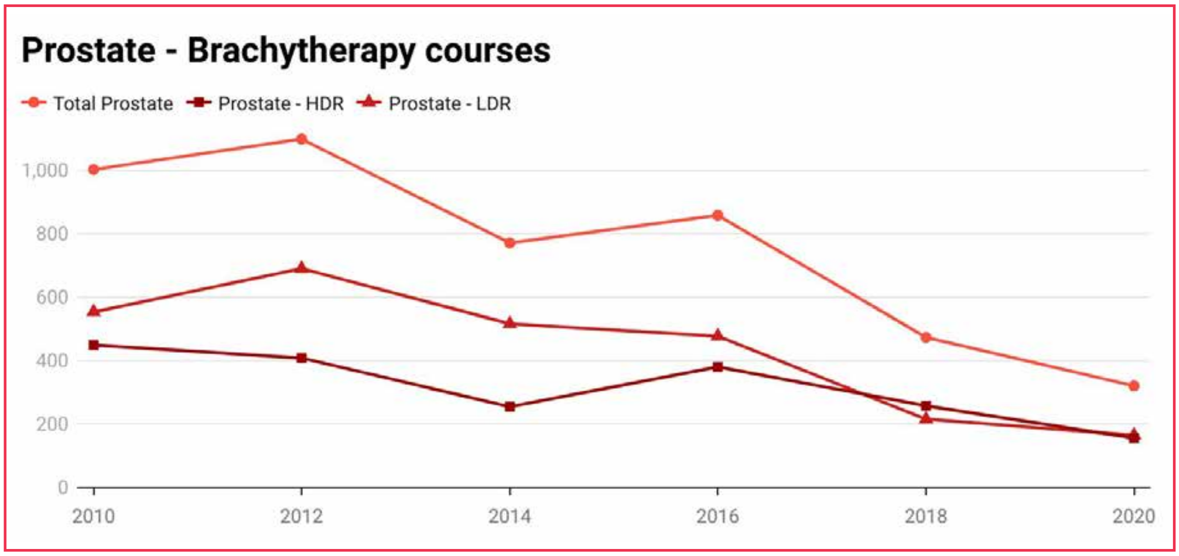

Figure 23: Total Brachytherapy courses in prostate between 2010 and 2020

Brachytherapy Centres-Jurisdictional, Modified Monash Model and Ownership

The total number of brachytherapy centres has increased from 23 to 26 (1% increase) across Australia between 2010 and 2020.

Brachytherapy centres

	NSW/ACT	QLD	SA/NT	TAS	VIC	WA	AUS
2010	12	3	2	0	4	2	23
2012	12	3	3	1	4	2	25
2014	12	4	4	1	5	2	28
2016	14	4	3	1	5	2	29
2018	12	3	3	1	6	2	27
2020	10	4	2	1	6	3	26

Figure 24: Brachytherapy centres between 2010 and 2020

However, *Figure 24* reveals that the growth is fluctuating. There is a steady increase throughout the years 2010 till 2016 (from 23 to 29) which is followed by a dip to 27 (2018) and 26 (2020). The data indicates that the majority number of brachytherapy centres are in NSW.

Figure 25 indicates the distribution of brachytherapy centres under different ownership and MM code between 2010 and 2020. Most centres (24 out of 26) are concentrated in metropolitan regions and are predominantly under public ownership.

Brachytherapy centres under different ownership and MMM classification

	MM1	MM2	MM3	Private	Public
2010	22	1	0	4	18
2012	22	3	0	7	18
2014	24	3	0	13	15
2016	24	3	1	10	19
2018	22	3	1	9	18
2020	24	2	0	8	18

Figure 25: Brachytherapy centres under different ownership and Classification

4. STAFFING

Over the past decade, the disparity in the numbers recorded for radiation oncology staffing has continued to widen between public and private ownership, as well as among the various MM locations, despite the consistent growth in staffing.

a. Radiation Oncologists

As depicted in *Figure 26*, the number of FTE radiation oncologists in Australia increased steadily from 227.8 FTE (2011) to 310.4 FTE (2019). However, this number dropped to 286 FTE in 2021.

It is worth noting that some data collected in 2011 may be inaccurate due to incomplete responses, however this is unlikely to have significantly impacted the observed trends. It is also important to highlight that although one centre did not report data in 2021, this centre was small, and its exclusion would not have significantly impacted the observed trends.

Despite the decline since 2019, WA saw the largest growth in FTE radiation oncologists, with an increase from 8.6 (2011) to 20.5 (2021). This growth represents a CAGR of 9%. Meanwhile, NSW/ACT has the highest number of FTE radiation oncologist positions recorded - 109.7. However, despite the absolute increase in FTE – when measured against average workload *Figure 27* clearly demonstrates that the drop in FTE in 2021 had a significant impact on individual workload for the remaining radiation oncologists with record case numbers at a timing of increasingly complex case mix.

Full-time equivalent radiation oncologist positions

	NSW/ACT	QLD	VIC	TAS	SA/NT	WA	AUS
2011	84.9	44.5	66.9	6.0	16.9	8.6	227.8
2013	95.7	51.3	68.3	5.0	17.4	14.0	251.6
2015	101.8	50.0	67.4	5.0	18.6	16.9	259.7
2017	113.7	55.4	66.6	4.6	18.3	15.9	274.5
2019	122.5	64.9	76.7	5.7	18.5	22.3	310.4
2021	109.7	60.6	70.9	5.7	18.6	20.5	286.0

Figure 26: Full-time equivalent radiation oncologist positions

On average, there are 2.8 FTE radiation oncologists per radiation therapy facility (1.2 FTE per LINAC) in Australia. Further discussion specifically regarding the radiation oncologist workforce based on the 2018 Faculty of Radiation Oncology Workforce Census has been published[7].

Total courses per full-time equivalent radiation oncologist positions

	NSW/ACT	QLD	VIC	TAS	SA/NT	WA	AUS
2011	211.0	239.9	207.2	350.0	342.8	427.6	237.1
2013	201.8	243.3	236.8	388.0	334.1	416.9	244.5
2015	214.4	261.4	246.4	350.2	353.5	350.4	253.2
2017	200.5	253.8	283.0	418.4	340.5	406.6	256.2
2019	194.7	254.0	245.4	371.1	352.1	313.8	240.7
2021	240.1	338.5	272.2	384.8	369.0	420.2	293.0

Figure 27: Total courses per full-time equivalent radiation oncologist positions

Figure 27 shows the total courses per full-time equivalent radiation oncologist positions in all states between 2011 and 2021. Overall, the data shows a predominantly steady increase in most regions, with the Australian average of courses per FTE radiation oncologist increasing from 237.1 (2011) to 293.0 (2021).

Figure 28 indicates the FTE radiation oncologist positions per LINAC under public and private ownership and MM code between 2011 and 2021. The data indicates that the number of FTE radiation oncologists per LINAC has reduced significantly in MM1 from 1.7 to 1.3, and in the public sector from 1.8 to 1.4.

Full-time equivalent radiation oncologist positions per Linac

	MM1	MM2	MM3	Private	Public
2011	1.7	1.1	1.0	1.0	1.8
2013	1.6	1.1	0.9	1.1	1.7
2015	1.5	1.1	1.1	1.0	1.7
2017	1.5	1.1	1.1	0.8	1.8
2019	1.6	1.2	1.2	1.0	1.8
2021	1.3	1.1	1.2	1.0	1.4

Figure 28: Full-time equivalent radiation oncologist positions per LINAC under different ownership and MMM code

b. Radiation Therapists

From 2011 to 2021, there was a significant increase in the number of FTE radiation therapists in Australia, with the numbers rising from 1,408.0 to 1,859.5 (as shown in *Figure 29*). WA reported a large increase where FTE numbers rose from 79.0 (2011) to 183.1 (2021). Meanwhile, a slight decrease was observed in SA/NT with the number of FTE positions falling from 117.0 (2011) to 110.0 (2021).

Full-time equivalent radiation therapist positions

	NSW/ACT	QLD	VIC	TAS	SA/NT	WA	AUS
2011	498	302	363	49	117	79	1,408
2013	555	344	402	47	109	121	1,578
2015	595	342	395	46	130	119	1,627
2017	602	374	411	43	100	121	1,651
2019	598	383	426	61	102	133	1,702
2021	689	364	446	68	110	183	1,860

Figure 29: Full-time equivalent radiation therapist positions

The data reveals that there is an average capacity for 18.4 FTE radiation therapists per facility in Australia with 7.9 FTE per LINAC. As indicated in *Figure 30*, the FTE radiation therapist positions per LINAC has declined across the public and private sectors, as well as MM codes between 2011 and 2021. The only exception to this is found in MM3 where the number increased from 7.6 to 8.8. The decline of FTE radiation therapists can be more prominently seen in MM1 and in the public sector.

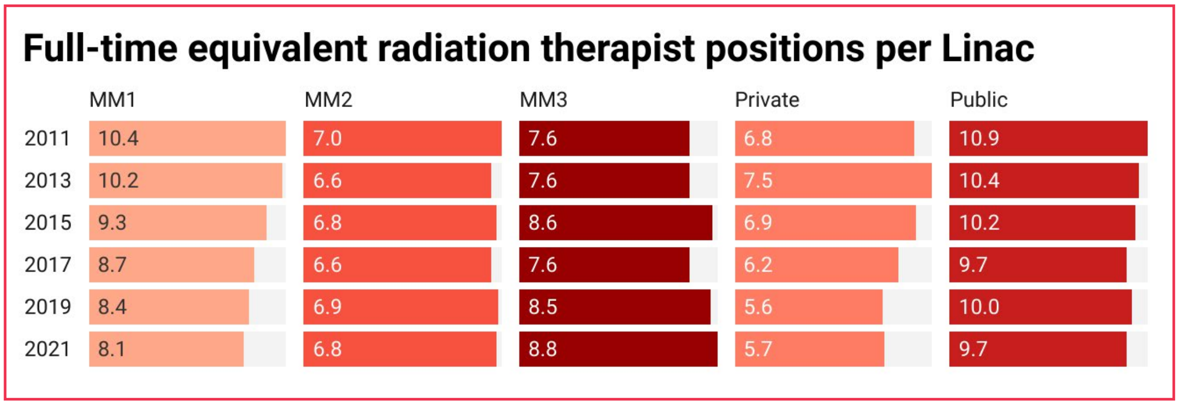

Figure 30: Full-time equivalent radiation therapist positions under different ownership and MMM code

c. Radiation oncology medical physicists

Between 2011 and 2021, the number of radiation oncology medical physicist positions in Australia increased by a notable CAGR of 6% from 219.0 to 363.3 as shown in *Figure 31*. The most significant growth occurred in WA where the FTE increased from 12.0 to 29.2, representing a CAGR of 9.3%. QLD has shown similar growth with a CAGR of 8.8%. These increases can be considered a reflection on the increased numbers of radiation therapy centres in WA and QLD. However, despite the national increase, SA/NT and WA reported a drop in numbers since 2019.

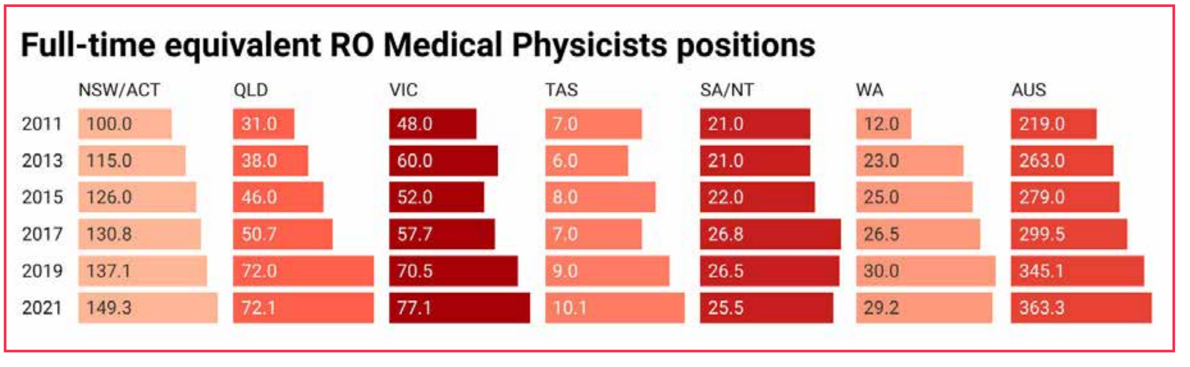

Figure 31: Full-time equivalent RO Medical Physicist positions in Australia

The number of FTE radiation oncology medical physicists per LINAC has increased. The data indicates a slight increase over the past decade across Australia in both public and private sectors and at most MM locations. MM1 is the only location where the FTE numbers have remained steady at 1.6.

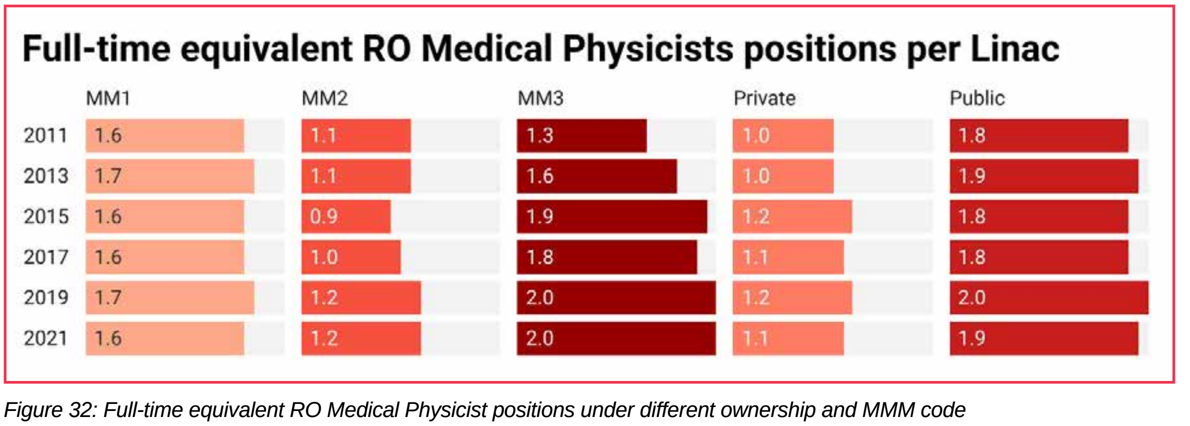

Figure 32: Full-time equivalent RO Medical Physicist positions under different ownership and MMM code

d. Nurses

As shown in *Figure 33*, the number of nurse positions in Australia increased steadily accounting to a CAGR of 3.9% from 212 to 310.8 since 2011. The most significant growth occurred in WA where the FTE increased from 11 to 33.3, which indicates a CAGR of 11.7%. Growth is also found in VIC with a CAGR of 5.9%. However, the most FTE nurse positions were recorded in VIC followed by NSW/ACT.

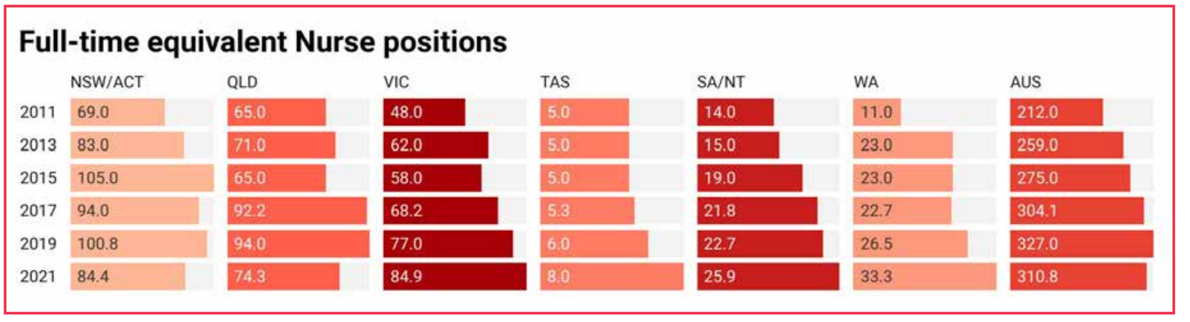

Figure 33: Full-time equivalent nurse positions in Australia

DISCUSSION

This is the first published report that has surveyed Australian radiation therapy facilities since 2009 and presents the combined results of 10 years of data. From the time of the last report there has been a drive to improve access to radiation therapy for cancer patients via a number of advocacy strategies. Data from evidence-based modelling[8] suggests that the optimal radiation therapy utility (RTU) rate is 48% of new reportable cancer diagnoses receiving radiation at some point in their cancer journey. Unfortunately, recent publications suggest continuation of the historic low utility rates[9, 10, 11, 12, 13, 14, 15,16] of radiation therapy within Australia (as low as 30%) - with evidence of even greater disadvantage in regional and rural populations. Given the long course length and limited treatment centres (traditionally based in large metropolitan hospitals) – access is of particular importance for regional patients.

It is also important to note that the closure of any gaps requires even more resources accounting for the increased number of courses required to treat the absolute increase in cancer cases due to Australia's growing and aging population over time. In 2020, 77,200 people received over 2.5 million Medicare Benefits Schedule (MBS) - subsidised radiation therapy services. Of these, 9 in every 10 patients receiving MBS were aged 50 and above.[17]

This report analyses longitudinal (but patient anonymous) data provided by facilities. It must be emphasised that figures presented here cannot and should not be used to estimate RTU. There are many reasons for this including anonymous data, individual facilities treat patients from multiple states, individual patients have multiple courses of radiation, radiation for non-reportable - e.g skin – cancers, and RTU assigned to the year of diagnosis rather than the year of radiation therapy, to name a few. Nevertheless, when coupled with population data it can inform trends and be used to advocate for resources where required.

This report confirms a doubling in the number of radiation therapy centres from 51 to 101 between 2011 and 2021. Wigg et al[18] reported a 44% increase in centres between 1986 (18) and 1999 (26). Between 1999 and 2010 there was a 96.2% increase. Similarly, the number of LINACs has also increased. Wigg et al[18] reported 95 megavoltage units in 1999, while Kolybaba et al[19] in 2009 reported a 20% growth to 113 LINACs. This report confirms an acceleration in that growth to 60% (145 to 233) from 2011 to 2021. Importantly, there is evidence that at least some of the growth has been directed to areas with barriers to access. WA's number of LINACs have increased from only 8 machines in 2011 to 21 in 2021. This increase improved WA's LINAC population density from 3.57 to 7.89 per million people (target 7 per million). There was also some sign of an improved distribution of LINACs for regional patients. The rate of growth was highest in MM3 (populations 15,000 to 50,000) areas but there was still more growth in MM1 (major metropolitan) than MM2 (non-metropolitan populations over 50,000).

Moreover, this increase has come from an accelerated growth in the private sector and smaller centres. The majority (60%) of facilities are now privately operated and the average LINAC per centre has fallen from 2.8 to 2.3. Although there is 57%-43% public/private split in terms of LINACs, the average patient in 2021 is more likely to be treated in a smaller, privately run facility, slightly further from the centre of a major city than they were in 2011.

When it comes to the number of treatment courses there has also been an increase. Nationally there was a CAGR of 4.5%. Growth was lower in TAS and SA/NT and greatest in WA. However, when looking at courses per 1,000,000 population the data appears to show that those states with the greatest growth were closing historic gaps of undertreatment, with WA increasing from 164 courses per million to 323 courses per million (compared with Australia's total increase of 251 to 329). As stated previously, these crude rates cannot be used to compare across jurisdictions as other demographics such as case mix, age, increasing rates of retreatment or second cancer, and socioeconomic factors determine what the true rate should be. *Figure 16* also shows some encouragement for regional populations with the number of courses taking place outside metropolitan areas rising from 16% to 21%. While it is inevitable that some regional and rural patients will need to travel to metropolitan areas for treatment the fact that 30%[2] of Australians live outside major cities suggests that there are still a significant number of regional patients travelling for radiation therapy – or perhaps even missing out. Of course, for multiple reasons it is unlikely that all regional patients will be able to avoid travel.

Important findings in this report are the changes in complexity and fraction rate. There is great angst in the world of radiation therapy that changing patterns of practice could have significant impact on the sustainability of services unless accounted for in economic and workforce planning.

There is no doubt that treatments are becoming more complex with greater use of IMRT, VMAT and stereotactic treatments. *Figure 20* leaves no doubt that there has been a remarkable change in practice in Australia in these 10 years with the vast majority of cases being delivered by complex techniques. It is also clear that the introduction and safe delivery of these techniques require significantly more human resources[20] that must be accounted for in order for centres to remain sustainable. There is an intricate relationship between complexity, course length and workforce requirements that perhaps is yet to be fully explored. Complex techniques also lend themselves to shorter courses of radiation therapy that can be beneficial to both individual patients and the wider society as long as they can deliver at least the same control rates and toxicity rates of traditional courses.

Figure 18 shows that there has been a modest reduction in the length of treatment courses, perhaps partly enabled by complexity. While our data shows there has been an absolute numerical increase in all staffing groups over the 10 years of the survey when looked at per LINAC or per course (medical physics aside), there has been a reduction in relative staffing for the workload. While perhaps the reduction in average course length may have given some role for realignment within radiation therapy – the combined and sustained increase in case complexity (and work per case) along with absolute increase in case number – at greater rates than growth in workforce personnel could raise concerns about increasing workloads for individuals overtime and risk of burnout. Indeed, the fall in radiation oncologist FTE in 2021 with no lessening in the ongoing rise in the number of cases clearly increased the demand on radiation oncologists. It must be remembered that this was an extremely stressful time for all and these workforce pressures probably explain the real disengagement from RANZCR activity from members at that time. We have a duty to monitor this very closely in upcoming surveys and it has implication for patients, employers and our own wellbeing.

Other craft groups – especially radiation therapist – are currently suffering from a recruitment crisis. The reasons are complex and beyond the scope of this document. This data clearly shows that while the number of therapists has increased in absolute terms, the way we work – with more caseloads in smaller departments will hopefully provide this and other craft groups data that they can use to model their ideal workforce for the future.

The way radiation therapy is reimbursed in Australia is weighted to both treatment complexity and number of fractions. With patterns of practice changing in such a way that complexity increases, and course length decreases there is great risk of an imbalance between reimbursement and the costs of delivering a quality modern service. The clear trends from these data have helped inform decisions made around the new proposed MBS scheduling for Australia which will hopefully provide a framework for reimbursement that promotes evidence-based quality radiation therapy that is economically sustainable.

In modern health care we should pay particular focus on inequalities and gaps. It is good to see that our data shows encouraging trends in reducing historical gaps between states and for regional patients in terms of access. However, there are other important potential gaps (quality of treatment, socio-economic, Aboriginal and Torres Strait Islander access, ethnicity, sex, gender and countless others) that we simply cannot measure in this survey. In the 2023 survey we will try to ascertain some data around patient and staffing levels in our centres for Aboriginal and Torres Strait Islanders and Māori and Pasifika.

What is also clear from this study is that the traditional model for delivery of radiation therapy – a large centre with five or greater linacs in large cities – is no longer the dominant model. More treatments being given to more patients in smaller facilities often in the private sector provides both opportunities and challenges. Maintaining high standards of treatment access to training and research must be widened to these new locations as both medical training and medical research must take place in the environment, where patients are treated in order for it to be valuable and sustainable.

Future trends to observe will be the impact of automation and introduction of artificial intelligence. It is possible that centres may re-deploy staff with specific skill sets to adapt to the changing health care needs. As more centres and LINACs come online, it is feasible that there will be a saturation point in the next 5 to 10 years, but this should not be at the expense of staff training and job opportunities.

The data trends demonstrated by the surveys undertaken by RANZCR over the last 10 years, coupled with horizon summits, paves the way for ongoing workforce and funding reviews. The federal government and the College will continue to work together to ensure radiation therapy services are maintained at a high level.

The facilities survey also collects data on brachytherapy where unfortunately the data appears less encouraging. This is a complex area, but it appears that while there were increases in brachytherapy rates from 2011 to 2017 since then there has been a stagnation or a fall.

Total numbers are small for brachytherapy and therefore long-term trends can be difficult to find. Nevertheless, 2017 was also the year when brachytherapy funding was removed from the Radiation Oncology Health Program Grant (ROHPG) Scheme. It is tempting to speculate that this has contributed to the fall in courses and facilities offering brachytherapy (a fall more pronounced in regional locations and in the private sector) in the second half of this survey. As well as delivering essential cancer treatment to important populations (particularly in gynaecological cancers) there are concerns about sustainability of service and training requirement for future generations[21]. RANZCR has commissioned a working group with the aim of reviewing current economics, workforce and practice challenges around the delivery and sustainability of brachytherapy services intended to commence in the latter half of 2023.

CONCLUSION

This report summarises RANZCR FRO Facilities Surveys from 2011 to 2021 which provides a unique and rich selection of data painting the picture of radiation therapy services over time.

The clear growth in facilities and EBRT as well as the reach into regional areas should be celebrated – however there are concerns that these may simply be keeping up with increasing populations rather than closing the known and persistent access gaps.

The embracing of technology along with the growth of in complexity of treatment is a clear positive outcome for patients. However, there is real concern that there is a disconnect between reimbursement structure and the work required in order to deliver the inevitable developments in radiation therapy, risking the future and sustainability of our field.

The continuing rise in workload that is not being met by a parallel increase in workforce, alongside a slight increase in the aging of the treatment equipment, are trends that must be monitored in future surveys. Quality data collected from our members through the Facilities Survey is essential and crucial to enable us to advocate for our members, the College, and our patients.

REFERENCES

1. Versace VL, Skinner TC, Bourke L, Harvey P, Barnett T. National analysis of the Modified Monash Model, population distribution and a socio-economic index to inform rural health workforce planning. Aust J Rural Health. 2021 Oct;29(5):801-810. doi: 10.1111/ajr.12805. PMID: 34672057.
2. Australian Government Department of Health. Modified Monash Model - fact sheet; 2020. https://www.health.gov.au/resources/publications/modified-monash-model-fact-sheet. Accessed June 9, 2023.
3. James M, Munro PL, Adams G, Keogh S. The Changing Radiation Oncology Landscape in New Zealand. Journal of Medical Imaging and Radiation Oncology. 2022;66(5):694–700.
4. COCIR Radiotherapy Age Profile & Density December 2019 edition. COCIR, the European Coordination Committee of the Radiological, Electromedical and Healthcare IT Industry; 2019 [cited 2023 Jun 8].
5. Australian Bureau of Statistics https://www.abs.gov.au/ausstats/abs@.nsf/lookup/3101.0main+features1dec%202010
6. Cancer data in Australia, summary [Internet]. [cited 2023 Jun 21]. Available from: https://www.aihw.gov.au/reports/cancer/cancer-data-in-australia/contents/summary
7. Leung J, Forstner D, Chee R, James M, Que E, Begum S. Faculty of Radiation Oncology 2018 Workforce Census. Journal of Medical Imaging and Radiation Oncology. 2019;63(6):852–61.
8. Barton MB, Jacob S, Shafiq J etal. Estimating the demand for radiotherapy from the evidence: a review of changes from 2003 to 2012. Radiotherapy and Oncology. 2014; 112: 140–4.
9. Ong WL, Finn N, Te Marvelde L, Hornby C, Milne RL, Hanna GG, et al. Disparities in radiation therapy utilization for cancer patients in Victoria. Journal of Medical Imaging and Radiation Oncology. 2022;66(6):830–9.
10. Gabriel G, Barton M, Delaney GP. The effect of travel distance on radiotherapy utilization in NSW and ACT. Radiotherapy and Oncology. 2015;117(2):386–9.
11. Yap ML, O'Connell DL, Goldsbury D, Weber M, Barton M. Factors associated with radiotherapy utilisation in New South Wales, Australia: Results from the 45 and up study. Clinical Oncology. 2020;32(5):282–91.
12. Vinod SK, Simonella L, Goldsbury D, Delaney GP, Armstrong B, O'Connell DL. Underutilization of radiotherapy for lung cancer in New South Wales, Australia. Cancer. 2010;116(3):686–94.
13. Yap ML, O'Connell DL, Goldsbury D, Weber M, Barton M. Comparison of four methods for estimating actual radiotherapy utilisation using the 45 and up study cohort in New South Wales, Australia. Radiotherapy and Oncology. 2019;131:14–20.
14. Merie R, Gabriel G, Shafiq J, Vinod S, Barton M, Delaney GP. Radiotherapy underutilisation and its impact on local control and survival in New South Wales, Australia. Radiotherapy and Oncology. 2019;141:41–7.
15. Luke C, Chapman P, Priest K, Roder D. Use of radiotherapy in the primary treatment of cancer in South Australia. Australasian Radiology. 2003;47(2):161–7.
16. Radiation Oncology in Queensland Indicators of safe, quality cancer care delivered by public and private services 2009 – 2018
17. Cancer in Australia 2021. Cat. no. CAN 144. Canberra: AIHW. [cited 2023 Jul 3]. Available from: https://www.aihw.gov.au/getmedia/0ea708eb-dd6e-4499-9080-1cc7b5990e64/aihw-can-144.pdf.aspx?inline=true
18. Wigg DR, Morgan GW. Radiation oncology in Australia: Workforce, workloads and equipment 1986-1999. Australasian Radiology. 2001;45(2):146–69.
19. Kolybaba M, Kron T, Harris J, O'Brien P, Kenny L. Survey of radiation oncology centres in Australia: Report of the radiation oncology treatment quality program. Journal of Medical Imaging and Radiation Oncology. 2009;53(4):382–95.
20. Thind K, Roumeliotis M, Mann T, Van Dyke L, Martell K, Smith W, et al. Increasing demand on human capital and resource utilization in Radiation therapy: The past decade. International Journal of Radiation Oncology*Biology*Physics. 2022;112(2):457–62.
21. Ong WL, Byrne A, Chelvarajah R, Chong C, Gallo J, Kain M, et al. Survey of brachytherapy training experience among radiation oncology trainees and fellows in the Royal Australian and New Zealand College of Radiologists (RANZCR). Journal of Medical Imaging and Radiation Oncology. 2022;66(7):980–92.
22. Australian Government Department of Health and Aged Care. Modified monash model [Internet]. Australian Government Department of Health and Aged Care; 2022 [cited 2023 Jul 24].Available from: https://www.health.gov.au/topics/rural-health-workforce/classifications/mmm

APPENDICES

APPENDIX A: METHODOLOGY

a. Aim

The biennial Facilities Survey serves as a snapshot of equipment, treatment, and workforce of all radiation therapy facilities in Australia and New Zealand. By presenting data at state level, we aim to allow analysis in more detail however, individual centres provide their own data in a confidential manner, so smaller territories are combined with their geographical neighbours to prevent the possibility of identifying individual centres. The survey is reviewed and developed by the Faculty of Radiation Oncology Economics and Workforce Committee (FRO EWC). The survey asks radiation therapy facilities for information regarding:

- **Equipment**, both linear accelerators (LINACs; including bunkers) and other (such as treatment planning systems, superficial/orthovoltage machines, brachytherapy systems, oncology information systems, and simulation systems)
- **Treatment**, LINAC (total new courses, total retreatment courses, and fractions/treatment attendances) and other (e.g., intensity modulated radiation therapy/volumetric modulate radiation therapy (IMRT/VMAT), brachytherapy courses, stereotactic ablative radiation therapy (SABR), and total body irradiation (TBI))
- **Staffing**, radiation oncologist (RO) and other (e.g., radiation therapists (RTs), radiation oncology medical physicists (ROMPs), engineers, nurses, information technology specialists, and other key staff).

This paper reports on trends within the Australian radiation oncology sector, particularly regarding facilities, equipment, treatment, and workforce since the first FRO Facilities Survey was undertaken in 2011.

b. Questionnaire Construction

The survey questions were developed by the EWC members, using questions from previous facilities surveys as a comparative base. This was done to ensure that the questions were relevant and comprehensive. New questions were added to investigate contemporary trends, while some older questions were excluded as they were no longer relevant. The survey collects information such as the Facility Name, State, Public/Private Practice, and Remoteness Area (by Modified Monash Model).

The survey is divided into six separate parts, each dealing with a different aspect of the radiation oncology facility. The six parts are:

1. Details of megavoltage equipment
2. Details of other equipment
3. Megavoltage treatment activity
4. Other treatment activity
5. Staffing – Radiation Oncologists
6. Staffing - Other

The questions have remained largely the same for each survey, with notes included at the bottom of each worksheet indicating any key changes. Only one note was included in the 2017 survey, requesting the inclusion of locums in the Radiation Oncologists staffing numbers. In 2019 and 2021, several changes were introduced in each of the six parts of the survey. The changes that the EWC made to the 2021 Facilities Survey template can be found in Appendix B.

c. Data Collection and Analysis

Data collected for equipment and treatment is by calendar year (for the calendar year preceding the survey) and workforce data is captured as of 31 March of the survey year. The survey data collected was for years 2011 to 2021.

A comprehensive list of radiation therapy facilities, including a contact person at each facility, is maintained by the FRO and continually updated on a regular basis. The survey tool has been developed as a Microsoft Excel file that is completed by each facility. The spreadsheet is reviewed and approved by the EWC ahead of the data collection period. This is pre-populated with basic facility information, such as the facility's name, state, whether public or private, and Modified Monash Model (MMM) code (for Australian facilities).

Each facility in Australia and New Zealand is contacted by email, advised of the use of the data, and assured of the privacy and confidentiality of all information collected. Attached to the email is the survey tool. The request is typically sent in late March, with follow up emails (and telephone calls, where necessary) until all facilities have returned completed surveys.

Responses to the survey are imported into a Microsoft Access database and data is analysed using Microsoft Excel, with aggregated summary data presented to the membership. Previous report structures were used as the foundation for the 2021 report and the draft reviewed, analysed, and amended by the EWC members.

APPENDIX B: SURVEY TEMPLATE

2021 RO Facilities Survey Template

Faculty of Radiation Oncology Radiotherapy Equipment Facilities Survey - Megavoltage Machines

Snapshot Date: ***31-March-2021***

Facility Name:		***State:***		***Public/privately owned facility***		***Remoteness Area (Aust)***	

Megavoltage Machines	Manufacturer/Model	Year of Installation	Number of treatment hours per machine on 31/03/2021	Energy/Energies		EPI (Yes/No)	IMRT (VMAT) Capable (Yes/No)	Is this Linac operational for IMRT (VMAT) (Yes/No)	On board kV Imaging (Yes/No)	Cone Beam CT (Yes/No)	6 degrees of freedom couch (Yes/No)	Surface Guided System		Tertiary Imaging/ online correction (Yes/No)	Is this Linac Gating capable? (Yes/No)
				Photons (MV)	Electron (MeV)							(Yes/No)	Type		

Empty Bunkers	Planned Year of Installation (If known)
1	
2	
3	

Changes

Incorporated MRI Linac and Other Machines into list of all Megavoltage machines. Manufacturer and model details enable identification of type of equipment, eg MRI Linac if required

Simplified Energy/Energies to Photon and electrons

Deleted MRI simulator Y/N as simulator is on next tab "Equipment other"

Added Explanatory Note on Instruction Tab

Allowed for 3 empty bunkers and reporting of planned year of installation only

Included collection of data for number of hours each machine was used for treatment on 31 March. If machine not operating on 31 March provide hours for earlier date.

Added Public/Privately Owned to Facility Sector above

Faculty of Radiation Oncology Radiotherapy Equipment Facilities Survey - Other Equipment

Snapshot Date:	*31-March-2021*			
Facility Name:	*0*	*0*	*0*	*0*

Treatment Planning System	Manufacturer	Product name and version	Year of Installation	Planning (Onsite/Offsite/Mixed))
TPS 1				
TPS 2				
TPS 3				
TPS 4				
TPS 5				
TPS 6				
TPS 7				

Superficial / Orthovoltage Machine (if applicable)	Manufacturer	Model	Year of Installation	Description of kV energy(ies)
Machine1				
Machine2				

Brachytherapy system (if applicable)	Manufacturer	Model name	Year of Installation	Description (including HDR/LDR, skin etc)
Brachytherapy 1				
Brachytherapy 2				
Brachytherapy 3				
Brachytherapy 4				
Brachytherapy 5				

Oncology Information System	Manufacturer

Simulation System (excluding primarily diagnostic machines) Eg CT, PET, MRI, US, Fluoro, Surface Guided	Manufacturer	Year of Installation	CT – 4D capable? (Yes/No)
System 1			
System 2			
System 3			

Changes and remaining questions

Column D for all equipment types changed to just accept e.g TPS1, TPS2 etc and nothing else, similarly Brachytherapy 1, Brachytherapy 2 etc. Then follows the manufacturer etc

Deleted column re Number of Computer Licenses as no longer relevant

Deleted description for TPS as information not useful.

Sim system equipment, CT column - deleted reference to IV contrast

Faculty of Radiation Oncology Radiotherapy Equipment Facilities Survey - Treatment Activity (Megavoltage)

Period:	*January - December 2020*			
Facility Name:	*0*	*0*	*0*	*0*

New Courses (including all megavoltage courses, e.g., IMRT, SRS, TBI, 3DCRT)	Courses	Fractions / Treatment Attendances
TOTAL New Courses		
Stereotactic		
Non-stereotactic		
TOTAL Retreatment Courses (refer to new course inclusions above)		
TOTAL Courses (New Courses +Retreatments)		
Curative		
Palliative		
Prophylactic		

Australian Sites only	
New Courses	
% Reportable Cancers	
% Interstate Patients	

Australian Sites only			
Patients treated			
If your Facility is classified above as a Private Facility		If your Facility is classified above as a Public Facility	
Do you see public patients?		Do you see private patients?	
If Yes, % public patients		If Yes, % private patients	

Total Megavoltage Fractions/Treatment Attendances on 31 March 2021	

Self-assessment of compliance with the Radiation Oncology Practice Standards
Required evidence for Standard 6.2 (*care is provided in a timely manner according to patient need*) is "a documented policy that specifies the management of unscheduled interruptions to treatment and prolongation of a course of radiation therapy". **Does your facility have such policy?**

Changes
Breakdown of fractions for stereo/non-stereo courses
Collect fractions for retreatments
Collect courses and fractions by treatment intent
Aust site only information on - % reportable cancers, % interstate patients and public and private patients treated in different facilities
Snapshot of workload on 31 March 2021.

Faculty of Radiation Oncology Radiotherapy Equipment Facilities Survey - Treatment Activity (Other)

Period:	*January - December 2020*
Facility Name:	***0 0 0 0***

	Total IMRT (VMAT)	Total Brachytherapy HDR	Breakdown by Main sites HDR					Total Brachytherapy LDR	Breakdown by Main sites LDR					Superficial	Orthovoltage	Total Stereotactic (incl SRS, SABR, SBRT) Courses	Paediatric Courses	Total Body Irradiation (TBI)/Total Skin (TS) Courses	
			GYN	Prostate Monotherapy	Prostate Boost	GI	Other (eg skin, breast, etc)		GYN	Prostate Monotherapy	Prostate Boost	GI	Other					TBI	TS
Courses																			
Fractions/ Attendances																			

Changes and questions remaining
Added Fractions/Attendances for IMRT and Brachytherapy
Split HDR and LDR for prostate into monotherapy and boost - is this useful?
Deleted questions about gynae and head and neck patients?
Deleted questions about Other courses, considered not useful.
Removed breakdown of different stereotactic courses
Removed breakdown of IMRT treatment methods

Faculty of Radiation Oncology Radiotherapy Equipment Facilities Survey - Staffing (Radiation Oncologists)

Snapshot Date: ***31-March-2020***

Facility Name: ***0*** ***0*** ***0*** ***0***

FILLED POSITIONS

Surname of Radiation Oncologist (Consultant)	First Name of Radiation Oncologist (Consultant)	Full Time Equivalent* (Consultant)	Number of New EBRT Treatment Courses Per Year	Number of New Patient Consultations Per Year	Surname of Rad Onc Trainee	First Name of Rad Onc Trainee	Full Time Equivalent* (RO Trainee)	Accredited Position (Yes/No)	Year of RANZCR Training	Surname of Rad Onc (International Med Graduate)	First Name of Rad Onc (IMG)	Full Time Equivalent* (IMG)	Surname of Rad Onc (Fellowship/ research)	First Name of Rad Onc (Fellowship/ research)	Full Time Equivalent* (Fellowship/ research)
Total filled FTE		0.0					0.0					0.0			0.0
VACANT POSITIONS		**VACANT Full Time Equivalent (Consultant)**					**VACANT Full Time Equivalent (RO Trainee)**					**VACANT Full Time Equivalent (IMG)**			**VACANT Full Time Equivalent (Fellowship / research)**
(must have existing funding)		0.0					0.0					0.0			0.0
Total positions FTE		0.0					0.0					0.0			0.0

Director of Department / Clinical Lead on Site for Private Practice	
Director of Training	

Changes
Change to new treatment courses and new patients as above
Some explanatory notes added to Instruction tab

Faculty of Radiation Oncology Radiotherapy Equipment Facilities Survey - Staffing (Other)

Snapshot Date: ***31-March-2020***

Facility Name:	***0***	***0***	***0***	***0***

	Occupation	FTE filled	FTE vacant (must have existing funding)	FTE TOTAL
RT	Radiation Therapists			0
RT	Radiation Therapists (PDY)			0
ROMP	RO Medical Physicists (Aus & NZ qualified) Accredited by ACPSEM			0
ROMP	RO Medical Physicists (Aus & NZ qualified) **Not** accredited by ACPSEM			0
ROMP	RO Medical Physicists (Overseas qualified) Accredited by ACPSEM			0
ROMP	RO Medical Physicists (Overseas qualified) **Not** accredited by ACPSEM			0
ROMP	RO Medical Physicists (trainees)			0
Other	Engineers (incl. Biomedical)			0
Other	Information Technology specialists			0
Other	Nurses			0
Other	Data Managers			0
Other	Clinical Trials			0
Other	Administrative			
Other	Others (Please Specify)			0

Chief Radiation Therapist	
Chief Radiation Oncology Medical Physcist	

The Royal Australian
and New Zealand
College of Radiologists®

The Faculty of Radiation Oncology

Name of document and version:
Facilities Survey Report: Insights and Trends from 2010-2020, Australia, Version
Approved by:
Faculty of Radiation Oncology Council, The Royal Australian and New Zealand College of Radiologists

Date of approval:
TBA

ABN 37 000 029 863

The Royal Australian and New Zealand College of Radiologists
Level 9, 51 Druitt Street
Sydney NSW 2000 Australia

New Zealand Office:
Floor 6, 142 Lambton Quay,
Wellington 6011, New Zealand

Email: ranzcr@ranzcr.edu.au
Website: www.ranzcr.com
Telephone: +61 2 9268 9777