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Table of Contents

KEY MESSAGES	3
1 LITERATURE REVIEW METHODOLOGY	9
1.1 Introduction	9
1.2 Context.....	9
1.3 Search strategy.....	9
2 OVERVIEW OF THE LITERATURE.....	12
2.1 Scope	12
2.2 Exclusions.....	12
2.3 Schema for evaluating the evidence	12
2.4 The academic literature.....	13
2.5 The practice literature	13
3 FINDINGS	16
3.1 Options.....	16
3.1.1 Work existing machines smarter	16
3.1.2 Work existing machines harder	16
3.1.3 Key factors.....	17
3.2 Extended hours models in use.....	18
3.2.1 International.....	18
3.2.2 National.....	22
3.3 Workforce	23
3.4 Costs	27
3.5 Efficiency.....	28
3.6 Patient preferences	30
4 SYNTHESIS OF KEY MESSAGES FROM THE LITERATURE FOR NSW HEALTH	32
4.1 The evidence.....	32
4.2 Concluding Remarks	37
REFERENCES.....	38

List of Tables

Table 1	Search strategy.....	11
Table 2	Journals generating most relevant academic literature	13

List of Figures

Figure 1	Schema for summarising the strength of the evidence.....	12
Figure 2	Five models for radiotherapy service delivery from the NRAG report.....	20

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Key messages

Our brief

The need to ensure efficient use of radiotherapy infrastructure is well recognised by NSW Health. The issues regarding the 'extended hours' were first considered by the Department in 1993 (CHERE Discussion Paper Series. Number 14. *Options for the efficient expansion of radiation therapy services*: February 1993). In 2006/07, in conjunction with the Cancer Institute NSW (CI NSW), a Business Process Improvement (BPI) project was undertaken for radiotherapy services in NSW. This was completed in 2009. The BPI project has demonstrated that improvements in efficiencies can be realised with existing infrastructure with the improvements in operational processes.

In 2009, the NSW Audit Office conducted a Performance Audit of NSW radiotherapy services and recommended that NSW Health, assess options for increasing capacity of radiotherapy facilities, which might include the feasibility and 'value for money' of extended hours operation. The NSW Department of Health therefore commissioned the Centre for Health Service Development (CHSD) to undertake a targeted literature review to continue to assist NSW Health in responding to this issue.

Radiotherapy

Radiation treatment is one of the fundamental tools available in cancer treatment and one of the three cornerstones of multidisciplinary cancer care, along with chemotherapy and surgery as part of a quality comprehensive cancer service. Radiotherapy can be given in two ways, through external beam radiotherapy (which uses high energy machines) and brachytherapy (which uses radioisotopes). 'Megavoltage' treatments are an external beam radiotherapy, which is delivered by linear accelerators. These machines are often referred to as linacs.

The number and duration of the radiotherapy sessions depends on the type of cancer and where it is located in the body. A superficial skin cancer may need only a few treatments, whereas a cancer deeper in the body may need longer duration of treatment. It may also depend on whether the purpose of the treatment is to cure the cancer or the purpose of the treatment is to reduce symptoms in the case of palliative care. Depending on this, some patients receive only one treatment of radiotherapy; others may receive regular treatments for one to seven weeks. It is usually (but not always) given once a day, five times a week.

Search strategy and literature

Our approach is based on purposive literature review techniques aimed at finding key articles/documents from the academic and practice literature (both national and international). The US National Library of Medicine's MeSH terminology was used to generate search terms which were then used in various combinations. The results from our primary search were promising with several key references emerging from the academic and practice literature. Whilst the majority of this literature focuses on aspects of workforce shortage, there were several recent references specific to extended working hours, predominantly based on the UK experience.

Exclusions

Whilst there are many factors that influence the model of care and service delivery of radiotherapy, this targeted literature review focuses particularly on the feasibility and 'value for money' of extended hours operation.

It is not our role to make judgements about what actions may or may not be required but simply to present the evidence within the literature.

Findings and evidence

This section aims to summarise the main findings from the literature in a series of bullet points to assist the reader to form their own conclusions on the basis of the evidence presented.

The evidence from this targeted literature review is reasonably clear; however it is mainly generated from expert opinion and surveys of radiotherapy treatment centres. It is feasible to extend hours of operation of radiotherapy services however the literature shows that decisions about introducing extended hours services are context specific and need to be made in light of a range of factors that may be unique to each service catchment. This includes, but is not limited to, current demand for radiotherapy as evidenced by cancer incidence projections and waiting times to start of treatment; workforce availability; financial resources to meet increased operating costs and patient preferences. Any decision to increase radiotherapy throughput cannot occur in isolation from other related cancer and hospital support services.

The trade-off between increased patient throughput and faster utilisation of the available life of linacs has not received any recent attention in the literature. There is however recognition that sufficient down-time must be factored into workload benchmarks to ensure that machines receive appropriate quality assurance and maintenance.

In summary the major findings from the literature are:

Options and issues

- Options for increasing capacity of radiotherapy facilities fall broadly under three headings:
 1. Increase the number of linear accelerator machines available
 2. Work existing machines smarter
 3. Work existing machines harder
- As our brief centres on the issue of extended hours operation, option three is most relevant. In addition, NSW Health already has strategies underway for options one and two, hence the focus on option three.¹⁸
- Those not directly involved in managing radiotherapy services often feel that the hours of use of this expensive equipment should be as high as possible to 'sweat the assets'.^{38, 39, 55}
- Approximately 50% of the cost of running a radiotherapy service is attributable to staff and 30% to equipment and maintenance costs. The remaining 20% includes cost inputs relating to space, materials and departmental overheads.^{12, 32}
- Radiotherapy facilities, like most outpatient departments, have traditionally based appointment times around a 9.00 am to 5.00 pm, five day working week; however some facilities are introducing extended hours to more effectively manage patient workflow.^{10, 68}
- From the Radiation Oncology Jurisdictional Implementation Group (ROJIG) parameters, the indicative capacity used in service planning for a linear accelerator in Australia, is 414 courses of treatment per year, consisting of 331 new patients and 83 patients (25% of 331) being re-treated.⁴⁹
- To extend the working hours means that the existing pool of linear accelerators will need to be run for longer periods. This option is reliant on an available and appropriately skilled workforce.^{38, 39}
- There are several considerations in determining the viability of extended hours services including:
 - The impact on clinical treatment regimes (ensuring adequate time for tissue recovery between treatments);

- The demand for palliative radiotherapy (which has a different treatment regime to therapeutic radiotherapy);
- The current status of waiting times for commencement of radiotherapy, for example, whilst waiting lists may exist, actual waiting times may or may not equate with accepted clinical benchmarks.^{1, 9, 10, 13, 22, 38, 39.}

Extended Hours Models in Use

- A study of extended working hours in UK cancer centres, published in 2007, revealed that 95% of all departments involved in the study had experience of using extended working hours. More recently in the UK, a number of departments have implemented long-term, sustained extended hours to address waiting lists.⁶⁸
- The most cost-effective models for extending the working day vary, however there is most evidence for a model using four radiographers each working two shifts and extending the working day by one hour at the start of the day and two hours at the end of the day, to give an 11.5 hour day. In the UK context, this model provided a 31% increase in fractions at a cost increase of only 1.8% per fraction. This study reports the following capacity measures for the 11.5 hour day: 51.8 potential fractions per day; 9 machine hours with two staff and 46.9 net fractions per day.^{40, 41, 68}
- The UK National Radiotherapy Advisory Group Capacity and Efficiency Sub-Group planning recommendation notes that linacs within the UK context, should be run at an average of 9.2 hours per day and only a minority of the machines in the department should run the extended 11.5 hour day. Each linac is expected to deliver between 4 and 4.5 fractions per hour.³⁸
- Overall the nine day fortnight was found to be the most cost-effective method for organising radiotherapy staff.⁶⁸
- The option of adding a sixth day was also considered with cancer centres operating on a Saturday. This was generally not found to be cost-effective unless there was a waiting list for palliative radiotherapy that could be delivered on a Saturday because of its different fractionation requirements.^{51, 68}
- Internationally the whole of radiotherapy practice is based on a 5 day working week. Whilst this has arisen because of social convenience, nevertheless, recommended doses for radical treatment have been developed and proven over the years on this basis. There are very few studies of altered fractionation.^{38, 39}
- The Scottish Executive Health Department, recommends increasing the core clinical service to a ten hour day, five day week with a reduction in days lost as a result of closure for public holidays and routine maintenance to achieve 257 clinical days per annum. They decided not to pursue Saturday services.^{55, 56}
- The delivery of radiotherapy is multidisciplinary and additional staffing costs are not just limited to radiation oncologists, radiation therapists and medical physicists. Any additional hours worked by radiation therapy staff should also be reflected in the workload of other medical oncology staff, nurses and clerical workers.^{12, 32}
- Multidisciplinary patient care must be available to provide equitable care to patients attending outside of core service hours.⁵¹
- There are pitfalls in operating extended working days. The additional hours worked often occur when back-up or support services in the hospital are no longer available. There may be difficulties with patient attendance at these times or the absence of complementary services such as pharmacy or transport.⁵¹
- There is less flexibility to maintain treatment continuity with extended working days in the event of a linac machine breakdown, as there will be more patients to redistribute and less available time in the day in which to reschedule. Interruptions to planned radical courses of treatment

have been shown to worsen outcomes and should be avoided. Extended hours operation without appropriate scheduled maintenance of equipment is problematic.^{38, 39, 40, 68}

- Operating extended working days may also adversely impact on staff recruitment and retention in a service with existing staffing difficulties.^{10, 51}
- In NSW most radiotherapy services work within the normal working week, only using weekends and public holidays for emergency cases. Services will work extended hours for short periods, e.g. 8am to 8pm, to deal with extended waiting lists or whilst equipment is being replaced.^{18, 42}
- In Victoria, whilst the usual operating day is 8.5 hours, extended hours have been provided by some centres with 10 hour operating days and some Saturday services.⁶⁸
- Extended working hours may be used to deal with long waiting lists, however, the Royal Australian and New Zealand College of Radiologists (RANZCR) argue that it is generally not sustainable in the long term when a major reason underlying difficulties with access is staff shortages.^{63, 64}
- In Canada a rapid response clinic provides a one stop shop on Saturdays. Patients are seen, planned and treated with either single dose or two fraction schedules, accommodating palliative patients with minimum inconvenience.⁶⁴

Workforce

- The availability of staff and appropriate skills mix will be the rate limiting factor for many localities seeking to increase productivity and or utilisation of equipment, through extended hours.^{10, 30, 40, 41, 57}
- In the UK it is reported that the demand for radiotherapy is increasing faster than the rate trained radiographers become available and one of the main constraints to radiotherapy capacity is the number of radiographers available.⁵¹
- The issues impacting radiation oncology have been construed at times as a microcosm of the issues across the health system more broadly, both in regard to service planning, funding and workforce issues.^{63, 64}
- A review of radiotherapy workforce requirements in the UK by the National Radiotherapy Advisory Group (NRAG) found that the main limiting factor for achieving increased service capacity is workforce.^{38, 39}
- The Commonwealth Department of Health and Ageing supported state and territory governments examining options for extending the hours of operation of equipment up to 12 hours per day at the time of the Baume report in 2002.¹⁰
- The radiation therapy workforce problems previously evident in NSW have improved considerably for radiation therapists as a range of comprehensive strategies to address recruitment and retention issues for radiotherapy workforce groups have resulted in overall improvement.^{50, 44}
- Job satisfaction has a large impact on retention of qualified staff. Improved professional development opportunities are likely to positively impact upon retention rates.^{33, 38, 39}
- The social costs to employees of extended hours may also impact on recruitment and retention rates for various radiotherapy treatment centres, particularly those in rural or regional areas where workforce availability can be very different compared to metropolitan services.¹⁰

Costs

- The key cost factors relating to working extended hours are increases in staff overtime and increases in the rate of use-related depreciation of capital equipment. It is recognised that to

implement a longer working day across radiotherapy services would incur substantial increases in payroll costs, whether through overtime or an increase in staff.⁶⁰

- The report issued by the Centre for Health Economics Research and Evaluation, based in Sydney, published in 1993 (Smith R, Jan S et al. 1993) is one of the first reported studies of options for the expansion of radiation therapy services in NSW. Two options were compared: Option 1; increase the overtime performed by existing staff and use capital more intensively or Option 2; invest in new capital with associated increases in levels of staffing. Based on the actual operation of a four-machine service at Westmead Hospital, the authors concluded that Option 1 was most efficient for workloads up to 98,525 fields per year, but at higher rates of throughput this option was unfeasible.⁵⁹
- Whilst short term fluctuations in demand may be met most cost effectively by increasing the intensity of operation of existing capacity, a capital investment program is required to meet long term increases in demand.^{10, 19, 59}
- An Australian study found that for working days up to 12 hours, there is a decrease in the average cost per patient treated. After this, the costs increase, mostly because of the high penalty rates paid for radiation therapists.¹
- In Canada a study revealed that extended hours of operation did not appear to generate significant, if any savings when realistic assumptions about machine lifetime and overtime payments were made.²¹
- Much of the literature in the 1990s relating to the costs of radiotherapy reveal a considerable variation in the estimated costs based upon the differences in the methodology used and on the differences in the included costs components and radiotherapy activities.³²
- An Activity-Based Costing model could be used to measure the costs of radiotherapy more accurately.¹²
- More sophisticated radiotherapy equipment, without increases in personnel does not necessarily equate to increases in productivity. This is primarily because personnel costs remain the most important cost component of a radiotherapy department and more sophisticated equipment will not necessarily reduce the need for personnel.^{12, 32}
- The cost of staff overtime payments and the impact on machine lifetime in some scenarios will outweigh the potential throughput gains from extended hours.^{38, 39}

Efficiency

- A number of models exist which can be used to project linear accelerator requirements for a population. Throughput benchmarks for linear accelerators are another way that countries try to maximise efficiency and machine performance.^{9, 58, 52, 55, 56, 40, 41, 66}
- There is scope for reviewing and if necessary redesigning or improving work practices across the service continuum from consultation to planning and to treatment delivery.^{63, 64}
- Radiotherapy treatment centres need to develop and benchmark a set of key performance measures.^{17, 18, 42, 45}
- Linacs with multi leaf collimators (MLCs) were demonstrably more efficient, and while their capital costs were higher, the reduction in labour costs associated with block cutting and, particularly the increased throughput, more than offset these initial costs.^{20, 24}
- Extended working hours impacts on the reliability of linac machines. This in turn creates more unscheduled interruptions than normal due to additional maintenance and/or servicing sessions.^{13, 68}
- Radiotherapy treatments with long treatment times, either because of a high number of fractions or because of long daily irradiation times related to the complexity of the radiotherapy set up, are deemed to be most costly.³²

- Radiotherapy is an area where there is rapid development of new technologies. New techniques and technologies may often take longer in planning and treatment than those they supersede, with the advantage being improved clinical outcomes, particularly through better targeting of the tumour and subsequent reductions in peripheral organ toxicity.⁶⁶

Patient preferences

- Patient preferences are a key consideration in determining the feasibility of extended hours services.^{15, 16, 38, 39, 51, 68}
- A UK report identified that the majority of radiotherapy patients preferred to attend within a standard working day (9.00am to 5.00pm). However, a minority were willing to attend early in the morning, sufficient to fill the available slots. Evening attendance was more problematical and only a few patients stated that they would be willing to attend in the evening as they felt that this was family time. There was also less enthusiasm for attendance at the weekend.^{38, 39}
- For all age groups, 9am – 12pm was the most preferred time for treatment. Outside the normal working day, the 8am – 9am interval was the most selected. Approximately a third of patients would attend a reasonable appointment time outside the normal working day.¹⁶
- Patients prefer treatment outside of normal treatment times if this would reduce the time until the start of radiation therapy.¹⁵
- In an Australian study patients who had experienced less lifestyle inconvenience throughout their treatment (e.g. taken time off work or lived away from home during their treatment), and did not require semi-urgent or urgent treatment, were more willing to be treated outside of conventional treatment times with any amount of reduction in waiting time seen as a worthwhile trade-off for the potential inconvenience.¹⁵
- In the UK, the consideration of patient preferences is a key component of the patient's choice agenda.⁶⁸

Concluding Remarks

Several countries have extended the working day on linear accelerators, as a method of increasing treatment capacity. NSW Health should continue to monitor developments in radiotherapy models of care and workforce trends (including changes in legislation and regulation), particularly as they relate to different approaches to radiotherapy service provision.

In particular, the efforts to of NSW Health to better understand the costs of public radiation oncology treatment services in NSW¹; will also assist future evaluations of the costs and benefits of extended working hours.

Determining the feasibility and 'value for money' of extended hours operations must balance many competing factors – finding a balance between optimum patient access and the available human and financial resources is the challenge.

¹ NSW Health Request for Quotation: Costing of the public Radiation Oncology Treatment Services in NSW. July 2010

1 Literature review methodology

1.1 Introduction

The need to ensure efficient use of radiotherapy infrastructure is well recognised by NSW Health. The issues regarding the 'extended hours' were first considered by the Department in 1993 (CHERE Discussion Paper Series. Number 14. Options for the efficient expansion of radiation therapy services: February 1993). In 2006/07, in conjunction with the Cancer Institute NSW (CI NSW), a Business Process Improvement (BPI) project was undertaken for radiotherapy services in NSW. This was completed in 2009. The BPI project has demonstrated that improvements in efficiencies can be realised with existing infrastructure with the improvements in operational processes.

In 2009, the NSW Audit Office conducted a Performance Audit of NSW radiotherapy services and recommended that NSW Health, assess options for increasing capacity of radiotherapy facilities, which might include the feasibility and 'value for money' of extended hours operation. The NSW Department of Health therefore commissioned the Centre for Health Service Development (CHSD) to undertake a targeted literature review to continue to assist NSW Health in responding to this issue.

1.2 Context

Radiotherapy can be given in two ways, through external beam radiotherapy (which uses high energy machines) and brachytherapy (which uses radioisotopes). 'Megavoltage' services are an external beam radiotherapy, which is delivered by linear accelerators. These machines are often referred to as linacs. Radiation therapy (or radiotherapy), may be the sole means of treatment, or can be used with other treatment modalities such as chemotherapy and surgery.

The number and duration of the radiotherapy sessions depends on the type of cancer and where it is located in the body. A superficial skin cancer may need only a few treatments, whereas a cancer deeper in the body may need longer treatment. It may also depend on whether the treatment is being given to cure the cancer or to reduce symptoms².

Depending on the purpose of the treatment, some patients receive only one treatment of radiotherapy; others may receive regular treatments for one to seven weeks. It is usually (but not always) given once a day, five times a week³. Internationally, the whole of radiotherapy practice is based on a 5 day working week (National Radiotherapy Advisory Group 2006). Clinical radiotherapy schedules have been developed to exploit the differences in response between normal tissues and tumours and so maximise the therapeutic ratio. Fractionating a treatment schedule, (giving a number of treatments over a period of days or weeks), allows normal tissues to repair much of the radiation damage, since tumour cells are often less efficient at repair (Faculty of Radiation Oncology 2002).

1.3 Search strategy

Our approach is based on purposive literature review techniques. CHSD has developed a best practice literature search methodology to find key articles/documents from the academic and practice literature (both national and international). This methodology is based on state-of-the-art

² Source: http://hcd2.bupa.co.uk/fact_sheets/html/radiotherapy.html accessed 30 September 2010.

³ Source: http://www.betterhealth.vic.gov.au/bhcv2/bhcarticles.nsf/pages/Cancer_treatments_radiotherapy?open accessed 30 September 2010.

guidelines for health technology assessments and systematic reviews of the literature (Alderson, Green et al. 2005). This search methodology has a number of drills and layers to ensure optimal coverage of the academic and practice literature within the scope of our brief.

The US National Library of Medicine's MeSH terminology was used to generate search terms which were then used in various combinations. These search terms were entered into several databases. Initially searching focused on core clinical journals with the aim of identifying systematic reviews. Known sources of systematic reviews such as the Cochrane Library, Database of Abstracts of Reviews of Effects (DARE) and the Turning Research into Practice (TRIP) database for Evidence Based Medicine were individually searched using a range of MeSH headings in combination. Our approach is summarised below:

Academic literature

- Scientific literature searches (e.g. MEDLINE/PubMed, CINAHL, PsycINFO, Rural and Remote Health)
- Evidence-based health care search (e.g. Cochrane Library, DARE and TRIP databases, Health Reference Center)

Practice literature

- National libraries (National Library of Australia, US National Library of Medicine)
- Commercial web sites (e.g. AMAZON.com)
- Australian Government Department web sites (e.g. Commonwealth Department of Health and Ageing, State and Territory Health and Human Service Departments)
- Australian professional colleges and associations (e.g. Faculty of Radiation Oncology, Royal Australian and New Zealand College of Radiologists)
- International Government Department web sites in selected countries
- International professional colleges and associations relevant to the search strategy.

The search terms employed for this review are summarised in Table 1. Our search terms worked effectively, particularly the use of key words including extended hours treatment.

The resulting citations were culled to exclude those that did not focus on a key factor relevant to extended hours operations, such as costs, workforce, efficiency or patient preferences relating to service delivery. Only English language citations were retained. Additional citations were identified by reviewing the reference lists in recently published works. We have made extensive use of Google Scholar to 'work forwards' in the literature and snowball searching to 'work backwards' in the literature. Whilst we focused on literature published between 2000 and 2010, in some cases we included older publications that contributed to our understanding of the key issues.

We identified Australian experts and purposively searched for their publications. We also identified key Australian journals, such as the *Journal of Imaging and Radiation Oncology* and hand-searched current publications' *Table of Contents* to ensure we had identified the most recent and relevant material. A second round of culling was undertaken based on reading the abstract or executive summary of each paper. This methodology has revealed approximately 60 items. Where readily accessible, the full text copies of relevant papers/reports were reviewed. In addition we surveyed a wide range of practice or 'grey' literature sites to identify relevant sources that may not have appeared in the published literature. We focused on health related government sites, professional associations as well as some recognised grey literature hubs.

Table 1 **Search strategy**

Academic Literature		Period	Primary Search Terms	Secondary Search Terms
Databases	<ul style="list-style-type: none"> ▪ MEDLINE/PubMed ▪ CINAHL ▪ PsycINFO ▪ Rural and Remote Health ▪ Cochrane Library ▪ DARE ▪ TRIP ▪ Health Reference Center 	2000 - 2010	Radiotherapy Radiation Therapy* Radiation	Treatment Barriers Evidence Based Practice Treatment Effectiveness Evaluation
Practice Literature		Period	Primary Search Terms	Secondary Search Terms
Web site domains	<ul style="list-style-type: none"> ▪ All Commonwealth and State government web-sites ▪ NZ Government ▪ UK Government ▪ US Government ▪ Canadian Government ▪ French Government ▪ Singapore Government ▪ Joanna Briggs Institute ▪ Royal Australian & NZ College of Radiologists (equivalent professional associations in NZ, Canada, UK and US) ▪ Health Technology Assessment sites (international) ▪ Kaiser.edu.org ▪ Rand corporation ▪ IHI.org ▪ UK Policy Hub (http://www.nationalschool.gov.uk/policyhub/) ▪ NHS National Institute for Health and Clinical Excellence ▪ US National Center for Policy Analysis ▪ New York Academy of Medicine Grey Literature Report ▪ GreyNet – the Grey Literature Network Service ▪ WHO and OECD web-sites 	2010	Linear accelerator\$ Radiotherapy treatment machine\$	Extended hours treatment Week-end treatment Patient treatment preferences Facility size Radiotherapy throughput Workload Practice standards

2 Overview of the literature

2.1 Scope

From our primary search, we examined the literature to identify evidence relating to options for increasing capacity of radiotherapy facilities. The question we sought to particularly explore was: what are the implications of extended hours of operations for radiotherapy services? There are several current publications that specifically address this issue, predominantly emanating from the UK.

2.2 Exclusions

Whilst there are many factors that influence the model of care and service delivery of radiotherapy, this targeted literature review focuses particularly on the feasibility and 'value for money' of extended hours operation.

It is not our role to make judgements about what actions may or may not be required but simply to present the evidence within the literature.

2.3 Schema for evaluating the evidence

The focus is on including the best available evidence. The strength of the evidence has been assessed through the use of the classification system shown in Figure 1. The first five levels are hierarchical and relate to the strength of the evidence on interventions. The last five have been used to summarise evidence on relevant aspects of radiotherapy utilisation.

Figure 1 *Schema for summarising the strength of the evidence*

1. **Well-supported practice** – evaluated with a prospective randomised controlled trial
2. **Supported practice** – evaluated with a control group and reported in a peer-reviewed publication
3. **Promising practice** – evaluated with a comparison group
4. **Acceptable practice** – evaluated with an independent assessment of outcomes, but no comparison group (e.g., pre- and post-testing, post-testing only, or qualitative methods) or historical comparison group (e.g., normative data)
5. **Emerging practice** – evaluated without an independent assessment of outcomes (e.g., formative evaluation, service evaluation conducted by host organisation)
6. **Profiles** of treatment population (e.g., routine data)
7. **Service planning parameters** (e.g., legislation, policy)
8. **Patients' views** (e.g., surveys, interviews)
9. **Expert opinion** (e.g., peak bodies, government policy)
10. **Economic evaluation** (including service utilisation studies)

This system of evaluating and summarising the evidence for interventions was designed at the CHSD and is based on hierarchies originally developed by other organisations. In its document on developing clinical practice guidelines, the National Health and Medical Research Council of Australia (National Health and Medical Research Council 1999) states that '*recommendations ... should be based on the best possible evidence of the link between the intervention and the clinical outcomes of interest*'. This requirement is equally important in the field of social and educational interventions, where the goals of providing maximum benefit with minimum harm and acceptable cost also apply.

2.4 *The academic literature*

There is a reasonable amount of literature relating to increasing capacity for radiotherapy facilities. The most common themes that emerged from this literature relate to workforce availability and staffing, financial costs, aspects of efficiency and patient preferences.

However, very few articles identified through our search strategy, specifically focussed on working extended hours. The articles we did find explore the financial costs of extended hours, the impact of working extended hours on waiting lists, staffing levels required and patient preferences for appointment times outside 'normal' hours. Three of these articles were from the UK whilst the other two were from Australia and Canada.

We reviewed a range of other articles more generally linked to the issue of extended hours operation. These articles have been published in a variety of journals. The most common sources of academic literature are highlighted in Table 2 together with the number of articles that appeared in that particular journal.

Table 2 *Journals generating most relevant academic literature*

Journal	Country of origin	Number
Australasian Radiology/ Journal of Medical Imaging and Radiation Oncology	Australia	14
Radiotherapy and Oncology	Denmark	11
Clinical Oncology	United States	8
International Journal of Radiation Oncology-Biology-Physics	United States	8
Journal of Radiotherapy in Practice	United Kingdom	2

Whilst just under half of the papers were published from 2006 onwards most of the papers refer to research undertaken at the beginning of the millennia. Our search limits specified academic literature published between 2000 and 2010.

One article has been particularly influential in writing this review. This paper by White et al. (2007) is a review of extended hours working patterns within UK cancer centres from the perspective of both service managers and patients. Service managers were surveyed (response rate of 92%) to gain an understanding of their experience of working extended hours and its effects on staffing and efficiency whilst patients completed questionnaires to gauge their opinion of attending the clinics after hours. Themes that emerged from this paper have been very helpful and have contributed to the structure of this report.

Many papers used in this review focus upon the financial costs radiotherapy. However, they reveal a considerable variation in the costs based upon the differences in the methodology used and on the differences in the included costs components and radiotherapy activities.

No systematic reviews were identified and similarly no randomised controlled trials were found. In fact, with regards to research design the quality of evidence is limited to an analysis of routine data collected from national minimum data sets or from routine data collected at single study sites.

2.5 *The practice literature*

A search of the practice literature relating to radiotherapy identified Australia and the United Kingdom as most prolific in developing and publishing reports and material related to workforce planning and the use of extended working hours in radiotherapy service provision. Europe has also been strong in producing literature relating to the radiotherapy workforce, however, there

were few reports that discussed extended working hours in radiotherapy among the practice literature. While Canada and the United States were also strong in radiotherapy research and planning, there was very little practice literature relating to the use of extended working hours or out of hours service provision in radiotherapy. Very little practice literature relating directly to out of hours treatment was found for New Zealand or countries in Asia. In summary, while the practice literature often focussed on workforce requirements there was less information (if any in some cases), about the use of extended working hours or patient and staff preferences in relation to out-of-hours service provision.

Australian practice literature in radiotherapy has been stimulated by the Single Machine Unit Trial in Victoria and the National Radiation Oncology Inquiry (Baume 2002). In addition the work of the Australian Government Department of Health and Ageing Radiation Oncology Reform Implementation Committee (RORIC) and Radiation Oncology Jurisdictional Implementation Group (ROJIG) has also contributed significantly to practice literature in this field⁴

The Royal Australian and New Zealand College of Radiologists (RANZCR), as part of the Tripartite Committee, have produced a number of reports including the development of standards in radiation treatment (Faculty of Radiation Oncology, Australian Institute of Radiography et al. 2005) and the management of waiting lists for radiation therapy (The Royal Australian and New Zealand College of Radiologists 2005). There are a number of state government based cancer and radiotherapy planning, service framework and review documents, particularly with a focus on NSW, Victoria and Queensland (Victorian Government Department of Human Services 2007; Queensland Health 2008; NSW Department of Health 2010). The Tasmanian Government (Undated) has also produced a document including radiation therapy workforce planning information. The NSW Cancer Institute (2009) has auspiced a business improvement strategy for radiotherapy in NSW. The NSW Cancer Council (2009) has also produced a road map for improving radiotherapy services in NSW.

In June 2004, the Council of Australian Governments (COAG) commissioned the Australian Productivity Commission to examine the pressures on the health workforce and propose solutions to them. The resulting report '*Australia's Health Workforce*' identified a diverse range of issues common across many workforce groups (Productivity Commission 2005). The Clinical Oncological Society of Australia and the Cancer Council Australia (2005) and the RANZCR (2005) produced submissions to the Productivity Commission which provide useful insights into the pressures upon the radiotherapy workforce.

The United Kingdom has developed a number of excellent resources in relation to radiotherapy workforce capacity. The National Radiotherapy Advisory Group (NRAG) has produced several quality reports around radiotherapy service provision. These include a comprehensive report aimed at developing a world class radiotherapy service for England (National Radiotherapy Advisory Group 2007), a detailed report on capacity and efficiency in radiotherapy (National Radiotherapy Advisory Group 2006), a report on predicting future demand for radiotherapy (National Radiotherapy Advisory Group 2007) and a report by the NRAG workforce sub-group (National Radiotherapy Advisory Group 2006) on the provision of radiotherapy services. The UK College of Radiographers (Beardmore 2005) have produced a report on short term guidance for radiographic staffing. The Royal College of Radiologists has also been active in developing guidelines in service planning. These include a guide to planning radiology services (Royal College of Radiologists 2008) and a report on equipment, workload and staffing for radiotherapy in the UK from 1997-2002 (Royal College of Radiologists 2005). A report by the National Health Service in Scotland outlines radiotherapy activity planning from 2011-2015 for Scotland (Scottish Executive Health Department 2005). Cancer Research UK have produced a report on achieving a world class radiotherapy service across the UK which follows up on earlier documents on

4 Available at: <http://www.health.gov.au/internet/main/publishing.nsf/Content/health-roi-inquiry-report.htm> accessed 2 February 2011.

developing radiotherapy services (Gilbert and Jackson 2009). The UK also has a number of broader cancer documents that also provide information on radiotherapy practice, including the NHS cancer plan progress report (National Audit Office 2005).

Practice literature identified from European countries included mainly work done on the ESTRO QUARTS study and radiation safety reports. Radiotherapy planning in Europe has been characterised by the QUANTIFICATION of Radiation Therapy Infrastructure and Staffing Needs or QUARTS study that was undertaken in 2003-04 (Heeren, Slotman et al. 2004). This project was a survey of radiotherapy services in Europe.

The World Health Organisation has also published a number of reports, including a series of Cancer Control Guides for effective programmes, including a report on diagnosis and treatment of cancer (World Health Organisation 2008b).

Radiotherapy research in Canada has been lead by the organisation Cancer Care Ontario. This organisation has produced a report relating to access (Hanna 2009) as well as a web-based resource that gives up to date information on waiting times and radiation treatment utilisation and other aspects of radiotherapy services provision⁵.

A search of the practice literature in the United States produced only a few documents, for example, a report published by the American Association of Physicists in Medicine on the solo practice of medical physics in radiation oncology (American Association of Physicists in Medicine 2003).

Relevant practice literature was not identified for countries in Asia, including Singapore.

⁵ Source: <http://csqi.cancercare.on.ca/cms/One.aspx?portalId=63405&pageId=65668> accessed 23 Sep 2010

3 Findings

The major findings within the academic and practice literature are synthesised in this section of our report.

3.1 Options

Options for increasing capacity of radiotherapy facilities fall broadly under three headings:

1. Increase the number of linear accelerator machines available
2. Work existing machines smarter
3. Work existing machines harder

The first option is not addressed as this would require a comparative analysis of the various models used internationally to estimate the number of linacs required for given populations and treatment rates, this is out of scope. Option two is considered briefly, however full exploration of this option leads to the literature from operations research and quality improvement and is not the particular focus of this targeted literature review. As our brief centres on the issue of extended hours operation, option three is most relevant. In addition, NSW Health already has strategies underway for options one and two, hence the focus on option three.

3.1.1 Work existing machines smarter

This option to increase capacity is based on the belief that effective business process improvements can streamline service delivery and eliminate redundancies and inefficiencies allowing personnel to work existing machines 'smarter'. Redesign is about improving the processes underpinning the delivery of clinical care (Cancer Institute NSW 2009). Additional capacity is generated by these new efficiencies (Scottish Executive Health Department 2005).

Much of the literature exploring this option comes from the field of operations research and considers strategies such as queuing theory, waiting list management and a range of other business process improvement strategies. What is implicit in the business process improvement literature is the principle of extracting better utility and value from the machines and resources you have.

In NSW the 'Radiotherapy Business Improvement Process' found an across-the-board willingness to improve business processes in all participating centres which allowed all centres to treat significantly more patients compared to baseline, during the project period (Cancer Institute NSW 2009). In 2009, a suite of tools was rolled out to all the public radiotherapy centres in NSW, as part of this business process improvement project. These tools provide significant potential for performance and quality improvement through improved monitoring of key performance indicators relating to wait times, categories of patients etc. (NSW Department of Health 2009).

3.1.2 Work existing machines harder

Those not directly involved in managing radiotherapy services often feel that the hours of use of this expensive equipment should be as high as possible to 'sweat the assets' (National Radiotherapy Advisory Group 2006). However approximately 50% of the cost of running a radiotherapy service is attributable to staff and 30% to equipment and maintenance costs. The remaining 20% includes cost inputs relating to space, materials and departmental overheads. (Kesteloot et al. 2000, Lievens and Slotman 2003; Bentzen, Heeren et al. 2005).

There are several models in the practice literature that have been tried in various radiotherapy centres which vary:

- Number of treatment fractions delivered per hour
- Working hours a day
- Working days a week
- Working days a year (Scottish Executive Health Department 2005; National Radiotherapy Advisory Group 2006).

The number of fractions per linac hour depends on a number of factors including case-mix and the ability of the machine to support for example auto sequencing (Scottish Executive Health Department 2005).

Radiotherapy facilities, like most outpatient departments, have traditionally based appointment times around a 9.00 am to 5.00 pm, 5 day working week. For radiotherapy facilities that are struggling to meet demand one option for an immediate increase in capacity is to extend the working hours (National Radiotherapy Advisory Group 2007; White, Beckingham et al. 2007)). This means that the existing pool of linear accelerators will need to be run for longer periods.

This approach could also potentially benefit patients by providing them with more choice of appointment times causing less disruption to their daily commitments during treatment (Calman, White et al. 2008). This option is reliant on an available and appropriately skilled workforce.

In Australia the Radiation Oncology Jurisdictional Implementation Group (ROJIG) planning parameters for linear accelerator capacity are as follows:

- 4.1 attendances per hour;
- 8 operating hours per day⁶;
- 240 working days per annum;
- 25% re-treatment rate (Radiation Oncology Jurisdictional Implementation Group 2003).

From the ROJIG parameters, the maximum capacity for a linear accelerator is 414 courses of treatment per year⁷, consisting of 331 new patients and 83 patients (25% of 331) being re-treated.

There are several considerations in determining the viability of extended hours services including:

- The impact on clinical treatment regimes (ensuring adequate time for tissue recovery between treatments);
- The demand for palliative radiotherapy (which has a different treatment regime to therapeutic radiotherapy);
- The current status of waiting times for commencement of radiotherapy.

3.1.3 Key factors

We have structured our findings around four factors that most frequently appeared in the literature relevant to extended hours of operation in radiotherapy. These include issues relating to:

- Workforce
- Costs

⁶ Victoria has different award agreements and operates on 8.5 operating hours per day.

⁷ Victoria radiotherapy planning adjusts this parameter to 450 courses of treatment per year for a linear accelerator. Victorian Government Department of Human Services (2007). Victorian Radiotherapy Service Plan. Metropolitan Health and Aged Care Services Division. Melbourne, Victorian Government Department of Human Services..

- Efficiency
- Patient preferences

Prior to exploring the literature relevant to these factors, we discuss current models of extended hours operation.

3.2 Extended hours models in use

3.2.1 International

White et al.'s (2007) study of extended working hours in UK cancer centres revealed that 95% of all departments involved in the study had experience of using extended working hours. Of this 95%, there were 55.4% of radiotherapy departments currently working extended hours and 39.3% that only had short term experience of working extended hours. Short term extended working hours were most often used to compensate for reduced capacity during machine breakdowns or increased demands on the service. More recently in the UK, a number of departments have implemented long-term, sustained extended hours to address waiting lists.

The study revealed five different models of working arrangements to extend the working day. The most cost-effective model used four radiographers each working two shifts and extending the working day by one hour at the start of the day and two hours at the end of the day, to give an 11.5 hour day. This model provided a 31% increase in fractions at a cost increase of only 1.8% per fraction. This is a shift pattern that has been shown to be sustainable over a prolonged period of time (White et al., 2007). However, it allows for only two radiographers on the machine for 78% of the day with no allowance for service development or the learning of new techniques, a process that is essential in any modern department. It is significant that one-third of these departments stated that they would not be able to implement extended hours again without an increase in staff and the radiotherapy budget.

The authors also compared different shift patterns for radiographers. A standard five day working week was compared with a four day week involving an individual working their contracted hours over four days, rather than five days, with a rolling day off. A nine day fortnight was also considered involving some shift work for staff. Overall the nine day fortnight was found to be the most cost-effective method for organising radiotherapy staff (White et al., 2007).

The option of adding a sixth day was considered with cancer centres operating on a Saturday. For this to be effective it was found that the centre would have to stay open for a significant part of the day. Ideally the Saturday should include all members of staff and peripheral services as it would not be cost-effective or good governance to open a centre just for a few hours using a skeleton staff. However, it was revealed that a sixth day would also potentially require a 20% increase in staff on every machine working the additional day.

These findings highlight that the delivery of radiotherapy is multidisciplinary and that additional staffing costs are not just limited to radiographers. Any additional hours worked by radiographers should also be reflected in the working patterns of physicists, engineers, treatment planners, medical staff, nurses and clerical workers. This is significant since staff have been shown to account for about 50% of the costs of operating a radiotherapy department (Lievens and Slotman 2003; Bentzen, Heeren et al. 2005).

In another paper from the UK, Routsis et al. (2006) reviewed a number of different patterns of machine use to investigate which delivers the greatest return on radiographer time. Results revealed that the working pattern requiring the least radiographer time per machine hour is a seven hour day. Provided part-time radiographers are available to cover the lunch breaks, eight

hour days can be achieved as efficiently, while increasing capacity. Small extensions to the length of the working day beyond this require significant increases in radiographer time per linac-hour.

This study highlighted the pitfalls of operating extended working days. The additional hours worked often occur when back-up or support services in the hospital are no longer available. This could be an issue if linac machines breakdown creating an adverse effect on patient throughput. There may be difficulties with patient attendance at these times or the absence of complimentary services such as pharmacy or transport. The authors warn that operating extended working days may also adversely impact on staff recruitment and retention in a service with existing staffing difficulties.

The NRAG Capacity and Efficiency Sub-Group (2006, pp.3-4) reported that working an extended day of 11.5 hours was feasible and can be an economical use of radiography staff, however the impact on related staffing groups required to provide multidisciplinary patient care must be available to provide equitable care to patients attending outside of core service hours. The planning recommendation notes that linacs within the UK context, should be run at an average of 9.2 hours per day and only a minority of the machines in the department should run the extended day. Radiotherapy departments should operate 239 days per year, a standard five day week, closing only for three bank holidays and allowing no more than 19 days for QA/servicing a year (National Radiotherapy Advisory Group 2007). In the case of larger departments (with seven or more linacs), this workload appears to be predicated on radiotherapy departments having a 'service efficiency machine' i.e. an additional machine in use 50-75% of the time thereby providing capacity to deal with unexpected peaks in workload of linac breakdown (National Radiotherapy Advisory Group 2006).

The number of operational hours per day achievable on a linac is dependent on several factors. These include the availability of the staff required to operate and maintain the equipment, the willingness of patients to attend and the time required per day for non-operational factors such as quality checks, training and research and development (National Radiotherapy Advisory Group 2006). A key message is that it is not advisable to work all machines in a department in an extended hours model.

Internationally the whole of radiotherapy practice is based on a 5 day working week. Whilst this has arisen because of social convenience, nevertheless, recommended doses for radical treatment have been developed and proven over the years on this basis. There are very few studies of altered fractionation (National Radiotherapy Advisory Group 2006). Alterations to therapy could not be accepted without evidence from randomised clinical trials because of the risk of adversely changing the therapeutic ratio and harming patients. On this basis, alterations in the working week to include Saturdays would pose complex scheduling problems. Only a seven day week would avoid this issue but is unlikely to be attractive to radiography or physics staff. The alternative is to use Saturdays for single palliative treatments.

The NRAG planning recommendation is for radiotherapy to be provided over a standard five day working week with some servicing, palliative radiotherapy and Continuous Hyperfractionated Radiotherapy (CHART) only on Saturdays and CHART on Sundays (National Radiotherapy Advisory Group 2006).

The following models (refer to Figure 2) are excerpted directly from the NRAG report (National Radiotherapy Advisory Group 2006). They look at five permutations where the hours per day and number of bank holidays are varied for a given number of linacs.

The NRAG report (2006) concludes that these models demonstrate the linac activity of 8,000 fractions per machine per year is achievable in the English context. This is currently achieved by 50% of machines and therefore could be achieved by the remaining units (dependent on funds for staff and on overcoming recruitment difficulties). This report recommends over the next three to

four years an increased activity to 8,300 fractions per linac per year and in the longer term a further increase to 8,700 fractions per linac per year throughout England.

Figure 2 *Five models for radiotherapy service delivery from the NRAG report*

Model A (8 hour day, 8 Bank Holidays)	
Parameter/Calculation	Value
Days per annum	234
Hours per day	8
Hours per annum (Days per annum x hours per day)	1,872
Less downtime @3%	56
Available hours	1,816
Results	Value
Activity at full capacity and 4 fractions per hour	7,264
Activity at 87% capacity and 4 fractions per hour	6,320
Activity at full capacity and 4.5 fractions per hour	8,172
Activity at 87% capacity and 4.5 fractions per hour	7,110

Model B (8.5 hour day, 3 bank holidays, working other 5 at half capacity)	
Parameter/Calculation	Value
Days per annum	236.5
Hours per day (increased for Agenda for Change)	8.5
Hours per annum (Days per annum x hours per day)	2,010
Less downtime @3%	60
Available hours	1,950
Results	Value
Activity at full capacity and 4 fractions per hour	7,800
Activity at 87% capacity and 4 fractions per hour	6,786
Activity at full capacity and 4.5 fractions per hour	8,775
Activity at 87% capacity and 4.5 fractions per hour	7,634

Model C (1/3 of machines 11.5 hour day, 2/3 8 hour day 8 bank holidays)	
Parameter/Calculation	Value
Days per annum	234
Hours per day	9.17
Hours per annum (Days per annum x hours per day)	2,145
Less downtime @3%	64
Available hours	2,081
Results	Value
Activity at full capacity and 4 fractions per hour	8,324
Activity at 87% capacity and 4 fractions per hour	7,241
Activity at full capacity and 4.5 fractions per hour	9,365
Activity at 87% capacity and 4.5 fractions per hour	8,147

Model D (7 linacs: 3 on 11.5 hour day, 3 on 8 hour day, 1 service continuity machine; 3 bank holidays, working other 5 at half capacity)	
Parameter/Calculation	Value
Days per annum*	255.5
Hours per day 3 linacs @	11.5
3 linacs @	8
Hours per annum (Days per annum x hours per day)	14,947
Less downtime @ 1.5%	224
Available hours	14,723
Results per linac	Value
Activity at full capacity and 4 fractions per hour	8,413
Activity at 87% capacity and 4 fractions per hour	7,319
Activity at full capacity and 4.5 fractions per hour	9,465
Activity at 87% capacity and 4.5 fractions per hour	8,234

* Note that there is no scheduled maintenance factored in here because the service continuity machine will be used instead of the main linac. Unscheduled downtime will also be reduced as the service continuity machine will be available approximately half the time to be used in its place.

Model E (1/2 of machines 11.5 hour day, 1/2 7.5 hour day 3 bank holidays, working other five at half capacity)	
Parameter/Calculation	Value
Days per annum	236.5
Hours per day	9.5
Hours per annum (Days per annum x hours per day)	2,247
Less downtime @ 3%	67
Available hours	2,180
Results per linac	Value
Activity at full capacity and 4 fractions per hour	8,720
Activity at 87% capacity and 4 fractions per hour	7,586
Activity at full capacity and 4.5 fractions per hour	9,810
Activity at 87% capacity and 4.5 fractions per hour	8,535

The NRAG (2007) outlines the performance expectations for linacs throughout England. Each linac is expected to deliver between 4 and 4.5 fractions per hour; with linacs within a radiotherapy department working an average of just over nine hours per day with a minority of the machines running for an extended day of 11.5 hours.

In Scotland, the current average service model is five fractions per clinical hour, 7.25 hours per day, five days per week and 240 days a year (noting that some linacs are working longer to meet service pressures in local areas). The Scottish Executive Health Department, Report of the Radiotherapy Activity Planning Group (2005) recommends increasing the core clinical service to a

ten hour day, five day week with a reduction in days lost as a result of closure for public holidays and routine maintenance to achieve 257 clinical days per annum.

Whilst the Scottish Executive considered the option of extending the working week from five days to six days per week, the National Health Service NRAG Capacity and Efficiency Sub-group (2006, p.17) concluded that:

'...it is likely that fractionation schedules of five fractions per calendar week will remain in most cases.'

This means that no significant increase in capacity will result from a change to a six day working week, since if patient schedules require a two day gap (Sat/Sun or Sun/Mon) then half the capacity will be unused on Saturdays and Mondays, giving no benefit from the change.

White's (2007) survey of radiotherapy managers revealed that some cancer care departments in the UK are running a short extension on several machines, whereas others are working a much longer day on just one or two machines. The pros and cons of both models are neatly summed up in the following quote:

'Clearly, spreading the additional workload across several machines is only an option for larger departments. However, a department that operates extended hours on most machines risks problems when a machine breaks down. There is less flexibility to maintain treatment continuity as there will be more patients to redistribute and less available time in the day in which to reschedule. Interruptions to planned radical courses of treatment have been shown to worsen outcomes and should be avoided at all costs.' (White, 2007, pp.220).

In conclusion, effective and efficient staffing of linear accelerators is a very complex subject, with many variables contributing (Routsis, Thomas et al. 2006).

3.2.2 National

The NSW Audit Office (2009) found that most radiotherapy services in NSW work within the normal working week, only using weekends and public holidays for emergency cases. They also found services will work extended hours for short periods, e.g. 8am to 8pm, to deal with extended waiting lists.

In Victoria, whilst the usual operating day is 8.5 hours, extended hours have been provided by some centres with 10 hour operating days and some Saturday services (Victorian Government Department of Human Services 2007).

The current NSW Strategic Plan for radiotherapy services up to 2016 (2010, p.36), states that:

'Extending working hours to weekends and other options are available to consider for improving efficiency and utilisation of equipment. NSW has invested significant funding in radiotherapy services and exploring options to better utilise those resources are recommended.'

Extended working hours may be used to deal with waiting lists, however, the Royal Australian and New Zealand College of Radiology (RANZCR) (2005) argue that it is generally not sustainable in the long term when a major reason underlying difficulties with access is staff shortages. It is not recommended that departments adopt this approach as a long term strategy. One suggestion given by RANZCR is an approach similar to that used in Canada where a rapid response clinic provides a one stop shop on Saturdays. Patients are seen, planned and treated with either single dose or two fraction schedules, accommodating palliative patients with minimum inconvenience (The Royal Australian and New Zealand College of Radiologists 2005).

In the Baume Report (2002) it was stated that if working extended hours, facilities must consider staff availability and willingness to work extended hours. An example of one facility was given who reported that extended hours increased the social cost of staff and made it more difficult to recruit and retain staff.

3.3 Workforce

The literature relating to radiotherapy is replete with the reported difficulties of recruiting radiotherapy staff and radiotherapy staff shortages (Baume 2002). The availability of staff and appropriate skills mix will be the rate limiting factor for many localities seeking to increase productivity in this way (National Radiotherapy Advisory Group 2007).

International Context

In the US According to the 2002 Radiation Oncology Workforce Study conducted by the American Society for Therapeutic Radiology and Oncology (ASTRO), a shortage of 2.6 radiation oncology healthcare professionals exists per practice (Kresal and Drummond 2004). In the US this shortage has been equated with oversupply in the 1990s leading to a reduction in traineeships, reduced reimbursement from managed care plans, reduced revenues for hospitals, salary stagnation and low unemployment levels (Kresal and Drummond 2004). An increase in the number of cancer cases is also cited as follows:

'Aging of the "Baby Boomer" generation and an associated aging of the U.S. population have led to an increased number of cancer cases putting added stress on the system. Longer working hours, mandatory overtime, and patients who are more demanding, have further increased the problem by creating an unpleasant work environment in an already emotionally trying profession'. (Kresal and Drummond 2004, p. 10).

In the UK it is reported that the demand for radiotherapy is increasing faster than the rate trained radiographers become available and one of the main constraints to radiotherapy capacity is the number of radiographers available (Routsis, Thomas et al. 2006).

The Royal College of Radiologists and the College of Radiographers published a report in 1979 recommending a minimum of four whole time equivalent radiographers to staff a linear accelerator working an eight hour day. Excluding break times, this equates to 0.5 radiographers for every hour the linear accelerator is run (Routsis, Thomas et al. 2006). More recently, a paper by Slotman et al. (2005) revealed that guidelines for the number of personnel (specifically radiation oncologists and physicists) are available in about 45% of the European countries surveyed as part of the ESTRO project. There is considerable variation between countries in part due to the large differences in demographics, cancer incidence and treatment strategies between the various countries. Rather than guidelines, a better approach would be to use the actual incidence rates for the various types and stages of cancer for the various countries and regions to project radiotherapy requirements.

Australian Context

It has been estimated that the health workforce in Australia constitutes just over 8.9% of the total workforce and is one of the largest workforce groups (Brooks 2008).

In addition workforce accounts for the highest proportion of recurrent costs in the delivery of health care services. Expenditure on workforce services currently accounts for about two-thirds of total health care spending (Productivity Commission 2005b). Ensuring an available appropriately trained and affordable health workforce is a significant challenge nationally and for all States and Territories in the future.

Workforce shortages range across health disciplines and specialty areas, particular service areas, and geographic areas. In the face of these shortages, service agencies are examining new ways of responding to demand (e.g. job-redesign, workforce re-engineering and a greater emphasis on community-based care and on self-directed care) (Australian Health Ministers Conference 2004).

Both consumers and government have increasing expectations about the standards, quality, and outcomes of care. With rising incomes, people will spend more on health care and expect timely access to high quality health services (Productivity Commission 2005b). Poorer outcomes are reported as a result of: long waits and delays in emergency care; difficulties in accessing GPs and specialists; and risks associated with unnecessary admissions. Poorer outcomes translate, in terms of workforce impact, to consumers requiring higher levels of care (either ongoing or temporarily) than may otherwise have been required (Productivity Commission 2005b).

For many years, experts have remarked on the relatively diminishing appeal of health-related careers. Once viewed as high-tech, hospital work (for example) is now often viewed as low-tech. The healthcare fields, once seen as secure and stable, are now viewed as somewhat volatile and not as insulated as they once were from market forces (Association of Academic Health Centers 2008). The workforce is ageing and is already overworked and poorly distributed, new professionals with large education debts up to over \$200,000, and demands for a team care approach mean that action needs to be taken to match workforce availability to need (Russell 2007).

The demand for health care is growing at rates that funders (government and private) find difficult to sustain. Technological change will continue to be an important contributor to growing demand for, and spending on, health care. Different models of care and new workforce practices will be required to accommodate and utilise the wider range of treatment possibilities. More efficient ways of using the workforce are being actively sought to ensure acceptable levels of access to services (Australian Health Ministers Conference 2004). In addition, reforms that shift care from hospitals to the community may also generate needs for a different mix of staff and offer opportunities for substitution of one professional group by another (Laurant, Reeves et al. 2004). Given that many health services are labour-intensive, sizeable wage-related cost pressures are likely (Productivity Commission 2005b).

Given these economic pressures, increasing specialisation, changing modes of service delivery and workforce shortages it is not surprising that there is strong support for an approach to health workforce planning that facilitates the development of more consumer-focused and cost-effective ways of using the health workforce. Underpinning these sentiments is the perception that current approaches to workforce utilisation, particularly the utilisation of qualified professionals, are in some cases inappropriate and unsustainable (Australian Health Workforce Advisory Committee, Australian Medical Workforce Advisory Committee et al. 2005).

Radiotherapy workforce

The RANZCR (2005) submission to the Productivity Commission Health Workforce Study notes that workforce matters have been a matter of concern, investigation and report for a significant period. A Tripartite Committee consisting of the professional bodies of Radiation Oncologists, Radiation Therapists and Radiation Oncology Medical Physicists developed in 2001, a *National Strategic Plan for Radiation Oncology (Australia)* with funding from the then Commonwealth Department of Health and Aged Care. The RANZCR notes (2005, p.12):

'The issues impacting radiation oncology have been construed at times as a microcosm of the issues across the health system more broadly, both in regard to service planning, funding and workforce issues.'

The 'Cancer Control and Workforce Stock take and Needs Assessment' describes the present and future requirements for linear accelerators and staff in New Zealand and identifies similar workforce pressures (Ministry of Health 2007).

The workforce groups required in radiotherapy centres include:

- Radiation Oncologists
- Radiation Therapists
- Radiation Oncology Medical Physicists
- Administrative Staff
- Para-Medical Staff (Morgan, Barton et al. 2009)

Workforce supply

A review of radiotherapy workforce requirements in the UK by NRAG (2006) found that the main limiting factor for achieving increased service capacity is workforce. Whilst it was recognised that it was likely that many centres will be required to work an extended day and offer a service on bank holidays and Saturdays, this would only be possible with a larger workforce.

In Scotland, increasing the core clinical working time of radiotherapy services will have major human resource implications (as would increasing the number of linear accelerators) not only for the medical, radiography and physics staff but for all support, administrative and clerical staff. NHS Education for Scotland has agreed to develop a cancer service education strategy that will address current and new roles (Scottish Executive Health Department 2005, p.vi).

The Commonwealth Department of Health and Ageing (Baume 2002) supported state and territory governments examining options for extending the hours of operation of equipment up to 12 hours per day before the end of 2004, and this could be implemented where staff numbers were adequate. Some states, for example Tasmania, determined that with the present fluctuations in staffing levels in Tasmanian radiation oncology services and the predicted worsening situation, it was unlikely that extension of hours of operation would be implemented by this time-frame in Tasmania (Tasmanian Department of Health and Human Services Undated). The Tasmanian Department of Health and Human Services implemented a staff survey which asked radiation therapists if they considered their current workload was about right, too much or too little. Of the 21 radiation therapy respondents:

- 62 per cent stated that their workload was about right
- 33 per cent stated that their workload was too much
- 5 per cent did not respond (Tasmanian Department of Health and Human Services Undated, p.19)

The radiation therapy workforce problems previously evident in NSW have improved considerably over subsequent years for radiation therapists. The vacancy rate for radiation therapists in NSW continued to remain under 5% in 2008. The vacancy rate for qualified and unqualified Radiation Oncology Medical Physicists (ROMPs) across public and private Radiation Oncology Treatment Centres was 15.8% in 2008 (Radiation Therapy Advisory Panel 2001; NSW Department of Health 2009). NSW Health has led nationally, in developing a comprehensive suite of strategies to address recruitment and retention issues for radiotherapy workforce groups. NSW Health's experience of these strategies is that educational support is a key success factor (NSW Department of Health 2010).

The RANZCR noted in their review of waiting lists for radiotherapy (2005) that individual departments may choose to alter the length of the working day to accommodate extra treatment slots for patients. There has been extensive debate as to whether this is cost-effective and safe. Although a potential means of increasing access in the short term, it is generally not sustainable in the long term when a major reason underlying difficulties with access is staff shortages. In

addition, operating extended working hours has an impact on all staff groups, not just the radiation therapists.

Where staff shortages (medical, physics or radiation therapists) contribute to waiting lists, staff redeployment has proven unsuccessful without pre-existing functioning links between departments and within or across Area Health Services. Greater planned cooperation of departments should be encouraged as a potential means to address some of the access and resourcing inequities across some regions and states (The Royal Australian and New Zealand College of Radiologists 2005, p.9).

A National Health Workforce Agency, known as Health Workforce Australia was established as part of the Council of Australian Governments, \$1.6 billion health workforce reform package. This entity is a statutory authority established by the *Health Workforce Act 2009* and will report directly to Health Ministers. Their role includes providing advice on projected workforce shortages (NSW Department of Health 2010).

Workforce redesign

The NRAG report (2006) notes that skill mix and flexible working are often cited as some of the solutions to workforce capacity issues. However in practice, much of this is due to lack of staff rather than true redesign needs of the workforce. The solutions suggested by this group include:

- Changes in skills mix and current working patterns are required which should include role redesign challenging current practice;
- New and extended roles within and across traditional boundaries should be developed utilising skills and competences to give greater efficiency, job satisfaction and career progression;
- Accredited Education and Training will be essential to support this;
- Education and training packages should be developed to support changes in technology and the increases in capacity which reflect the skills and competences required irrespective of the profession;
- Many centres will be required to work an extended day and offer a service on bank holidays and Saturdays; this will require a larger workforce.

Whilst many workforce strategies are longer term, there is interest in workforce redesign focussing on skills (rather than job titles) to address shortages and recruitment difficulties. This may include the applicability of advanced practitioner roles in radiotherapy (National Radiotherapy Advisory Group 2007; Australian Institute of Radiography Advanced Practice Working Group 2009).

Stress and burnout

In the UK, a contributing factor to the low numbers of available radiographers is the poor retention rate from both the radiographer training courses and the newly qualified. Job satisfaction has a large impact on retention of qualified staff. Improved professional development opportunities are likely to positively impact upon retention rates (National Radiotherapy Advisory Group 2006).

A questionnaire consisting of various aspects of radiology-specific work stress and job satisfaction was sent to all radiologists in New Zealand. This study found that radiologists in the public hospital environment experience more work stress, a lower level of job satisfaction and higher rates of burnout compared to private practice. The present study highlights the various aspects of work stress important to radiologists, so that they can be addressed to improve their mental health. Additionally, the results of this study may have implications for workforce planning, recruitment and retention of related radiotherapy specialities in the public health system (Lim and Pinto 2009).

The social costs to employees of extended hours may also impact on recruitment and retention rates for various radiotherapy treatment centres (Baume 2002).

The social costs to employees of extended hours may also impact on recruitment and retention rates for various radiotherapy treatment centres, particularly those in rural or regional areas where workforce availability can be very different compared to metropolitan services (Baume 2002, Victorian Department of Human Services-undated).

3.4 Costs

Staff have been shown to account for about 50% of the costs of operating a radiotherapy department (Lievens and Slotman 2003). It is recognised that to implement a longer working day across radiotherapy services would incur substantial increases in payroll costs, whether through overtime or an increase in staff (White, Beckingham et al. 2007).

The report issued by the Centre for Health Economics Research and Evaluation, based in Sydney, published in 1993 (Smith R, Jan S et al. 1993) is one of the first reported studies of options for the expansion of radiation therapy services in NSW. Two options were compared: Option 1; increase the overtime performed by existing staff and use capital more intensively or Option 2; invest in new capital with associated increases in levels of staffing. Based on the actual operation of a four-machine service at Westmead Hospital, the authors concluded that Option 1 was most efficient for workloads up to 98,525 fields per year, but at higher rates of throughput this option was unfeasible. This result is 24,630 fields on average for each machine annually (Smith R, Jan S et al. 1993; Smith, Jan et al. 1995; Capital Insight 2007) or the equivalent of 1,970 to 2,190 individual courses of treatment (Baume 2002, p.95). Whilst short term fluctuations in demand may be met most cost effectively by increasing the intensity of operation of existing capacity, a capital investment program was required to meet long term increases in demand.

The total treatment activity for all NSW Radiation Oncology Treatment Centres in 2008 was 293,252 fractions (70,951 were provided in the private sector and 222,301 fractions in the public sector) (NSW Department of Health 2009).

Smith et al. (1995) identified the key cost factors relating to working extended hours as increases in staff overtime and increases in the rate of use-related depreciation of capital equipment. The key cost factors relating to the purchase of equipment related to the cost of linear accelerators and the recruitment of new staff. The results of this case study suggest that as demand for radiation therapy services increases, the delaying of, rather than early, capital investment by working existing facilities more intensively need not be more cost efficient (Smith, Jan et al. 1995).

The ACIL report (1998) found that for working days up to 12 hours, there is a decrease in the average cost per patient treated. After this, the costs increase, mostly because of the high penalty rates paid for radiation therapists.

Another example of an attempt to investigate the economic effects of changes in selected operational parameters within a radiation treatment program was carried out in Canada in the late 1990's. This study by Dunscombe et al. compared the costs per standard treatment course for four work weeks in a fully utilised four machine facility based on a 40 (1600 patients treated per year), 48 (1920 patients treated per year), 50 (2000 patients treated per year) and 60 hour week (2400 patients treated per year). The study revealed that extended hours of operation did not appear to generate significant, if any savings when realistic assumptions about machine lifetime and overtime payments were made (Dunscombe, Roberts et al. 1999). The study does not address another key driver for extended hours of operation which is to reduce waiting times. Savings may not be the primary consideration.

Much of the literature in the 1990s relating to the costs of radiotherapy reveal a considerable variation in the computed costs based upon the differences in the methodology used and on the

differences in the included costs components and radiotherapy activities (Lievens and Slotman 2003). More recently, a paper by Bentzen et al. (2005) discussed how an Activity-Based Costing model could be used to measure the costs of radiotherapy more accurately. They make the point that even in this era of very sophisticated (and costly) radiotherapy equipment, personnel costs remain the most important cost component of a radiotherapy department. This study casts doubt on the assumption that more sophisticated equipment will reduce personnel need and the associated service delivery costs. More sophisticated radiotherapy equipment, without increases in personnel does not necessarily equate to increases in productivity. Higher patient numbers will inevitably require new capital investments, as well as increases in the numbers of personnel. However in the short term the use of overtime hours may help to cope with small increase in workload (Lievens and Slotman 2003).

A report by the Royal College of Radiologists in the UK (2005, p.12) argued that it may not be cost effective to extend working hours, citing reports from the 1990's which suggested that working extended hours may be more costly than purchasing an extra linac to work during normal hours.

The Scottish Executive Health Department (2005) note that preliminary economic evaluation suggests that a ten hour day, five day week is the most cost effective option for Scotland with the establishment of additional radiotherapy treatment centres and machines the most expensive.

The cost of staff overtime payments and the impact on machine lifetime in some scenarios will outweigh the potential savings from extended hours (National Radiotherapy Advisory Group 2006).

3.5 Efficiency

A number of models exist which can be used to project linear accelerator requirements for a population. Throughput benchmarks for linear accelerators are another way that countries try to maximise efficiency and machine performance. (Barbera, Jackson et al. 2003; Slotman and Leer 2003; Royal College of Radiologists 2005; Scottish Executive Health Department 2005; National Radiotherapy Advisory Group 2007; Victorian Government Department of Human Services 2007; NSW Department of Health 2010).

The RANZCR (2005) recognises the scope for reviewing and if necessary redesigning or improving work practices across the service continuum from consultation to planning and to treatment delivery. They advocate for the introduction of national benchmarking as part of the process to integrate accreditation into practice and encourage sharing between members of work practices that deliver improvements in efficiency while maintaining quality and safety. Improvement in throughput of only a few percent may result in proportionately large gains in waiting time reduction. Flexibility in scheduling, for example by providing the wherewithal to offer same day appointments to fill gaps, and diverting resources to areas of potential bottleneck are established means of improving waiting times within available resources.

Radiotherapy treatment centres need to develop and benchmark a set of key performance measures. This will require a workload measure that facilitates comparison of centres with different case-mixes and different techniques (Cancer Institute NSW 2009; NSW Audit Office 2009). The Cancer Council, NSW (2009), supports continued acceptance of the international benchmark of 52.3% of patients with notifiable cancer with an approximate re-treatment rate of 25%. The ROJIG and NSW Health recommended throughput rate of 331 new patients treated with radiotherapy per linear accelerator per year, is also supported (NSW Department of Health 2010).

In 2006/07, in conjunction with the Cancer Institute NSW (CI NSW), a Business Process Improvement (BPI) project was undertaken for radiotherapy services in NSW. This was completed

in 2009. The BPI project has demonstrated that improvements in business processes, such as more efficient utilisation of patient bookings, improved schedules for liaison with radiation oncologists for signing off plans; improved procedures for gaining patient consent in a timely manner; improved scheduling of clinic bookings and communications, have resulted in incremental increases in numbers of patients treated on the linear accelerators and reduced times from consultation to treatment completion. These improvements have been realised without additional costs, and within existing staff and machine capacity, and with “buy-in” in the process improvements by the staff involved, and demonstrate that improvements have been made within the existing infrastructure more effectively.

Delaney et al. (2005) discuss the effect that the age of linear accelerators and recent changes in technology have had on linear accelerator throughput in New South Wales, Australia. Specific analyses were carried out to assess the effect that new technologies, such as automatic field-sequencing (AFS) and multi-leaf collimator (MLC), have had on fraction duration. The application of AFS and MLC, and the use of newer linear accelerators, resulted in shorter treatment times for common treatment techniques. Foroudi et al. (2000) demonstrated the differences in efficiency generated by using linacs with and without a multi-leaf collimator (MLC) in a radiation oncology department in Sydney. Whilst this cost study was completed some time ago, it did show that linacs with MLCs were demonstrably more efficient, and while their capital costs were higher, the reduction in labour costs associated with block cutting and, particularly the increased throughput, more than offset these initial costs.

Fractionation schedules for radical and palliative treatment differ. Far fewer fractions are required for palliative treatment which means that it does not have to be delivered over a five day schedule (Hui, Berry et al. 1999). Palliative radiotherapy has been delivered on Saturdays in the UK to improve utilisation of radiotherapy infrastructure. Availability of staff and the appropriate skills mix has been the rate limiting factor for many localities seeking to increase productivity this way (National Radiotherapy Advisory Group 2007).

Routsis et al. (2006) commented about the advantages of using two radiotherapy treatment units operating side by side. In this instance, both treatment units would operate a 9 am to 5 pm working day resulting in larger increases in capacity with the same number of staff required for an extended day. This would have the additional benefit of providing a backup for unplanned machine breakdowns and staff absences. A second linear accelerator offers double the choice of preferred appointment times for patient (Routsis, Thomas et al. 2006).

Bridge et al. (2003) in their overview of staffing and equipment levels in the UK concluded that extended working hours impacted on the reliability of linac machines. This in turn created more unscheduled interruptions than normal due to additional maintenance and/or servicing sessions.

White et al. (2007) outlined the risks to the continuity of patient care if an attempt is made to work all linac machines in a particular department for extended hours. This paper highlighted that in the case of breakdown or routine maintenance it is extremely difficult to transfer patients to another compatible machine unless there is a service continuity machine available. They argue that smaller cancer care departments should only work some machines for longer hours as a safe alternative. This study revealed that servicing and quality assurance carried out during the normal working day accounted for an average of about 161 hours per year for each linear accelerator. In view of this it is recommended that all maintenance occur out of hours (where possible) allowing a significant increase in capacity without increasing the length of the working day.

Lievens and Slotman (2003) found that radiotherapy treatments with long treatment times, either because of a high number of fractions or because of long daily irradiation times related to the complexity of the radiotherapy set up, are deemed to be most costly.

Radiotherapy is an area where there is rapid development of new technologies. New techniques and technologies may often take longer in planning and treatment than those they supersede, with the advantage being improved clinical outcomes, particularly through better targeting of the tumour and subsequent reductions in peripheral organ toxicity (Victorian Government Department of Human Services 2007)

3.6 Patient preferences

The Picker Institute⁸ is an independent non-profit organisation dedicated to advancing the principles of patient-centred care and is internationally recognised for its work in measuring patient satisfaction. The Institute outlines eight principles of patient-centred care:

- Respect for patients' values, preferences and expressed needs
- Coordination and integration of care
- Information, communication and education
- Physical comfort
- Emotional support and alleviation of fear and anxiety
- Involvement of family and friends
- Continuity and transition
- Access to care

Patient preferences are a key consideration in determining the feasibility of extended hours services (National Radiotherapy Advisory Group 2006; Routsis, Thomas et al. 2006; Calman, White et al. 2008; Brown, Atyeo et al. 2009). Findings reported by the NRAG (2006, p.7) included information on a survey of patient views relating to extended hours.

'This identified the fact that the majority of patients preferred to attend within a standard working day (9.00am to 5.00pm). However, a minority were willing to attend early in the morning, sufficient to fill the available slots. Evening attendance was more problematical and only a few patients stated that they would be willing to attend in the evening as they felt that this was family time. There was also less enthusiasm for attendance at the weekend. However, a small proportion of patients would be willing to attend; indeed some of them would prefer to do so, either at the weekends or out of hours. It is not necessary that everyone accepts this service in order to make it viable to offer it'.

Brown et al. (2009) found that many patients prefer treatment outside of normal treatment times if this would reduce the time until the start of radiation therapy. They state that evaluating the effect of waiting times on patients' perceptions of their disease control provides important information in allocation treatment hours and appointment times.

Delivering treatment during extended hours, as a trade-off for waiting for the start of treatment, is an important question both for patients and resource planners. Knowing patient preferences for potential changes in treatment appointment times allows for more targeted use of extended and out-of-hours resources (Brown, 2009).

The most recent survey relevant to extended hours service delivery was completed by Calman et al. (2008). Published in 2008 the data in the study was collected in 2005 and 2006 from a survey of radiotherapy outpatients on two single days. There were four departments in the first cohort and five in the second cohorts. Departments were selected from across the UK and were chosen to reflect both city centre and out of town locations. For all age groups, 9am – 12pm was the most preferred time for treatment. Outside the normal working day, the 8am – 9am interval was the most selected. Approximately a third of patients would attend a reasonable appointment time

⁸ Source: <http://picker.institute.org/about/picker-principles/> accessed 30 September, 2010.

outside the normal working day. There were also a reasonable proportion of respondents who would attend on Saturdays and Sundays (39.3% and 31.1% respectively). The study concluded:

'There is sufficient support from patients for attendance outside the normal working day to ensure appointment slots would not go unfilled during a moderate extension to the working day. However, the percentage of patients that would attend varied between departments. This demonstrates the need for local evaluation of patient preference before the introduction of extended working hours' (Calman, White et al. 2008, p.188).

Basically the literature divides patients' into two groups, those patients who are willing to be treated outside of conventional treatment times and those who are not. Brown et al. (2009) in their study on patient preferences determined that patients who had experienced less lifestyle inconvenience throughout their treatment (e.g. taken time off work or lived away from home during their treatment), and did not require semi-urgent or urgent treatment, were more willing to accommodate variation from the routine. In other words, these patients were more willing to be treated outside of conventional treatment times with any amount of reduction in waiting time as compensation for the potential inconvenience. In view of this they recommend that that appointment times outside conventional hours should be offered to patients who have to accommodate fewer changes in their routine during treatment.

Calman et al. (2008) in their survey of just over 800 radiotherapy outpatients suggest that the general preference continues to be for radiotherapy patients to attend the hospital during the normal working day. Survey results revealed that only one-third of patients wanted to have out of hour's appointments or have access to radiotherapy at the weekends. Of those patients that would consider out-of-hours appointments more patients were willing to come for treatment early in the morning than would consider leaving the house for treatment after their evening meal. The opportunity to receive treatment outside the normal working day was found to be more attractive to younger, fitter patients and particularly to those who wish to continue working during treatment. Whereas, those patients over 60 years old and over displayed the least preference for out of hours treatment (Calman, 2008).

In the UK, the consideration of patient preferences is a key component of the patient's choice agenda (White, 2007).

4 Synthesis of key messages from the literature for NSW Health

4.1 The evidence

This section aims to summarise the main findings from the literature in a series of bullet points to assist the reader to form their own conclusions on the basis of the evidence presented.

The evidence from this targeted literature review is reasonably clear; however it is mainly generated from expert opinion and surveys of radiotherapy treatment centres. It is feasible to extend hours of operation of radiotherapy services however the literature shows that decisions about introducing extended hours services are context specific and need to be made in light of a range of factors that may be unique to each service catchment. This includes, but is not limited to, current demand for radiotherapy as evidenced by cancer incidence projections and waiting times to start of treatment; workforce availability; financial resources to meet increased operating costs and patient preferences. Any decision to increase radiotherapy throughput cannot occur in isolation from other related cancer and hospital support services.

The trade-off between increased patient throughput and faster utilisation of the available life of linacs has not received any recent attention in the literature. There is however recognition that sufficient down-time must be factored into workload benchmarks to ensure that machines receive appropriate quality assurance and maintenance.

Like most service planning issues, multiple factors will influence decision-making about the best methods for improving radiotherapy capacity. Any decisions must consider the local context, as the factors discussed in this review: workforce, costs, efficiency and patient preferences will be differ by location. This literature review provides opportunity for reflection; it will be supplemented by new and emerging evidence, advances in best practice, and the advice of clinical and technical experts, patient preferences and undoubtedly available public funds.

In the words of Baume (2002, p.95):

'...there is a continuum between increasing equipment and working existing equipment for longer, and in the short to medium term a different position on the continuum may suit Australia better.'

In summary the major findings from the literature are:

Options and issues

- Options for increasing capacity of radiotherapy facilities fall broadly under three headings:
 1. Increase the number of linear accelerator machines available
 2. Work existing machines smarter
 3. Work existing machines harder
- As our brief centres on the issue of extended hours operation, option three is most relevant. In addition, NSW Health already has strategies underway for options one and two, hence the focus on option three.¹⁸
- Those not directly involved in managing radiotherapy services often feel that the hours of use of this expensive equipment should be as high as possible to 'sweat the assets'.^{38, 39, 55}
- Approximately 50% of the cost of running a radiotherapy service is attributable to staff and 30% to equipment and maintenance costs. The remaining 20% includes cost inputs relating to space, materials and departmental overheads.^{12, 32}

- Radiotherapy facilities, like most outpatient departments, have traditionally based appointment times around a 9.00 am to 5.00 pm, five day working week; however some facilities are introducing extended hours to more effectively manage patient workflow.^{10, 68}
- From the Radiation Oncology Jurisdictional Implementation Group (ROJIG) parameters, the indicative capacity used in service planning for a linear accelerator in Australia, is 414 courses of treatment per year, consisting of 331 new patients and 83 patients (25% of 331) being re-treated.⁴⁹
- To extend the working hours means that the existing pool of linear accelerators will need to be run for longer periods. This option is reliant on an available and appropriately skilled workforce.^{38, 39}
- There are several considerations in determining the viability of extended hours services including:
 - The impact on clinical treatment regimes (ensuring adequate time for tissue recovery between treatments);
 - The demand for palliative radiotherapy (which has a different treatment regime to therapeutic radiotherapy);
 - The current status of waiting times for commencement of radiotherapy, for example, whilst waiting lists may exist, actual waiting times may or may not equate with accepted clinical benchmarks.^{1, 9, 10, 13, 22, 38, 39.}

Extended Hours Models in Use

- A study of extended working hours in UK cancer centres, published in 2007, revealed that 95% of all departments involved in the study had experience of using extended working hours. More recently in the UK, a number of departments have implemented long-term, sustained extended hours to address waiting lists.⁶⁸
- The most cost-effective models for extending the working day vary, however there is most evidence for a model using four radiographers each working two shifts and extending the working day by one hour at the start of the day and two hours at the end of the day, to give an 11.5 hour day. In the UK context, this model provided a 31% increase in fractions at a cost increase of only 1.8% per fraction. This study reports the following capacity measures for the 11.5 hour day: 51.8 potential fractions per day; 9 machine hours with two staff and 46.9 net fractions per day.^{40, 41, 68}
- The UK National Radiotherapy Advisory Group Capacity and Efficiency Sub-Group planning recommendation notes that linacs within the UK context, should be run at an average of 9.2 hours per day and only a minority of the machines in the department should run the extended 11.5 hour day. Each linac is expected to deliver between 4 and 4.5 fractions per hour.³⁸
- Overall the nine day fortnight was found to be the most cost-effective method for organising radiotherapy staff.⁶⁸
- The option of adding a sixth day was also considered with cancer centres operating on a Saturday. This was generally not found to be cost-effective unless there was a waiting list for palliative radiotherapy that could be delivered on a Saturday because of its different fractionation requirements.^{51, 68}
- Internationally the whole of radiotherapy practice is based on a 5 day working week. Whilst this has arisen because of social convenience, nevertheless, recommended doses for radical treatment have been developed and proven over the years on this basis. There are very few studies of altered fractionation.^{38, 39}
- The Scottish Executive Health Department, recommends increasing the core clinical service to a ten hour day, five day week with a reduction in days lost as a result of closure for public

holidays and routine maintenance to achieve 257 clinical days per annum. They decided not to pursue Saturday services.^{55, 56}

- The delivery of radiotherapy is multidisciplinary and additional staffing costs are not just limited to radiation oncologists, radiation therapists and medical physicists. Any additional hours worked by radiation therapy staff should also be reflected in the workload of other medical oncology staff, nurses and clerical workers.^{12, 32}
- Multidisciplinary patient care must be available to provide equitable care to patients attending outside of core service hours.⁵¹
- There are pitfalls in operating extended working days. The additional hours worked often occur when back-up or support services in the hospital are no longer available. There may be difficulties with patient attendance at these times or the absence of complementary services such as pharmacy or transport.⁵¹
- There is less flexibility to maintain treatment continuity with extended working days in the event of a linac machine breakdown, as there will be more patients to redistribute and less available time in the day in which to reschedule. Interruptions to planned radical courses of treatment have been shown to worsen outcomes and should be avoided. Extended hours operation without appropriate scheduled maintenance of equipment is problematic.^{38, 39, 40, 68}
- Operating extended working days may also adversely impact on staff recruitment and retention in a service with existing staffing difficulties.^{10, 51}
- In NSW most radiotherapy services work within the normal working week, only using weekends and public holidays for emergency cases. Services will work extended hours for short periods, e.g. 8am to 8pm, to deal with extended waiting lists or whilst equipment is being replaced.^{18, 42}
- In Victoria, whilst the usual operating day is 8.5 hours, extended hours have been provided by some centres with 10 hour operating days and some Saturday services.⁶⁸
- Extended working hours may be used to deal with long waiting lists, however, the Royal Australian and New Zealand College of Radiologists (RANZCR) argue that it is generally not sustainable in the long term when a major reason underlying difficulties with access is staff shortages.^{63, 64}
- In Canada a rapid response clinic provides a one stop shop on Saturdays. Patients are seen, planned and treated with either single dose or two fraction schedules, accommodating palliative patients with minimum inconvenience.⁶⁴

Workforce

- The availability of staff and appropriate skills mix will be the rate limiting factor for many localities seeking to increase productivity and or utilisation of equipment, through extended hours.^{10, 30, 40, 41, 57}
- In the UK it is reported that the demand for radiotherapy is increasing faster than the rate trained radiographers become available and one of the main constraints to radiotherapy capacity is the number of radiographers available.⁵¹
- The issues impacting radiation oncology have been construed at times as a microcosm of the issues across the health system more broadly, both in regard to service planning, funding and workforce issues.^{63, 64}
- A review of radiotherapy workforce requirements in the UK by the National Radiotherapy Advisory Group (NRAG) found that the main limiting factor for achieving increased service capacity is workforce.^{38, 39}

- The Commonwealth Department of Health and Ageing supported state and territory governments examining options for extending the hours of operation of equipment up to 12 hours per day at the time of the Baume report in 2002.¹⁰
- The radiation therapy workforce problems previously evident in NSW have improved considerably for radiation therapists as a range of comprehensive strategies to address recruitment and retention issues for radiotherapy workforce groups have resulted in overall improvement.^{50, 44}
- Job satisfaction has a large impact on retention of qualified staff. Improved professional development opportunities are likely to positively impact upon retention rates.^{33, 38, 39}
- The social costs to employees of extended hours may also impact on recruitment and retention rates for various radiotherapy treatment centres, particularly those in rural or regional areas where workforce availability can be very different compared to metropolitan services.¹⁰

Costs

- The key cost factors relating to working extended hours are increases in staff overtime and increases in the rate of use-related depreciation of capital equipment. It is recognised that to implement a longer working day across radiotherapy services would incur substantial increases in payroll costs, whether through overtime or an increase in staff.⁶⁰
- The report issued by the Centre for Health Economics Research and Evaluation, based in Sydney, published in 1993 (Smith R, Jan S et al. 1993) is one of the first reported studies of options for the expansion of radiation therapy services in NSW. Two options were compared: Option 1; increase the overtime performed by existing staff and use capital more intensively or Option 2; invest in new capital with associated increases in levels of staffing. Based on the actual operation of a four-machine service at Westmead Hospital, the authors concluded that Option 1 was most efficient for workloads up to 98,525 fields per year, but at higher rates of throughput this option was unfeasible.⁵⁹
- Whilst short term fluctuations in demand may be met most cost effectively by increasing the intensity of operation of existing capacity, a capital investment program is required to meet long term increases in demand.^{10, 19, 59}
- An Australian study found that for working days up to 12 hours, there is a decrease in the average cost per patient treated. After this, the costs increase, mostly because of the high penalty rates paid for radiation therapists.¹
- In Canada a study revealed that extended hours of operation did not appear to generate significant, if any savings when realistic assumptions about machine lifetime and overtime payments were made.²¹
- Much of the literature in the 1990s relating to the costs of radiotherapy reveal a considerable variation in the estimated costs based upon the differences in the methodology used and on the differences in the included costs components and radiotherapy activities.³²
- An Activity-Based Costing model could be used to measure the costs of radiotherapy more accurately.¹²
- More sophisticated radiotherapy equipment, without increases in personnel does not necessarily equate to increases in productivity. This is primarily because personnel costs remain the most important cost component of a radiotherapy department and more sophisticated equipment will not necessarily reduce the need for personnel.^{12, 32}
- The cost of staff overtime payments and the impact on machine lifetime in some scenarios will outweigh the potential throughput gains from extended hours.^{38, 39}

Efficiency

- A number of models exist which can be used to project linear accelerator requirements for a population. Throughput benchmarks for linear accelerators are another way that countries try to maximise efficiency and machine performance.^{9, 58, 52, 55, 56, 40, 41, 66, 67, 68}
- There is scope for reviewing and if necessary redesigning or improving work practices across the service continuum from consultation to planning and to treatment delivery.^{63, 64}
- Radiotherapy treatment centres need to develop and benchmark a set of key performance measures.^{17, 18, 42, 45}
- Linacs with multi leaf collimators (MLCs) were demonstrably more efficient, and while their capital costs were higher, the reduction in labour costs associated with block cutting and, particularly the increased throughput, more than offset these initial costs.^{20, 24}
- Extended working hours impacts on the reliability of linac machines. This in turn creates more unscheduled interruptions than normal due to additional maintenance and/or servicing sessions.^{13, 68}
- Radiotherapy treatments with long treatment times, either because of a high number of fractions or because of long daily irradiation times related to the complexity of the radiotherapy set up, are deemed to be most costly.³²
- Radiotherapy is an area where there is rapid development of new technologies. New techniques and technologies may often take longer in planning and treatment than those they supersede, with the advantage being improved clinical outcomes, particularly through better targeting of the tumour and subsequent reductions in peripheral organ toxicity.⁶⁶

Patient preferences

- Patient preferences are a key consideration in determining the feasibility of extended hours services.^{15, 16, 38, 39, 51, 68}
- A UK report identified that the majority of radiotherapy patients preferred to attend within a standard working day (9.00am to 5.00pm). However, a minority were willing to attend early in the morning, sufficient to fill the available slots. Evening attendance was more problematical and only a few patients stated that they would be willing to attend in the evening as they felt that this was family time. There was also less enthusiasm for attendance at the weekend.^{38, 39}
- For all age groups, 9am – 12pm was the most preferred time for treatment. Outside the normal working day, the 8am – 9am interval was the most selected. Approximately a third of patients would attend a reasonable appointment time outside the normal working day.¹⁶
- Patients prefer treatment outside of normal treatment times if this would reduce the time until the start of radiation therapy.¹⁵
- In an Australian study patients who had experienced less lifestyle inconvenience throughout their treatment (e.g. taken time off work or lived away from home during their treatment), and did not require semi-urgent or urgent treatment, were more willing to be treated outside of conventional treatment times with any amount of reduction in waiting time seen as a worthwhile trade-off for the potential inconvenience.¹⁵
- In the UK, the consideration of patient preferences is a key component of the patient's choice agenda.⁶⁸

4.2 Concluding Remarks

Several countries have extended the working day on linear accelerators, as a method of increasing treatment capacity. NSW Health should continue to monitor developments in radiotherapy models of care and workforce trends (including changes in legislation and regulation), particularly as they relate to different approaches to radiotherapy service provision.

In particular, the efforts to of NSW Health to better understand the costs of public radiation oncology treatment services in NSW⁹; will also assist future evaluations of the costs and benefits of extended working hours.

Determining the feasibility and 'value for money' of extended hours operations must balance many competing factors – finding a balance between optimum patient access and the available human and financial resources is the challenge.

⁹ NSW Health Request for Quotation: Costing of the public Radiation Oncology Treatment Services in NSW. July 2010

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