

CANCER IN SCOTLAND



RADIOTHERAPY ACTIVITY PLANNING FOR SCOTLAND 2011-2015



Scottish Executive Health Department
Report of the Radiotherapy Activity Planning Group

RADIOTHERAPY ACTIVITY PLANNING FOR SCOTLAND 2011 – 2015

DECEMBER 2005

ACKNOWLEDGEMENTS

The Radiotherapy Activity Planning Steering Group gratefully acknowledge the support and commitment of all those who have contributed to the Project and the completion of this final report. Special thanks go to the members and contributors of the subgroups who sourced valuable data for discussions which led to the conclusions and recommendations presented here. Thank you to Dr Sara Erridge (South East Scotland Cancer Centre, Edinburgh) and Dr Carrie Featherstone (West of Scotland Cancer Centre, Glasgow) for their work in modelling radiotherapy indications and demand estimations. To Mr Roger Black, Dr Diane Stockton and Ms Jillian Campbell (Scottish Cancer Intelligence Unit) for their work on *Cancer Scenarios* and additional statistical support.

EXECUTIVE SUMMARY & RECOMMENDATIONS

1. Radiotherapy is a key component of modern cancer treatment and is likely to remain so for the foreseeable future.
2. Demand for radiotherapy will increase substantially over the next 10-15 years due to a combination of demographic and clinical factors. Large increases are anticipated in the number of oesophageal, prostate and colorectal cancers, with a fall in only lung, cervix and stomach cancers (Chapter 2).
3. Of the estimated 31,500 new cancer patients that will be diagnosed annually by 2015, around 14,000–15,000 are likely to require radiotherapy as part of their initial disease management (Chapter 3, para 39).
4. Projected future clinical demand and the basis for capacity planning is achieved by modelling stage and incidence with likely patterns of treatment, using best evidence guidelines and clinical expectations of future practice. These estimates absorb all currently unmet need.
5. In 2015, between 242,384 and 318,422 fractions of treatment (clinical demand) is expected; a 38% - 81% increase on the number of fractions delivered in 2003 (Chapter 3, para 54–73).
6. As recommended by the Royal College of Radiologists (2004), demand should represent 90% of capacity, and therefore, the projected service capacity for 2011-2015 is between **270,000** and **354,000** fractions (Chapter 3, para 101–108). Required capacity projections include allowance for unscheduled machine downtime, research and development needs and ensure that waiting times are not built into the system.

7. By 2007-2008, Scotland will have 25 modern linear accelerators (4.98 per million of population) distributed between the five cancer centres (Glasgow - 11, Edinburgh - 6, Dundee - 3, Aberdeen - 3 and Inverness - 2).
8. This total includes a second linear accelerator (linac) in Inverness which is essential to ensure a sustainable service and secure non-surgical oncology services in the northwest of Scotland. The lack of a reliable backup linac is prejudicing the quality of treatment currently able to be offered to patients in Highland (Chapter 4, para 111-116).
9. Continuing to operate the planned 25 linacs on the current average service model (5 fractions per hour, 8 hours per day, 5 days per week with 8 public holidays and 16 planned maintenance days) will provide capacity to deliver about 234,00 fractions per annum. To achieve 354,000 fractions, a 51% increase in capacity will be essential – an additional 13 linear accelerators for Scotland if the current service model is maintained. This is equivalent to two centres the size of the Edinburgh centre or another four the size of Dundee or Aberdeen and would be a major acute and tertiary service expansion for NHS Scotland. (Chapter 4).
10. Service redesign and a smaller service expansion (3/4 additional linacs) provides a more feasible option for increasing service capacity (Chapter 5). The following service change is recommended as a first step:
 - Increase the core clinical service to a 10 hour day, 5 day week.
 - Reduce the days lost as a result of closure for public holidays and routine maintenance to achieve 257 clinical days per annum.
 - Optimise the capacity of all linacs in Scotland and redistribute workloads.
11. Increasing the clinical time of each linac through the above service redesign will achieve only 65% (providing 312,500 fractions) of the maximum additional capacity required. Assuming incremental increases in clinical demand, it is estimated that this service redesign alone will allow adequate capacity until about 2011-2012.

Therefore, there is no immediate requirement to increase the number of linacs in Scotland beyond 25.

12. However, achieving the proposed service redesign will be dependent on a number of factors and require immediate action to:
 - review workforce shift patterns, working practices, skill mix, new roles, and additional staff requirements to meet the new core service model.
13. Furthermore, ensuring that, as far as possible, all 25 linacs carry an equal workload is important to optimise the potential capacity across the Scottish service. This will require some changes to referral practices and further development of collaborative working. Unless this can be achieved, it is likely that demand will still exceed capacity in the central belt (Chapter 5, para 162-165).
14. Preliminary economic evaluation suggests that the 10 hour day, 5 day week is the most cost effective option, with additional centres and machines the most expensive. Further work, including further sensitivity analysis, is ongoing (Chapter 5, para 166).
15. Demand and capacity projections should be reviewed on a recurrent basis in-line with new available data and emerging evidence (paragraphs 22,44,46,70). This should be underpinned by monitoring of actual radiotherapy service demand and activity between now and the review period. It is recommended that the next review be carried out in 3 to 4 years time, to ensure adequate lead time for purchase of additional linacs and associated equipment – if it is concluded that these are required by 2010-2012 (as above).
16. If the review determines that demand projections hold true and capacity for 354,000 fractions per annum is required, up to 3/4 additional linacs will be necessary to enhance the service redesign detailed above to achieve the required capacity. Alternatively, a 6 day working week may be considered.

17. Assuming that an additional 3/4 linacs are required for Scotland, the location of these will need further debate. Capacity exists to house additional linacs at the Aberdeen, Dundee, Edinburgh and Glasgow cancer centres. Utilisation of this building space could provide an immediate and short-term solution but may not be the preferred permanent option and should be re-assessed as part of the review in 3-4 years time.
18. Increasing the core clinical working time of the machines will have major human resource implications (as would increasing the number of machines) not only for the medical, radiography and physics staff but for all support, administrative and clerical staff. NHS Education for Scotland (NES) has agreed to develop a cancer service education strategy that will address current and new roles (Chapter 5, para 152 – 157 and Chapter 7).
19. A cancer-specific human-resource strategy is required to look at:
 - a) workforce numbers and working practices
 - b) identify and address recruitment and retention issues
 - c) skill-mix initiatives across all cancer-related disciplines
20. Specific consideration should be give to:
 - a) identifying funding required to increase the number of medical physicists in training for four to six per year for therapy physics.
 - b) providing pump-priming funding for advanced practitioners and/or consultant therapy radiographers in at least the larger centres to enhance recruitment and retention.
21. A Radiotherapy Advisory Group, reporting to the Scottish Cancer Group is being established to:
 - a) monitor clinical practice, impact of extended hours and capacity constraints
 - b) coordinate developments such as IMRT (intensity modulated radiotherapy) and IGRT (image guided radiotherapy) to ensure equitable access across Scotland
 - c) coordinate efforts to ensure that all linear accelerators have an approximately equal workload
 - d) repeat the current review of capacity and demand in 3-4 years time to ensure adequate lead time if additional capacity is found to be required.

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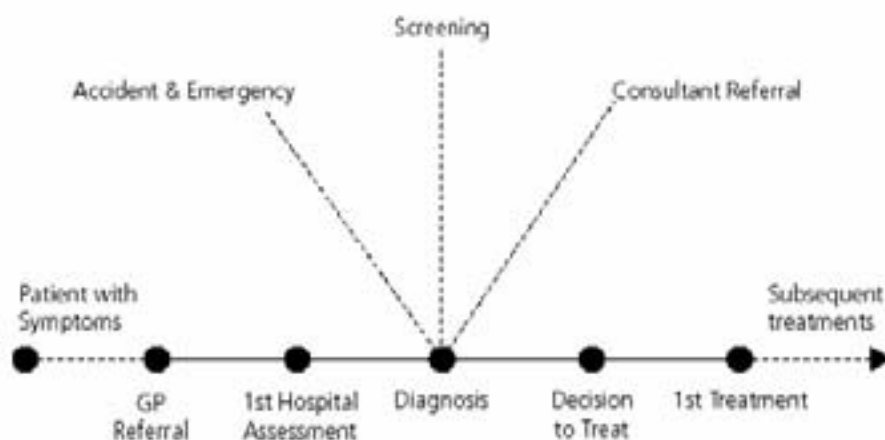
CHAPTER ONE

INTRODUCTION

CONTEXT

1. *'Cancer Scenarios: An aid to planning cancer services in the next decade'* (Scottish Executive Health Department 2001) projected considerable increases in most cancers to 2014 and thus presented far reaching implications and potential additional demands for a wide spectrum of clinical and non-clinical services which contribute to the patient pathway (Figure 1).
2. Radiotherapy is a core component of modern cancer therapy and is unique to cancer (although a small number of benign tumours are treated with radiotherapy). As such, the current review will not resolve any associated pressures resulting from increased cancer incidence in other areas of the NHS. The impact of projected increases in cancer incidence on wider NHS services e.g. primary care, radiology, surgery, pathology as well as other aspects of oncology care; need to be considered so that the potential contribution made by radiotherapy services to improve cancer outcomes, through the successful implementation of recommendations proposed in this review, are not frustrated by capacity constraints in other NHS services essential to the patient pathway.

Figure 1:



Source: Department of Health (2000)

BACKGROUND

3. Against a background of increasing cancer incidence, *Cancer in Scotland: Action for Change* (Scottish Executive Health Department 2001a), provided the framework for this review of capacity and gave the Scottish Executive Health Department (SEHD), NHS staff and patients a unique opportunity to plan services over the long-term, up to 10 years hence, so that capacity to meet projected future demand is in place.
4. An initial report was submitted to the Health Department Management Board (HDMB) in April 2003, indicating that an additional 5 to 10 linear accelerators might be required to meet demand 2010–2014 (appendix B). In June 2003, the HDMB accepted the findings in principle, and requested that further work be undertaken to test the assumptions and further explore service options for achieving capacity by 2015.
5. In November 2003, an exploratory meeting involving 40 NHSScotland staff and patients identified and agreed four work streams:
 - projected patterns of disease; (Chapter 2)
 - technology and medical advances (Horizon Scanning); (Chapter 3)
 - patient and carer involvement; (Chapter 6)
 - workforce (Chapter 7).

METHODS

6. The Radiotherapy Activity Planning Group (RAPG), chaired by Dr Michael Cornbleet, Senior Medical Officer (SEHD), was reconstituted in April 2004 (membership in appendix A), and a dedicated project manager appointed.
7. Two primary objectives were identified:

Objective 1: re-test previous assumptions and determine more robust conclusions of projected future demand and required service capacity.

Objective 2: assuming that objective 1 confirms the need for increased capacity; explore options to achieve additional capacity, either through modification of current service delivery and/or by determining optimum location(s) and service model(s).

8. A Horizon Scanning Subgroup and a Patient/Carer Involvement Subgroup were established to progress these particular work streams.

SCOPE

9. The remit of the RAPG was to consider radiotherapy service capacity needs in Scotland for the period 2011 to 2015.
10. The focus of the work is external beam radiotherapy (XRT), which is delivered by linear accelerators (linacs). Other methods of radiotherapy delivery (interstitial, intracavity or intra-operative) and cancer management are referred to when a potential impact on the required capacity of future external beam services is indicated.
11. **While this report focuses on linacs it should be noted that radiotherapy is a complex multi-step process (appendix C) requiring a much larger complement of equipment e.g. simulators and planning systems. Any recommendations for radiotherapy therefore need to be considered on the understanding that associated additional equipment requirements also need to be met.**
12. **Furthermore, the demand and subsequent capacity required at various other stages of the patient radiotherapy journey should be reviewed and monitored locally, to ensure optimal and timely delivery throughout the service/care continuum.**

CHAPTER TWO

PROJECTED PATTERNS OF DISEASE

13. 'Cancer Scenarios' predicted trends in cancer incidence and mortality in Scotland up to 2014 and provided an aid for planning future cancer services. To support the RAPG work, incidence projections were updated and extended in 2004 using data extracted from the Scottish Cancer Registry (April 2004) and updated (2001) population estimates obtained from the General Registrar Office for Scotland (GROS).
14. A report of the revised cancer incidence 'Cancer in Scotland: Sustaining Change, Cancer Incidence Projections for Scotland 2011-2020' was published in December 2004 (Scottish Executive Health Department 2004).

METHODS

15. All malignancies excluding non-melanoma skin cancer (C00-C96 excluding C44) were considered. The most common 19 malignancies were considered separately (covering 90% of all malignant cancers), and the remainder combined into a category labelled "Other and Unspecified". Only persons aged 35 or more years were included in the analyses, with the exception of melanoma skin cancer (ages 20+), cervical cancer (25+), testicular cancer (20+) and Hodgkin's disease (15+). Due to a recent (late 1990s) change in the coding of bladder cancers it was necessary to combine malignant, in situ and uncertain behaviour bladder tumours.
16. As noted in *Cancer Scenarios*, statistical predictions for values outside the range of observed data used in a model should always be interpreted with caution. There are theoretical reasons why the predictions may be fallible and, in addition, changes may occur in the future which are independent of the historical data and so cannot be predicted in the statistical analysis. These include changes in the exposure of the population to risk factors either in the new time periods or in birth cohorts too young to be included in the predictive analyses.

SUMMARY OF MAIN RESULTS

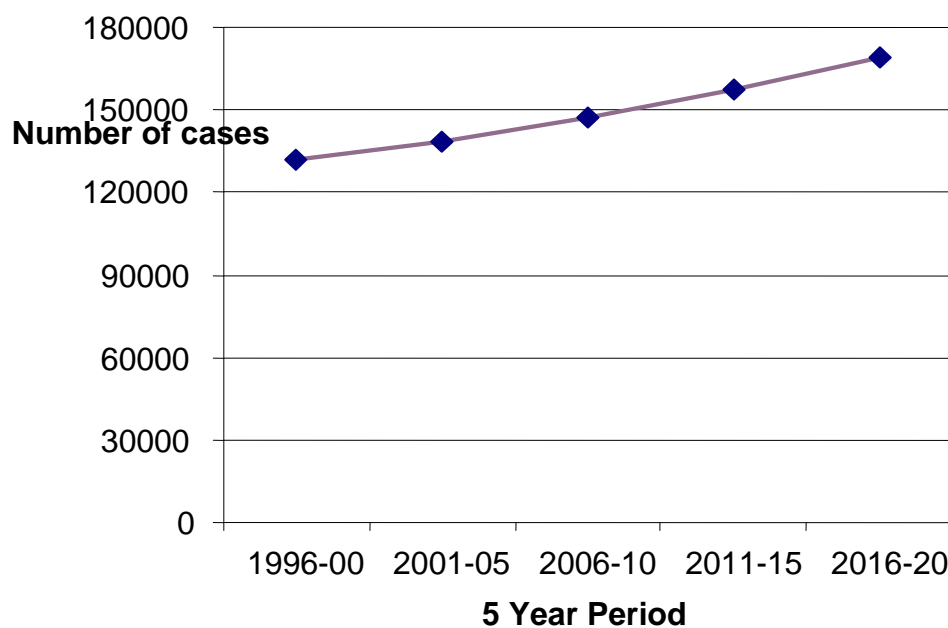
17. Overall, it is predicted that there will be about 31,500 new cancer cases diagnosed in Scotland per annum 2011-2015. This is about 6000 cases more than in 2001 but 1500 cases fewer than previously projected.
18. Table 1 presents the projected incidence for all cancer types considered in the analysis. The overall predicted increase in cancer incidence from 1996–2000 to 2011–2015 is 18.9%. The incidence of all cancers is expected to rise with the exception of stomach, lung and cervix which are predicted to decline.
19. Marked increases are expected for some cancers, most notably oesophagus, prostate, colorectal, non-Hodgkin's lymphoma (NHL) and melanoma.
20. Most of the predicted increase is attributed to a growing number of elderly in the population; however, the individual risk of some cancers is also predicted to increase.
21. **Although the remit of this project is up to 2015, cancer incidence in Scotland is projected to increase steadily (Figure 2) to an annual incidence of about 34,000 cases per annum by 2020. Future service planning considerations should therefore be reviewed against this background.**
22. **It is also recommended that cancer projections are revised and updated on a recurrent basis to provide an invaluable baseline for forward planning.**

Table 1: Projected Cancer Incidence in Scotland 2011 - 2015

CANCER	Actual incidence 1996 2000	Predicted incidence 2011 2015	Actual annual incidence 1996 2000	Predicted annual incidence 2011 2015	% Change in incidence 1996 2000/ 2011 2015
Head and neck (C00-C14, C30-C32)	4,999	6,246	1,000	1,249	+ 24.9
Oesophagus (C15)	3,907	5,630	781	1,126	+ 44.1
Stomach (C16)	4,824	3,931	965	786	- 18.5
Colorectal (C18-C20)	17,310	22,336	3,462	4,467	+ 29.0
Lung (C33-C34)	23,354	21,122	4,671	4,224	- 9.6
Pancreas (C25)	3,165	3,805	633	761	+ 20.2
Melanoma (C43)	3,312	5,027	662	1,005	+ 51.8
Breast (C50)	17,752	21,902	3,550	4,380	+ 23.4
Cervix (C53)	1,737	1,169	347	234	- 32.7
Corpus uteri (C54)	2,204	2,710	441	542	+ 23.0
Ovary (C56)	3,174	4,013	635	803	+ 26.4
Prostate (C61)	10,062	13,581	2,012	2,716	+ 35.0
Testis (C62)	966	1,225	193	245	+ 26.8
Kidney (C64)	2,727	4,112	545	822	+ 50.8
Bladder, all (C67, D09.0, D41.4)	7,538	9,196	1,508	1,839	+ 22.0
Brain, meningies and CNS (C70-C72)	1,790	2,065	358	413	+ 15.4
Hodgkin's disease (C81)	628	671	125	134	+ 6.8
Non-Hodgkin's lymphoma (C82-C85)	4,156	6,249	831	1,250	+ 50.4
Leukaemia (C91-C95)	2,996	3,956	599	791	+ 32.0
Other and unspecified	15,606	18,239	3,121	3,648	+ 16.9
Total	132,207	157,185	26,441	31,437	+ 18.9

Source: Adapted from Scottish Executive Health Department (2004)

Figure 1: Projected Trend in Cancer Incidence 1996 – 2020



Source: Adapted from Scottish Executive Health Department (2004)

CHAPTER THREE

HORIZON SCANNING

23. Estimating future demand for radiotherapy services is not a simple undertaking and while the method for projecting future cancer incidence is now well established, predicting the proportion of incident cases which will require radiotherapy is much more difficult. Furthermore, speculating about the technical developments which might be available and/or indicated in 2011–2015 introduces an additional level of uncertainty.

METHODS

24. A Radiotherapy Horizon Scanning Working Group (appendix D), chaired by Dr Sara Erridge, South East Scotland Cancer Centre (Edinburgh), was invited to facilitate work on demand predictions for future radiotherapy services in Scotland.
25. The group was tasked with presenting a consensus view, where possible, about the future of radiation oncology in Scotland (2011-2015), in response to predicted patterns of disease; indications for radiotherapy treatment; optimal and future radiotherapy schedules and treatment techniques; and the impact on service capacity of technological advancements.
26. Two aims were identified:
 - a) Achieve radiotherapy demand projections for Scotland 2011-2015
 - b) Estimate radiotherapy service capacity required to meet the projected demand
27. In order to achieve the above, work was progressed under four broad headings:
 - **INDICATIONS FOR RADIOTHERAPY TREATMENT**
 - > Current Versus Optimal/Appropriate Radiotherapy Utilisation
 - > Potential Changes to Radiotherapy Indications
 - > Gap Between Current and Optimal/Appropriate Radiotherapy Utilisation
 - **RADIOTHERAPY FRACTIONATION SCHEDULES AND TREATMENT TECHNIQUES**
 - > Current Fractionation Schedules and Treatment Techniques
 - > Optimal Future Fractionation Schedules and Treatment Techniques
 - > Sensitivities and Issues

- **TECHNOLOGIES**
 - > New and Emerging Technologies
 - > Streamlining Technologies
- **ESTIMATE REQUIRED RADIOTHERAPY SERVICE CAPACITY**

INDICATIONS FOR RADIOTHERAPY TREATMENT

28. An indication for radiotherapy is defined as ‘a clinical situation in which radiotherapy is recommended as the treatment of choice, either as a sole treatment or in combination, on the basis of evidence that including radiotherapy leads to superior clinical outcome compared to alternative treatment modalities (including no treatment) and where the patient is suitable to undergo radiotherapy based on an assessment of performance status indicators and the presence or absence of co-morbidities’ (Barton M & Delaney G 2003).

Current versus Optimal/Appropriate Radiotherapy Utilisation

29. Two measures of radiotherapy utilisation can be achieved
- (a) current utilisation which is a measure of the proportion of incident cancer patients receiving radiotherapy based on current practice but not necessarily best practice; and
 - (b) optimal/appropriate radiotherapy utilisation which is a measure of the proportion of incident cancer patients with an indication for radiotherapy based on best available evidence.
30. Optimal/appropriate radiotherapy utilisation offers the best available basis for future service planning since all potential cancer patients likely to benefit from radiotherapy are accounted for and the treatment indications are underpinned by clinical evidence, ensuring a more robust basis for demand projections.
31. Modelling studies provide a useful tool for determining appropriate radiotherapy indications and work has been carried out in Australia, Canada (Tyldesley *et al.* 2001) and Sweden (Frodin JE *et al.* 1996). Only the Australian modelling, conducted by the Collaboration for Cancer Outcomes Research and Evaluation (CCORE), Liverpool Hospital, Sydney has been completed and published (Barton M & Delaney G 2003). These models are constructed using a systematic review of international clinical

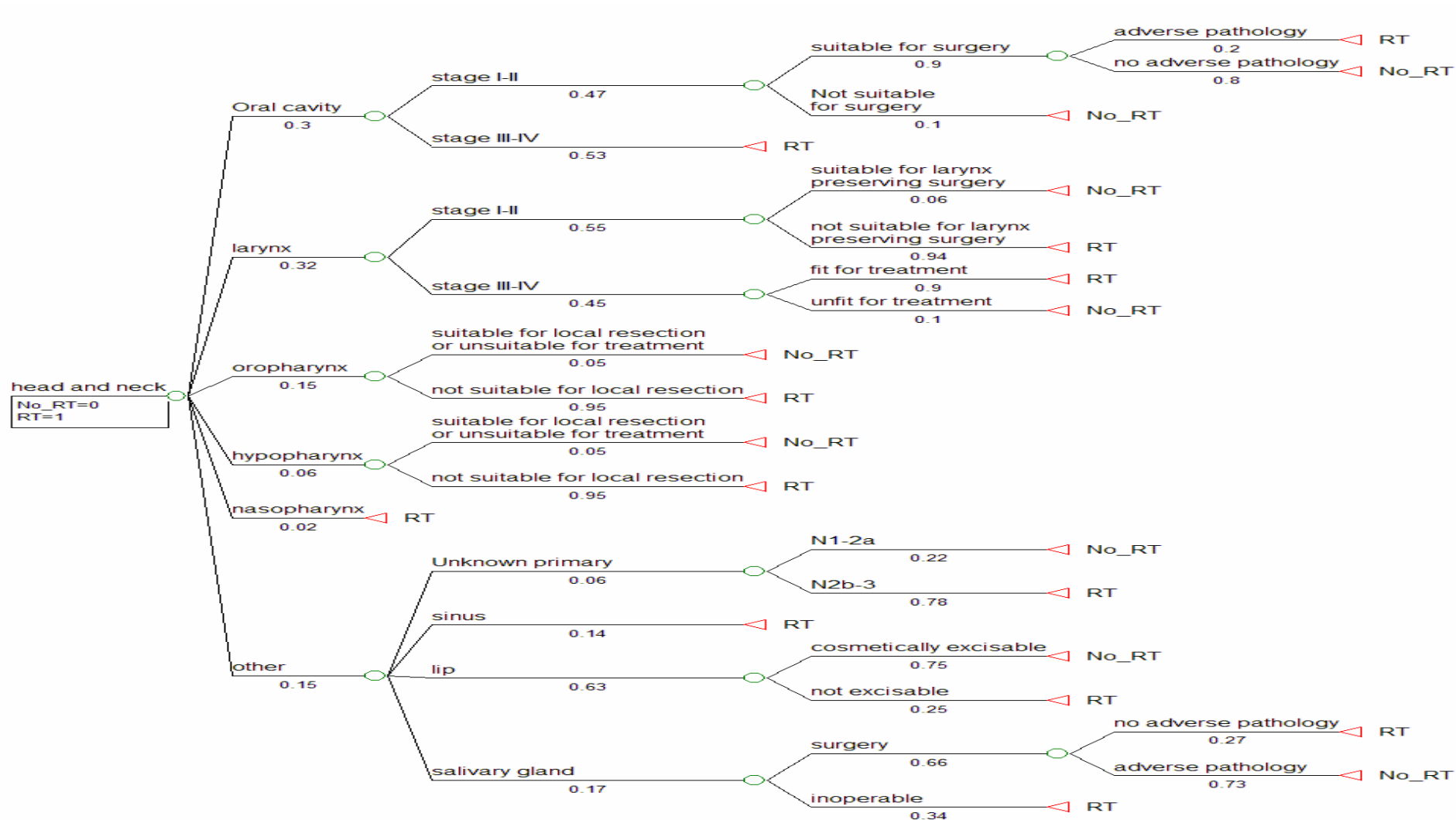
guidelines and evidence thus providing a globally relevant framework. Further details of the method for modelling adopted by the Horizon Scanning Group is detailed in appendix E.

32. Using the Australian model and adapting to fit 'Scottish' practice where divergence in clinical guidelines were noted, the Horizon Scanning Group applied Scottish data where available, in order to achieve optimal radiotherapy indications.
33. Caution should be expressed about making too many changes to the model since the focus is 'best evidence-based' practice not necessarily current practice. However, taking stomach cancer as an example, the indications for radiotherapy quoted in the Australian model are not shared by the UK clinical community because of different surgical practice and debates about the quality of the evidence (MacDonald JS *et al.* 2001; Hundahl SA *et al.* 2002). Thus modelling on such evidence would have resulted in an indication not applicable for Scottish practice.
34. Modelling was carried out and clinical decision trees created for 89.5% of all incident cancers in Scotland (appendix F). As an example, figure 3 shows the clinical decision tree depicted for head and neck cancers.
35. Population data, and more specifically data relating to stage distribution of disease and patient performance status is essential to calculating radiotherapy indications and completing the first level of the clinical decision tree. Applying data from other populations/countries inevitably leads to inaccuracies.
36. In this exercise the lack of quality primary Scottish data was a major limiting factor. For example, in 40% of prostate cancer cases captured in the recent Scottish Urological Cancer Audit (SUCA) (in preparation), stage was not recorded. Therefore, for the purposes of this current analysis, the unstaged disease was proportionately distributed through stages I – IV.
37. Table 2 shows the radiotherapy indications calculated for all major cancers, based on initial disease management. An overall optimal radiotherapy utilisation rate of 44.2% – 47.9% (for all cancers) was obtained with indications ranging from 4% for

leukaemia to 78.6% for head and neck cancers. Only radiotherapy indications for initial disease management were calculated at this stage; re-treatment rates were not calculated.

38. For some cancer types, more than one possible radiotherapy indication was modelled. In the case of rectal cancer, clinical opinion is still divided, due to changing surgical practice and conflicting evidence on the use of pre-operative XRT. As such, two indications were calculated, one indicating pre-operative XRT, one which does not.
39. In total, it is predicted that the Scottish radiotherapy services will see about 14,000 – 15,000 new referrals for treatment per annum, compared to the current estimated 11,000 new referrals per annum (2003). See table 2.
40. Further explanation and the detail of the modelling undertaken to achieve optimal Scottish radiotherapy utilisation rates and clinical demand (fractions) by cancer type, is presented in appendix G.

Figure 2: Head and Neck Cancer Clinical Decision Tree



Source: Adapted from Barton M & Delaney G (2003) using Scottish stage data

**Table 2: Radiotherapy Indications and Estimated Patient Numbers for Scotland
2011 - 2015**

<i>CANCER TYPE</i>	<i>Predicted average annual incidence 2011- 2015</i>	<i>Optimal XRT Indication (%)</i>	<i>Estimated no. XRT Patients 2011 - 2015</i>
Head and neck	1249	78.6	982
Oesophagus	1126	53.9	607
Colon	2939	1.0	29
Rectum	1528	27.8 - 88.7	425 - 1355
Lung	4224	62.8	2653
Melanoma	1005	15.7	158
Breast	4380	70.0	3066
Cervix	234	56.1	131
Corpus uteri	542	46.3	251
Prostate	2716	61.4	1668
Testis	245	46.0	113
Bladder, all	1839	28.2	520
Brain, meningies and CNS	413	60.7 – 81.9	257 - 338
Hodgkin's disease	134	71.4	96
Non-Hodgkin's lymphoma	1250	54.4	680
Stomach	786	13.4	105
Pancreas	761	41.9	319
Ovary	803	4.0	32
Leukaemia	791	4.0	32
Kidney	822	24.0	197
Myeloma	360	33.1	119
Other and Unspecified	3290	44.2 – 47.9	1436 - 1558
TOTAL	31,437	44.2 – 47.9	13,895 – 15,027

Potential Changes to Radiotherapy Indications

41. Previous radiotherapy planning assumptions were based on the premise that indications for radiotherapy would diminish as the use of other treatment modalities increased, but this did not happen (Royal College of Radiologists 2000). In reality the demand for radiotherapy has increased steadily at a rate of about 5% per annum. Caution must therefore be taken to avoid making similar misleading assumptions when planning for 2011–2015 since current indications may not hold true.
42. For example, the future impact on radiotherapy indications resulting from increased use of chemotherapy, intra-operative radiotherapy, radiosensitisers and brachytherapy can only be estimated since appropriate evidence is not yet available to support firm conclusions. In breast cancer, intra-operative radiotherapy (IORT), which is at the early stages of clinical evaluation, may potentially replace external beam radiotherapy in the treatment of stage I patients undergoing wide local excision (WLE). These patients represent about 33% of the projected 2011-2015 XRT breast cancer workload and therefore, if intra-operative radiotherapy is proven to be clinically effective and adopted as treatment of choice, a considerable workload would be directed away from external beam services. However, planning future service capacity based on this as yet unproven assumption could result in considerable unplanned demand if clinical trials demonstrate that IORT results in an unacceptable local recurrence rate.
43. To avoid replicating previous planning assumptions and underestimating future radiotherapy demand, influences which may potentially result in reduced indications for radiotherapy were omitted from the modelling. As a result, the radiotherapy indications achieved and which form the basis of future service demand estimations, reflect the maximum potential use of XRT based on what is currently evidenced.
44. **It is recommended that radiotherapy indications are reviewed on a recurring basis as appropriate evidence emerges to confirm or refute projected practice. In doing so, demand estimations calculated for planning purposes can be refined and relevant Scottish radiotherapy practice revised, if appropriate, to reflect emerging 'new' best evidence.**

45. A further sensitivity around XRT indications relates to possible changes in the stage distribution of disease in a population. In general it is expected that stage distribution for most cancers will remain reasonably stable with the exception of cancers where the introduction of population screening programmes may result in an initial shift. For example, results from the pilot colorectal screening programme show an increase in the proportion of Dukes A/B rectal cancers being diagnosed. The indications for radiotherapy in this stage of disease are greater than Dukes C/D, particularly if pre-operative radiotherapy is widely adopted in the clinical community, and may result in increased radiotherapy referrals.
46. **It is recommended that stage distribution of disease is monitored and the effects of any change applied to radiotherapy indications modelling to ensure most accurate indications and modified projected demand. Furthermore, given the limitations of the XRT and population specific data available to support this modelling, it is recommended that mechanisms for data collection be reviewed and new parameters agreed and implemented to support prospective data collection to underpin future radiotherapy modelling.**

The Gap between Current and Optimal Utilisation

47. Future demand predictions and capacity assumptions are based on ‘optimal utilisation’ of radiotherapy thus ensuring that all unmet need is accounted for. However, comparison of current and optimal utilisation rates for the major cancers (Table 3), suggest that a proportion of patients in Scotland who might benefit from radiotherapy are not receiving it.
48. While comparison of current and optimal utilisation is useful in as far as indicating the levels of unmet need and the gap to be bridged, the quality of current radiotherapy utilisation data may not accurately reflect reality thus making direct comparison difficult. For example, the Scottish Cancer Registry records only treatment administered within the first 6 months following a diagnosis of cancer, thus omitting a significant proportion of patients who receive radiotherapy beyond this time period. This is an increasingly common scenario given the growing use of for example, combined and adjuvant therapies.

Table 3: Comparison of Current Radiotherapy Utilisation with Optimal Radiotherapy Utilisation

<i>CANCER TYPE</i>	<i>Cancer Registryⁱ utilisation rate</i>	<i>Modelled radiotherapy indications</i>
Head and neck (C00-C14, C30-C32)	55.3	78.6
Oesophagus (C15)	27.4	53.9
Colorectal (C18-C20)	9.1	Colon 1.0 / Rectal 27.8 – 88.7
Lung (C33-C34)	33.0	62.8
Melanoma (C43)	0.9	15.7
Breast (C50)	35.7	70.0
Cervix (C53)	49.8	56.1
Corpus uteri (C54)	30.4	46.3
Prostate (C61)	9.1	61.4
Testis (C62)	42.0	46.0
Bladder, all (C67, D09.0, D41.4)	14.3	28.2
Brain, meningiomas and CNS (C70-C72)	45.0	60.7-81.9
Hodgkin's disease (C81)	14.1	71.4
Non-Hodgkin's lymphoma (C82-C85)	12.3	54.4
Stomach (C16)	4.7	13.4
Pancreas (C25)	2.8	26.7
Ovary (C56)	1.3	4.0
Leukaemia (C91-C95)	1.2	4.0
Kidney (C64)	9.2	24.0
Unspecified	15.1	44.2 – 47.9

49. The radiotherapy utilisation rates recorded by the Scottish Cancer Registry do however support current clinical opinion that radiotherapy utilisation in Scotland is potentially considerably less than the international consensus, '50 percent of all cancer patients require radiotherapy at some stage of their illness'.
50. A number of factors are likely to provide explanation for lower utilisation in Scotland:
- more advanced disease at presentation;
 - poor performance status of patients;
 - presence of co-existing medical conditions;
 - ageing population;
 - place of residence – remoteness from general medical services/support; and
 - distance from radiotherapy facility.

ⁱ Radiotherapy received 1999 – 2001 based on the provision in the first 6 months following a cancer diagnosis

51. It is widely acknowledged that many of these factors can influence treatment choice (Campbell N C *et al.* 2002), and may contribute to apparently lower use of radiotherapy within a Scottish context. The Scottish Executive is striving to reduce the impact of these factors with concerted efforts to address issues around for example, remote and rural communities and improved public awareness.
52. It may be reasonable to assume that increasing the service capacity alone will result in reduced levels of unmet need. Also, the increased use of specialist multi-disciplinary teams (MDTs) in the clinical decision process, which will influence treatment direction; and the collaborative working of regional and tumour specific networks, which are striving to provide a consistent framework for quality assurance in services, may positively improve XRT utilisation in Scotland.
53. **It is recommended that further work is undertaken to ascertain the full range of reasons for disparity between current and optimal practice so that appropriate steps may be taken to close the gap. Action should take into account the issues listed above and additional policy, operational and clinical management issues that may be influential e.g. use of skilled workforce, lack of clinical guidelines or non-uniform uptake of guidelines for both referral and treatment.**

RADIOTHERAPY FRACTIONATION SCHEDULES & TREATMENT TECHNIQUES

54. Having determined optimal radiotherapy indications by cancer type and disease stage, the next challenge is to translate indications into a more useable 'demand currency' for planning purposes. Fractions have been adopted as the measure of demand in this process.
55. Current fractionation schedules were collected through a retrospective audit (appendix H). In addition, Clinical Oncology Consultants were surveyed (appendix I) and asked to:
- Provide the fractionation schedules they currently use in a number of clinical scenarios
 - From knowledge of ongoing clinical trials provide best guesstimates of what fractionation schedules might be used in 2011-2015
 - Indicate any scenarios where more complex radiotherapy might be used, for example, Intensity Modulated Radiotherapy (IMRT),

Current Fractionation Schedules and Treatment Techniques

56. In 2003, a total of 175,954 treatment fractions were delivered to approximately 12,000 patients in Scotland. 82% of fractions delivered were with radical intent, 9.5% as part of a palliative treatment, 8% for the treatment of metastatic disease and 0.5% for treatment of benign disease.
57. The average number of fractions per radical treatment course was 24; 7 per palliative course to primary tumour; and 4 for metastatic treatment. Considerable difference in fractionation schedules were recorded across the Scottish radiotherapy service, with greatest variance in fractionation noted for prostate, and head and neck cancers (appendix H).

Optimal Future Fractionation Schedules and Treatment Techniques

58. Recent clinical experience would suggest that, in general, radiotherapy fractionation schedules are increasing and as a result of improved beam shaping and dose conformity, higher therapeutic doses can be delivered to the tumour with better sparing of healthy tissue (Dearnaley *et al.* 1999; Vijayakumar & Hellman 1997).

59. Advice on optimal future fractionation schedules was obtained from a survey of Clinical Oncologists in Scotland. The information was collected by tumour type and clinical scenario so as to be easily applied to the modelled radiotherapy indications.
60. In general, the following was concluded:
- While many treatment schedules will involve increased numbers of fractions, given either over a longer period of time or within a shorter or similar time i.e. hyper fractionated treatments such as CHART, there may be significant exceptions e.g. breast cancer START or FAST schedule (see para. 67-68).
 - More radical treatments will be indicated if increased public awareness and improved access to diagnostic services lead to earlier presentation for treatment – this would result in a higher proportion of patients requiring more fractions.
61. In order to achieve overall demand as a measure of fractions, estimated future fractionation schedules were applied to the equivalent radiotherapy population by cancer type and clinical scenario. To achieve the future XRT populations, each clinical decision tree (appendix F) was populated using 1996–2000 incidence data as a baseline. Table 4 presents the populated head and neck clinical decision tree with the calculated number of patients likely to receive radiotherapy (by scenario) highlighted in bold. To obtain the number of XRT patients 2011-2015, a percentage increase or decrease, as taken from *Cancer Scenarios* (2004), was applied. In the example of head and neck cancer an increase of 24.9% was applied.
62. Estimated future fractionation schedules were then applied to each scenario where radiotherapy is indicated. In the example of head and neck cancers (Table 5), Clinical Oncologists around Scotland predicted no change in optimal fractionation over the next 10 years and thus the radiotherapy demand resulting from the incident head and neck cancer population 2011-2015 is estimated to be about 34,370 fractions.
63. The same process was repeated for all the cancers individually modelled (89.5% of the projected incident population 2011-2015) and an estimated demand of between 211,134 and 269,129 treatment fractions calculated. However, this demand reflects

only the initial management and since a number of patients receive more than one radiotherapy treatment for the same cancer during their lifetime, further calculation was required.

64. Re-treatment currently represents about 4% of the total fractions delivered per annum in Scotland. Making correction for this, an estimated clinical demand of 219,931 – 280,342 fractions (#) was calculated for 89.5% of the incident cancer population 2011–2015.
65. Calculating required total fractions for the remaining 10.5% of incident cancers with an indication for radiotherapy was done as follows:
 - 10.5% of future incident cancer cases represent 3290 persons. Between 44.2% and 47.9% of these are likely to have an indication for radiotherapy (n1436 and n1558). From the retrospective audit of activity 2003 (appendix H), 52% of patients are treated radically, 20% palliatively and 28% for treatment of metastases. Therefore, it can be calculated that between 747 and 810 patients will receive radical treatment, 287 - 312 will receive palliative treatment and 402 - 436 will receive treatment for metastases. Again from the audit, the average fractionation for a radical course is 24, for a palliative 7 and for treatment of metastases 4. To determine an optimal number of fractions for 2011–2015, the fractionation was increased by 50%, acknowledging the general trend towards increased fractionation. Therefore, the following is assumed - radical 36#; palliative 10#; and metastatic 6#. In total, between 20,097 and 34,896 fractions will be required to treat this proportion of incident cancers 2011 – 2015.
66. Furthermore, about 1% of all fractions administered per annum are for the treatment of benign disease. Taking all these factors into account it is estimated that the clinical demand on radiotherapy for Scotland 2011-2015 is between **242,545** and **318,422** fractions, taking into consideration all patients with an indication for radiotherapy, including primary management, re-treatment, and benign disease (Table 6).
67. For most cancers, a range of fractions are presented (Table 6) highlighting the difference in clinical opinion and/or possible changes in fractionation that may result

from as yet unreported clinical trials (appendix G). For example, with breast cancer the possible future fractionation could be any of the following:

- Current (25 – 27)
- 15 fractions (START Trial)
- 5 fractions (FAST Trial)
- intra-operative radiotherapy

68. This example presents a huge variation in potential future fractionation for breast cancer, which is especially important given that it is currently one of the largest users of radiotherapy and any change in this particular treatment would impact significantly on linac workload.
69. Many trials considering alternative fractionation schedules for the treatment of various cancers are ongoing, making it challenging to predict future fractionation and estimate service demand.
70. **It is therefore recommended that fractionation practices are monitored and that any significant changes in standard fractionation schedules e.g. confirmation by the FAST trial of effectiveness of shorter fractionation schedule; are factored into demand models to ensure contemporary estimations for sustainable service planning.**

Table 4: Optimal Radiotherapy Utilisation for Head and Neck Cancers

<div>HEAD & NECK CANCER</div> <div>Average annual incidence Scotland (1996–2000)</div> <div>1000</div>	Oral cavity 0.3 ¹ 300	Stage 1-11 0.47 ¹ 141	Suitable for Surgery 0.9 ² 127		Adverse pathology 0.2 ³ 25	Post-operative radiotherapy 25
					No adverse pathology 0.8 ³ 102	No radiotherapy 102
			Not suitable for surgery 0.1 ² 14			Radical radiotherapy 14
		Stage III-IV 0.53 ¹ 159				
	Larynx 0.32 ¹ 320	Stage 1-2 0.55 ¹ 176	Suitable for larynx preserving surgery 0.06 ¹ 11			No radiotherapy 11
			Not suitable for larynx preserving surgery 0.94 ¹ 165			Radical / post-operative radiotherapy 165
		Stage 3-4 0.45 ¹ 144	fit for treatment 0.9 ¹ 130			Radical or postoperative radiotherapy 130
			unfit for treatment 0.1 ¹ 14			no treatment 14
	Oropharynx 0.15 ¹ 150	Suitable for local resection or unsuitable for treatment 0.05 ² 8				No radiotherapy 8
		Not suitable for local resection 0.95 ² 143				Radical /post-operative radiotherapy 143
	Hypopharynx 0.06 ¹ 60	Suitable for local resection or unsuitable for treatment 0.05 ² 3				No radiotherapy 3
		Not suitable for local resection 0.95 ² 57				Radical /post-operative radiotherapy 57
	Nasopharynx 0.02 ¹ 20					Radical radiotherapy 20
	Other ¹ 0.15 150	Unknown primary 0.06 ³ 9	N1-2a 0.22 ³ 2		Surgery	No radiotherapy 2
			N2B-N3 0.78 ³ 7			Radical /post-operative radiotherapy 7
		Sinus 0.14 ³ 21				Radical radiotherapy 21
		Lip 0.63 ³ 95	Cosmetically excisable 0.75 ³ 71			No radiotherapy 71
			Not excisable 0.25 ³ 24			Radical radiotherapy 24
		Salivary gland 0.17 ³ 26	Surgery 0.66 ³ 17	No adverse pathology 0.27 ³ 5		No radiotherapy 5
				Adverse pathology 0.73 ³ 12		Post-operative radiotherapy 12
			In operable 0.34 ³ 9			Radical radiotherapy 9

¹Data from CRAG audit

² Data from SCAN 2003 head and neck audit

³ Data from Australian publication

Table 5: Future Optimal Fractions Required for Head and Neck Cancers

<i>Clinical Scenario where XRT indicated</i>	<i>Baseline patient number using population 1996-2000 incidence data</i>	<i>Predicted patient population 2011-2015 (24.9% increase incidence)</i>	<i>Optimal number of fractions per radiotherapy treatment schedule 2011-2015</i>	<i>Total number of fractions required 2011-2015</i>
Oral cavity Stage I- II primary radical / post-operative radiotherapy	39	49	35	1715
Oral cavity Stage III-IV Radical /Post op radiotherapy	159	199	35	6965
Stage I and II larynx radical / post-op radiotherapy	165	206	35	7210
Stage III and IV larynx radical /post- operative radiotherapy	130	162	35	5670
Oropharynx Radical /post op radiotherapy	143	179	35	6265
Hypopharynx Radical /post op radiotherapy	57	71	35	2485
Nasopharynx Radical radiotherapy	20	25	35	875
Unknown primary Radical radiotherapy	7	9	35	315
Sinus Radical radiotherapy	21	26	35	910
Lip Radical radiotherapy	24	30	35	1050
Salivary gland Post-operative radiotherapy	12	15	35	525
Salivary gland Radical radiotherapy	9	11	35	385
Total	786	982		34,370

Table 6: Estimated Fractions (Demand) for Scotland by Cancer Type 2011 – 2015

<i>CANCER TYPE</i>	<i>Min total #</i>	<i>Max total #</i>
Head and neck (C00-C14, C30-C32)	34370	34370
Oesophagus (C15)	10670	13705
Colon	145	290
Rectum	8991	9931
Lung (C33-C34)	34698	41382
Melanoma (C43)	3085	3850
Breast (C50)	40,290	69090
Cervix (C53)	3185	3185
Corpus uteri (C54)	5810	5825
Prostate (C61)	30,930	39,426
Testis (C62)	0	1710
Bladder, all (C67, D09.0, D41.4)	11,005	13,025
Brain, meningies and CNS (C70-C72)	6090	8010
Hodgkin's disease (C81)	1440	1440
Non Hodgkin's lymphoma (C82-C85)	9090	12,555
Stomach (C16)	2625	2625
Pancreas (C25)	6575	6575
Ovary (C56)	160	160
Leukaemia (C91-C95)	320	320
Kidney (C64)	1060	1060
Myeloma	595	595
TOTAL (less re-treatment)	211,134	269,129
TOTAL (+ 4% for re-treatment)	219,931	280,342
Other & Unspecified	20,097	34,896
TOTAL (including 1% for benign treatments)	242,452	318,422

Issues and Sensitivities

Variation in Fractionation Schedules

71. Fractionation practices have varied over the years as emerging evidence has supported altered schedules.
72. Clinical practice and opinion about optimal fractionation schedules, for seemingly similar clinical indications, remains divergent across the profession with significant ranges in fractions being prescribed. For example, the recent Scottish Audit of Head and Neck cancers (in preparation) identified 5 different, but rationalised, radical head and neck fractionation schedules in use across the country. In some cases however, such ranges in fractionation are not fully rationalised other than by historical practice and thus result in a disparity of resource utilisation. If no therapeutic or outcome benefit can be shown to result from higher fractionation, it may prove difficult to justify such a schedule over one with fewer fractions - both from a resource but more importantly a patient perspective.
73. For example, the debate of single versus multiple fractions for bone metastases has for many years been fiercely disputed. Evidence suggests that single fraction radiotherapy is as effective as multifraction radiotherapy in relieving metastatic bone pain (Sze *et al.* 2002) yet, multifraction treatments are still common practice. Single fraction treatment has two immediate benefits over multiple fractions:
 - 1) patients have to attend only once for treatment, with reduced physical, social and emotional costs to them and their carers.
 - 2) the demand on linac time, resulting from treatment of bone metastases, may be reduced if a degree of uniformity in prescribing was adopted nationally.
74. **It is recommended that further work be undertaken to explore, map and challenge disparity in current fractionation practices across Scotland, and if appropriate, consider the development of clinical guidelines and approved 'Scottish practice' for standard treatments.**

TECHNOLOGIES

75. Two sub-groups were established within the horizon scanning working group to review and report on:
- (1) new and emerging technologies and techniques and the potential impact on treatment delivery and service capacity.
 - (2) opportunities to streamline technologies, enhance development and implementation, and improve efficiency of utilisation of national resources through improved communication.

New and Emerging Technologies and Techniques

76. The last decade in particular has seen a period of continued progress in medicine, with significant advances in the approaches to the treatment of cancer (Symonds 2001). The advances made in the field of radiation oncology and the development of new methods to target tumours has increased the scope of radiotherapy in the curative treatment of malignant disease. Indeed, current practice derived from clinical trials and established radiotherapy schedules may become obsolete as new technologies become available (RCR 1999).
77. The horizon scanning working group considered in detail many of the evolving technologies and the potential impact which these may impose on future radiotherapy practice and treatment delivery in Scotland 2011–2015. A full report is attached in appendix J.
78. Many of the technologies and techniques considered are not yet in clinical use across the UK and as such, some of the conclusions drawn represent the professional opinion of oncology colleagues about the potential role and impact of as yet, unsubstantiated radiotherapy technologies and practices.
79. In general, the move towards more complex treatments, made possible by a new generation of state-of-the-art linear accelerators is expected to have an initial impact on the capacity of linacs, potentially reducing the patient throughput especially during implementation phase, although this appears to improve as the technique enters routine clinical practice.

80. As previously shown, radiotherapy practice is not static and as one new technology and subsequent technique is implemented another appears on the horizon resulting in a changing demand on linac capacity.
81. Technologies currently on the horizon, and considered to be of greatest significance for a modern radiotherapy service in Scotland 2011–2015, include: CT Simulators, Intensity Modulated Radiotherapy (IMRT), Image Guided Radiotherapy (IGRT), Gating, Intra-operative radiotherapy (IORT) and possibly Tomotherapy.
82. The following technologies and practices were omitted from the deliberations as it was felt that these were unlikely to have a significant role in radiotherapy treatment in Scotland within the timescale of this project - either because of the vast financial implications or due to the complete lack of supportive evidence. **However, it is suggested that these technologies are reserved for consideration in any future review:**
- Hyperthermia therapy
 - Photodynamic therapy
 - Proton / neutron / carbon ion facilities
 - Intravascular brachytherapy

Intensity Modulated Radiotherapy

83. IMRT is not yet in clinical use anywhere in Scotland and only a few places have implemented it across the UK. **All Scottish departments have the capability of delivering IMRT and some collaborative national work is strongly indicated to ensure successful development of this technique across Scotland** (para 93-96). The proportion of patients likely to benefit from IMRT is unclear and although almost every radiotherapy site has been proposed as a target, the main sites being pursued are tumours that are in close proximity to dose limiting structures, and those which may benefit from dose escalation, for example, in head and neck, prostate, cervix, and brain cancers. It may also be used to compensate dose heterogeneity e.g. breast.

84. The impact on treatment time of IMRT is likely to be driven by the technology available by 2015 although delivery time of an IMRT technique is expected to be comparable with a standard treatment technique (Prizkall *et al.* 2000). However, the large number of fields involved in some IMRT techniques may result in a slightly longer delivery time (Budgell G 2002).

Image Guided Radiotherapy

85. Glasgow and Edinburgh have purchased IGRT equipment and expect to be using it clinically by 2008. The Netherlands Cancer Institute and the Christie Hospital, Manchester are performing clinical trials of IGRT, and estimate that it adds around an extra 5 minutes per patient (personal correspondence). However, as the system develops, it is likely that the algorithms will get faster, reducing the time requirements.

Intra-operative Radiotherapy

86. IORT is in the very early stages of development in Scotland with one centre preparing a research programme. It is difficult to quantify the impact of IORT on the external beam radiotherapy service but in general, it is expected to be used to treat some categories of patients traditionally receiving XRT and reduce the treatment requirement of others (para 42). Before this can happen more clinical trials are required to support the appropriate selection of patients suitable for this procedure, and to assess the long-term outcome, local recurrence, survival and late side-effects (Bartelink 2004).

Gating

87. Respiratory gating is also in the very early stages of development in the UK. Lung is the typical treatment site being considered for this technique; other areas under consideration include treatment sites within the abdomen/pelvis and also breast, given the possible benefits of reducing cardiac toxicity. In comparison to a 'standard technique' a respiratory gated technique protracts the length of time taken to deliver a treatment as the machine is only on when the patient is in the right phase of their breathing cycle (Kini *et al.* 2002).

88. Respiratory gating is unlikely to be a technology employed in its own right but rather used in combination with other technologies such as IMRT. Improvements in the speed of technologies will have only a limited influence on patient throughput due to the physical limitations of a patient's own respiratory cycle. It is likely that a treatment slot involving gated therapy will continue to need up to a 100% more time allocated to it than a 'standard treatment' (Medical Physics, Royal Marsden Hospital London, 2004). The number of patients suitable for this treatment technique is not known but is likely to be small.

Tomotherapy

89. There are about 30 Tomotherapy units worldwide but currently only about 6 – 8 of these are treating patients. It is early days for this equipment, so current practice is likely to change relatively quickly. Sites currently being treated include prostate, head and neck (including re-treatment) brain, spinal column, rectum, anus, pancreas, and abdomen.
90. There are currently no Tomotherapy facilities in the UK. It is possible that a single Tomotherapy unit may be considered as a national Scottish resource or that cross border partnerships may be formed particularly if Northern England is identified as a site for one of the two Tomotherapy facilities being considered for England.
91. **If in future, a Tomotherapy facility is proposed for Scotland, issues which may impact on existing radiotherapy services such as workforce, potential workload and others outlined, would need to be considered at that time (see appendix J for more detail).**

Streamlining Technologies

92. As described above, considerable changes and advances in radiotherapy are on the horizon. While the impact on Scottish radiotherapy services cannot yet be fully quantified, ways in which the transition may be made easier and more effective need to be explored. Appendix K sets out some considerations in detail.

93. Central to the debate is better collaboration between the five existing Scottish centres and/or the future configuration of Scottish centres. If each centre continues to work independently developing and implementing what is essentially the same process, each will have considerable resource requirements in terms of time, workforce and financial cost. In addition, the limited resources of some departments may restrict timely development resulting in inequitable access to modern treatment delivery across Scotland.
94. Collaborative working is likely to improve this, avoiding duplication of effort required to develop and implement new techniques/technologies and by hastening progress to enhance and modernise the Scottish radiotherapy service. Two approaches are considered taking, as an example, the scheduled introduction of IMRT.
95. The first approach involves the creation of national technology and technique development groups, inclusive of all 5 cancer centres and a mix of professionals involved in radiotherapy. **It is recommended that IMRT is prioritised for this national approach and consideration is given to a national Scottish IMRT Development Group. This may be progressed by the Radiotherapy Advisory Group or through the Scottish Cancer Group as an immediate work stream.** Other examples where this approach may prove useful either to further develop existing practice and/or develop new horizons, include brachytherapy, IGRT, gating and IORT.
96. The second consideration is to identify one centre or resource to develop specific techniques and install them nationally - including the teaching and training of staff across the Scottish cancer centres. Not all centres have sufficient resources to contemplate this option but consideration might be given to appointing supernumerary 'development' staff to assist with the development, implementation, audit, and monitoring of new technologies and treatment techniques; and the creation of quality control measures for new developments.
97. Improved collaboration may be further enhanced by optimising the untapped potential of information technology, making a number of possibilities conceivable :

- Transfer of images, radiation targets etc. to a virtual resource and completed treatment plans returned.
 - Video conferencing arrangements to allow interactive discussions based around planning system displays and possibly even enabling virtual planning with clinicians and physicists sited at different locations.
98. In practice, this makes ‘an interlinked planning resource for Scotland’ a possibility. Such a planning resource need not be a physical space but rather a virtual resource, enabling all treatment centres to contribute to the planning of Scottish radiotherapy treatments through a managed secure IT and conferencing network.
99. Although this idea has been considered before, earlier technology was unable to support it. Today however, data transmission is faster and security greater, making it feasible to properly consider such options. One potential drawback arises in the planning of more complex treatments which in many cases requires continuous interaction between planning and medical staff. The practicalities of scheduling this may prove difficult and may not be adequately managed through interactive media options.
100. **This option may need further consideration if future reviews support a devolved configuration of radiotherapy services for Scotland.**

ESTIMATING REQUIRED RADIOTHERAPY SERVICE CAPACITY 2011-2015

101. Having projected the future clinical demand for radiotherapy in Scotland and reviewed a number of technological advancements which may impact on capacity, it is possible to estimate the required radiotherapy service capacity 2011-2015.
102. Assuming that every incident cancer case with an indication for radiotherapy receives radiotherapy, and that optimal fractionation schedules are applied, it is estimated that the clinical demand for radiotherapy services in Scotland 2011–2015 will be between 242,500 and 318,500 fractions per annum.

103. As demonstrated through the various modelling stages (appendix G) and outlined in the example of breast cancer, the upper end of the projected demand may represent an overestimate. However, planning for any less than this could be unhelpful and leave future services under-resourced and patients at a disadvantage. Therefore, it is preferred to use the upper end of estimated clinical demand (318,500 fractions) as the basis for capacity modelling, acknowledging that this will be subject to change as new evidence emerges.
104. A number of useful demand and capacity models exist. For example, Steyn (2004) recommends that service capacity be set at 85% of the fluctuation in demand. This is demonstrated to have considerable benefit, producing reductions in waiting times and overcoming some service bottlenecks.
105. Considering the Steyn model in this instance; if the range (242,500 - 318,500) of projected demand is taken to represent the fluctuation in demand, setting the capacity at 85% of this fluctuation would give a threshold capacity of approximately 280,500 fractions. Given the level of uncertainty about where in the predicted range future demand may actually fall, and the potential adverse affect on radiotherapy services of under provision, it seems more reasonable at this stage to consider, as the baseline, the upper end of estimated demand.
106. The Royal College of Radiologists (2004), suggest that service capacity should include an additional 10% in order to allow for development and implementation of new techniques. Thomas (2003) suggests that in a radiotherapy service, capacity should be about 10% greater than a given level of demand to avoid treatment waiting times.
107. **Taking these factors into consideration and using the upper end of the clinical demand (318,000) as baseline, it is recommended that the capacity of Scottish radiotherapy service of 2011-2015 be planned using optimal clinical demand plus an additional 10%. Therefore, the Scottish radiotherapy service should have the capacity to deliver up to about 354,000 fractions per annum ($318,422 \div 0.9$). This will allow capacity for research and development/implementation of new**

techniques and technologies and ensure that waiting times are not built into the system.

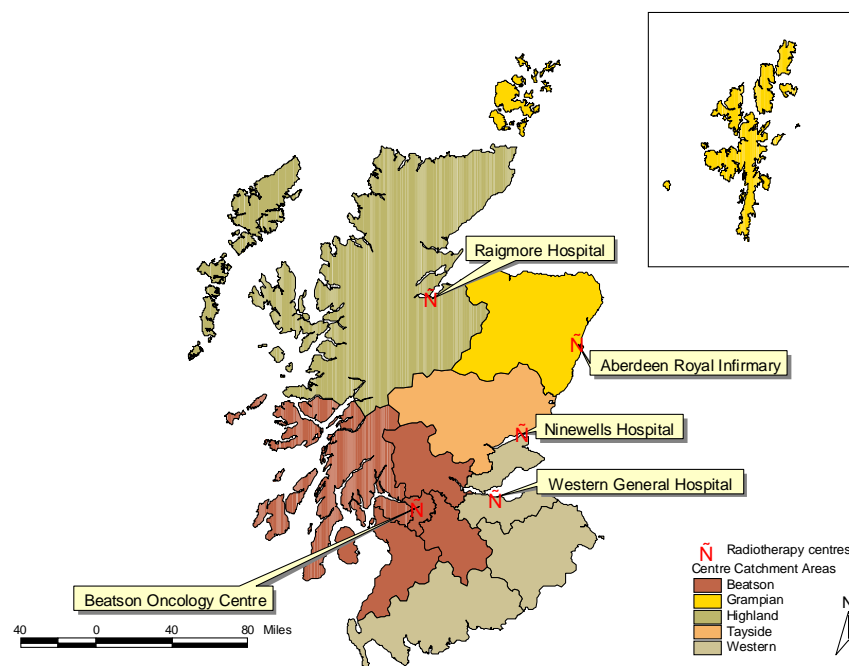
108. Achieving this capacity should, if demand projections hold true, result in no routine waiting time for radiotherapy once an XRT referral has been received. This will be achieved only after the effects of the current demand and capacity mis-match are overcome. Furthermore this hypothesis is dependent on timely access to associated services and progression through for example the disease staging and treatment planning phases of the patient pathway.

SERVICE MODELS

CURRENT SCOTTISH SERVICE CONFIGURATION

109. In Scotland, there are currently five cancer centres which plan and deliver external beam radiotherapy treatment to approximately 11,000 new radiotherapy patients per annum. These centres are sited across Scotland - Aberdeen, Dundee, Edinburgh, Glasgow and Inverness (Figure 4) - and serve very different populations.

Figure 3: Location & Geographical Area Served by Scottish Cancer Centres



110. The number of linear accelerators in Scotland was increased from 15 in 1997 to 22 in 2004. This expansion is providing considerable increased capacity in comparison to that which was available in 1997. However, demand on radiotherapy services has increased concurrently and, as demonstrated, will continue to do so. If the estimated clinical demand holds true (318,422 fractions), the Scottish radiotherapy service of 2011–2015 will be delivering 81% more treatment fractions per annum than in 2003.
111. The ongoing national radiotherapy and related equipment capital programme will see 25 modern linacs in place in Scotland by 2007/08. This includes a third linac in

Dundee and a second linac in Inverness which is yet to receive final approval from NHS Highland. This will give the following Scottish radiotherapy service configuration - Aberdeen 3 linacs, Dundee 3 linacs, Edinburgh 6 linacs, Glasgow 11 linacs and Inverness 2.

Highland Issues

112. The Department of Clinical Oncology at Raigmore Hospital, is the smallest oncology department in the UK and justification for such a department is mainly geographical - the Highland region is the most remote part of the UK with parts of it remote even from Inverness.
113. There is currently one modern linac at Raigmore, although the decommissioning of an older machine has been delayed to provide emergency back-up. This machine is nearly obsolete and the manufacturer has advised that spare parts are no longer available.
114. To support a safe sustainable service, at least two compatible linacs are required so that a back-up service is available if one machine breaks down, needs servicing etc. Herein lies the first difficulty faced by the oncology team at Raigmore with patients significantly disadvantaged by the need for double planning and the limitations of what the older back-up machine (if needed) can deliver. The option of transferring patients to Aberdeen or Dundee in the event of machine failure presents a very difficult situation, not least for patients who already travel considerable distances to access Raigmore. Also, transferring a patient workload to another busy centre may result in prolonged treatment and adversely impact on the service provided in that area.
115. The need for a continuing non-surgical oncology service in Highland is strongly supported in terms of both geography and political will and there may be a far reaching impact on the sustainability of other specialist services should this oncology service be withdrawn. While the current situation in Inverness is unsustainable the need for a treatment centre remains and supporting a second modern linac in

Inverness appears to be the most reasonable option to ensure that patients in the Highlands are not disadvantaged.

116. **A second linac at the Inverness site would therefore provide an additional resource across the North of Scotland and ensure that the current Highland service is sustained.**

MODELS FOR PROJECTING LINAC REQUIREMENTS

117. A number of models exist which can be used to project linear accelerator requirements for a population (RCR 2004). The first of these is a simple approach based on Royal College of Radiologists recommendations that there should be 5.5 linacs per million population by 2011. Assuming no additional change to the planned linac complement, Scotland will have 25 linacs in use by 2011 and a projected population of 4.983 million. This will give 5.02 linacs per million population. In order to achieve 5.5 linacs per million, 27.4 linacs would be required for Scotland.
118. This model is useful for assessing the equity of access to radiotherapy facilities across a population however, the simplicity of the model gives rise to questions about the robustness of it as a long-term planning aid since the rate of cancer in a population, rate of radiotherapy use, treatment indicated and productivity of linacs is not considered. Indeed, adopting linacs per million population as the basis for long-term service planning in Scotland, could work inversely since the declining population will over time result in the number of linacs per million population increasing without the addition of any more equipment - unhelpful given that decreases in the overall population is not expected to impact on radiotherapy demand which is predicted to continue to rise.

CURRENT SCOTTISH SERVICE MODEL

119. Linacs in Scotland currently work an average of 7.25 clinical hours a day (Robertson 2004), 5 days a week, and 240 days a year - acknowledging that some are working longer to meet service pressures in local areas. Assuming this service model is sustained with an average of 5 fractions delivered per clinical hour, it is estimated that 41 linacs might be required for Scotland to meet the projected capacity of 354,000 fractions per annum. This is 16 linacs more than the 25 planned under the current replacement and expansion programme and would mean a major acute and tertiary service development for NHS Scotland.

SERVICE MODEL VARIABLES

120. As noted above, it is projected that the Scottish radiotherapy service will require the capacity to deliver up to 354,000 fractions per annum by 2011-2015. Three options for achieving this capacity are considered:
- Increase the number of linacs
 - Increase the productivity of current linacs
 - Combination of the above
121. In order to explore the potential productivity of linacs several variables are considered:
- number of treatment fractions delivered per hour
 - working hours a day
 - working days a week
 - working days a year

Number of Treatment Fractions Delivered per Hour

122. 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. At present, linac workload in Scotland is poorly estimated and in this instance, reliance on number of fractions delivered per hour is placed on crude estimations making no obvious adjustment for varying complexity of treatment.

123. Estimations used in this instance were however supported by radiotherapy professionals, and through consultation it was agreed that linac activity should be based on the ability to deliver an average of 5 fractions per hour; acknowledging that up to 7 fractions may be delivered in some hours and in others this number may be less than 5. Consideration was given to the impact of increasing treatment complexity in these deliberations as was the additional Quality Assurance (QA) requirements, variation in patient performance status, beam-on time, auto-sequencing and other factors.
124. **To enable more accurate future activity estimations, it is recommended that appropriate data parameters are agreed and the data is collected to support ‘basic treatment equivalent’ modelling. This will be enhanced by the availability and accessibility of linac activity data via the new Varis 7 system, which will in time be standard across the service.**

Working Hours a Day

125. Optimising the current service model for every linac in Scotland would achieve a full 8 hour clinical day (Model A) and would in its self result in an immediate increase in the productivity of linacs and the radiotherapy service capacity in Scotland.
126. Models B and C both demonstrate a 10 hour clinical day.

Working days a Week

127. The standard working week for radiotherapy is 5 days, Monday to Friday (Models A and B). Radical fractionation schedules have evolved to accommodate this. Reviewing the core clinical service model to consider a 6 day working week presents a further option for increasing the productivity and capacity of linacs (Model C), although it is likely that fractionation schedules of 5 fractions per calendar week will remain in most cases.

Working Days a Year

128. Reducing the number of treatment days lost through interruption to clinical service as a result of closure for public holidays and routine machine maintenance also presents a further opportunity for increasing linac capacity. Reducing the interruption to service and subsequently radiotherapy treatments is also likely to improve control and cure rates in a number of tumour types (Hendry *et al.* 1996).
129. Closure for public holidays in some cases significantly contributes to reduced service capacity and can result in 8 to 10 treatment days lost per annum. Under Agenda for Change there will be eight public holidays per annum, 3 fixed and 5 flexible.
130. It is estimated that essential linac maintenance and quality checks for modern linacs will equate to one day per month for mechanical and electronic maintenance plus an additional day every quarter for dosimetry work, 16 days in total. While current standard servicing equates to about 10 days per annum, it is advisable to use the upper limit of 16 days per annum for future planning given the potential increase in calibration and dosimetry requirements of modern linacs.
131. In addition to the routine maintenance outlined above, daily morning run-up and quality checks can take up to an hour a day per linac. **Morning ‘run-up’ should not impact on the clinical time of a linac and most cancer centres should have or be considering local agreements to ensure that this is the case.**

PROPOSED SERVICE MODELS

132. A number of possible future service models are considered. The variables detailed above are altered in each model to illustrate the impact on linac capacity. For all models the possibility of moving routine maintenance to non-clinical service hours, such as weekends, is proposed since this could potentially enable up to 16 additional treatment days per annum.
133. Given that the current Scottish unscheduled downtime results in about 1 – 3% of clinical time lost, the total fractions that can be delivered per linac per annum has been corrected to account for this.

MODEL A

134. Model A considers an 8 hour clinical day, 5 day week and a variable number of days per annum. Scenario b (highlighted) best represents the base-line closest to the current service model. In order to achieve the required capacity (354,000 fractions) between 35 and 38.5 linacs would be required. This is 10 to 14 more linacs than will be in operation by 2007/08.

# / Hour	Hours Per Day	Days / Year	# per year/linac	# per year less 3% for unscheduled downtime	Total # with 25 linacs	Linacs required to meet capacity 354,000 #
5	8	236 ^a	9440	9200	230,000	38.5
5	8	241 ^b	9640	9350	233,750	37.9
5	8	257 ^c	10,280	9900	247,500	35.8
5	8	260 ^d	10,400	10,100	252,500	35.0

- a 236 days assumes department closure on all 8 public holidays and for all 16 essential service days, (total closure 24 days)
- b 241 days assumes department closure for only 'essential' public holidays - that is to say Christmas day, New Years day and one of good Friday or Easter Monday (3 days) and all 16 essential service days, (total closure 19 days)
- c 257 days assumes department closure for only 'essential' public holidays with all essential service days transferred to out of service hours (total closures 3 days)
- d 260 days assumes that the department is open for 5 days a week, 52 weeks of the year

MODEL B

135. Model B considers extending the core clinical service day to 10 hours. It assumes that the service continues to operate on a 5 day week. In order to achieve the required capacity, between 28 and 31 linacs would be required. This is 3 to 6 more linacs than will be in operation by 2007/08.

# / Hour	Hours Per Day	Days / Year	# per year/linac	# per year less 3% for unscheduled downtime	Total # with 25 linacs	Linacs required to meet capacity 354,000 #
5	10	236 ^a	11800	11,500	287,500	30.8
5	10	241 ^b	12050	11,700	292,500	30.3
5	10	257 ^c	12850	12,500	312,500	28.3
5	10	260 ^d	13000	12,600	315,000	28.1

- a 236 days assumes department closure on all 8 public holidays and for all 16 essential service days, (total closure 24 days)
- b 241 days assumes department closure for only 'essential' public holidays - that is to say Christmas day, New Years day and one of good Friday or Easter Monday (3 days) and all 16 essential service days, (total closure 19 days)
- c 257 days assumes department closure for only 'essential' public holidays with all essential service days transferred to out of service hours (total closures 3 days)
- d 260 days assumes that the department is open for 5 days a week, 52 weeks of the year

MODEL C

136. Model C considers extending the core clinical service to 6 days a week, 10 hours a day. In this case, the planned 25 linacs for Scotland would provide required capacity.

# / Hour	Hours Per Day	Days / Year	# per year/linac	# per year less 3% for unscheduled downtime	Total # with 25 linacs	Linacs required to meet capacity 354,000 #
5	10	288 ^a	14400	14,000	350,000	25.3
5	10	293 ^b	14650	14,200	355,000	24.9
5	10	309 ^c	15450	14,500	362,000	24.4

- a 288 days assumes department closure on all 8 public holidays and for all 16 essential service days, (total closure 24 days)*
- b 293 days assumes department closure for only 'essential' public holidays - that is to say Christmas day, New Years day and one of good Friday or Easter Monday (3 days) and all 16 essential service days, (total closure 19 days)*
- c 309 days assumes department closure for only 'essential' public holidays with all essential service days transferred to out of service hours (total closures 3 days)*

SERVICE MODEL APPRAISAL

SERVICE MODEL OVERVIEW

137. By maintaining the current working year (about 240 days per annum) but optimising the clinical use of each linac to an 8 hour day, the Scottish service should have the capacity to deliver around 234,000 fractions per annum with a full complement of 25 linacs. Assuming an incremental increase in clinical demand per annum, it is estimated that clinical demand will exceed this service capacity by about 2008. In order to achieve the required capacity (354,000 fractions per annum), a further 51% (120,000 fractions) increase in service capacity is required.
138. Adopting model A would require an additional 10 – 14 linacs for Scotland, depending on the variables applied. If a maximum of 260 days per annum are worked and all routine servicing transferred to non-clinical hours, only about 15% of the required additional capacity will be met with 25 linacs. In order to meet 100% of the required capacity for this scenario, a minimum of 10 additional linacs would be required.
139. Maintaining an 8 hour service day as indicated by model A, would result in a major acute/tertiary service development for NHS Scotland and could reasonably result in the need to develop up to 3 new cancer centres - regardless of the variables applied. The financial and workforce implications of a service development on this scale would be immense and consideration of this model without exploration of service redesign options cannot be justified. Model A should therefore be excluded from further consideration at this point.
140. Model B could reasonably enable the required additional capacity to be achieved through a combination of service redesign and a much smaller service expansion. If all planned machine maintenance is transferred to non-clinical hours (i.e. weekends) but 3 essential public holidays remain, resulting in a 257 day clinical service year, only 3/4 additional linacs would be required for Scotland.
141. Model C could enable all required capacity to be met through service modification alone. Working for 293 days a year would be the preferred option as the logistics of

managing the equivalent of 16 days machine maintenance per linac, within the remaining 47 non-clinical days a year would be nearly impossible especially in the larger centres.

142. **Model C concludes that all estimated service capacity may be achieved on less than the planned 25 linacs however, it is recommended that the number of linacs in Scotland does not drop below 25 given the projected continued increase in cancer incidence beyond 2015. This may be revised by future modelling.**

143. In conclusion, Model B and C both present theoretically viable options:

- All required capacity could be met through a combination of Model B and a smaller scale service expansion (3/4 linacs).
- All required capacity could be met through adoption of Model C.

ADOPTING MODEL B AND/OR C - THE ISSUES

144. Adopting service model B and/or C will require revision of the current core clinical service hours per week. While the benefits are substantial in terms of increasing overall service capacity, successfully implementing these models will require consideration of a number of issues:

- transition of core oncology service, including support services from 40 hours per week to 50 or 60 hours per week.
- attendance of patients outside the current Monday – Friday, 9 am to 5 pm model.
- recruitment, training and retention of staff to support new core service.
- life expectancy of linear accelerator.
- optimising the capacity of each linac in Scotland and ensuring comparable workloads.

Transition of Core Oncology Service

145. In support of a fair and equal service for all, the extension of radiotherapy service hours should be matched by the transition of all required support and ancillary services/facilities, ensuring equal provision for all patients at all times. **A core service change would therefore be a prerequisite.**

146. The core service includes: administrative, auxiliary, nursing, medical, hospital porter, hospitality, technical and pharmacy services. It may be the case that some of these services are already available for the majority of the proposed change in clinical service hours but it is unlikely that such services are currently available after 5pm and/or at weekends.

Patient Attendance

147. The current radiotherapy service in Scotland operates 9 am to 5 pm, Monday to Friday; although two linacs in one Scottish centre currently operate on a regular basis for 9 hours a day to manage local service pressures. Assuming model B or C is adopted, a 10 hour clinical service day would be required.
148. Although anecdotal evidence has suggested that patients may be reluctant to attend for 'out of hours' service, this has often been based on the premise of a 12 hour clinical day which requires either very early morning or late evening attendance (RCR 1997). In contrast, the proposed 10 hour service day could be delivered between the hours of 8 am and 6 pm, thus better resembling a 'normal' working day.
149. In light of the proposed moderate change to the clinical service day and following further exploration of patient issues in view of this, it was concluded that a new core service day of 8am – 6pm should not result in change limiting difficulties. Any potential problems or additional costs that may be incurred by for example arranging patient transport, may be alleviated or offset by targeting specific groups of patients to attend for treatment appointments between 8am – 9am and 5pm – 6pm e.g. inpatients, self-drive patients, accommodated patients, patients continuing to work during treatment, patients living close to the cancer centre.
150. Furthermore the transition of the core service to a 10 hour clinical day will ensure equity of service to all patients and dispel anxieties which may have arisen in the past as a result of ad-hoc extended day working with a skeleton service provision.
- Promotion of the radiotherapy service may be required to enhance patient understanding of the service hours and allocation of treatment appointments and**

to promote the increased appointment availability and options resulting from a new core service.

151. Extending the core radiotherapy service from a five to six day week, presents similar issues with regard to patient attendance. Although a 6 day working week would increase service capacity considerably, most patients would still require a two day break from treatment for radiobiological reasons and this is likely to be a Sat/Sun (as is currently the case) or Sun/Mon. Some of the issues which may arise from a Sun/Mon weekend may again be offset by targeting particular groups of patients.

Workforce: Recruitment, Training and Retention

152. Regardless of the service model adopted to meet future demand, an increased workforce will be crucial. Assuming models B and C still present the best option for increasing service capacity, immediate action will be required to review workforce requirements, skill mix and working practices to ensure a workforce supply and demand match that will reflect the needs of the proposed service model 2011–2015. This is considered further in Chapter 7.
153. **Adequate staff numbers must be a precondition of any service change. The proposed 10 hour clinical service day will NOT require existing staff to work beyond their contract hours and should not operate on the goodwill of existing staff as has been the case to manage some previous ad-hoc extended day working agreements. The new proposed core service would however require a shift system to meet the 10 hour clinical day requirements and to ensure that routine maintenance is undertaken outside clinical hours.**
154. With regard to dosimetrists and engineering staff, adoption of model B and/or C, will require staff cover from 7am to ensure that morning run-up and quality checks are done outside clinical hours. In addition, these models support the transfer of all routine servicing to non-clinical hours e.g. weekends. This will require weekend and/or evening working depending on local need and agreement, presenting a considerable contract change and a possible limiting factor.

155. Therapeutic radiography staff cover would be required to enable the first daily treatment appointment at 8 am with the clinical day finishing at 6 pm, ensuring optimal daily clinical use of the linac. Some departments already have staff working similar shifts to manage extended day working where indicated. A six day working week would require full staffing of a Saturday service.
156. In addition, a core service change will undoubtedly impact on a number of other staff groups as a matched transition of all services currently available to patients attending 9 am – 5 pm will be a pre-requisite of any new service model (see para 149-150).
157. Seven day working might permit recruitment of groups of staff not able to work Monday – Friday, however, such a culture change for the core workforce would not be easy to achieve (RCR 2000).

Linac Life Expectancy

158. Linacs have a finite working life expectancy, based on their hours of clinical use. Currently, the working life of a machine operating a 40 hour week is about 12 years. 'Information from several departments suggest that the life of a machine may be reduced by up to 15% if operated 50 hours per week, and up to 25% if worked 60 hours a week, although long-term prospective monitoring will be required to confirm these predictions' (RCR 1997).
159. As above, there is much uncertainty as to how hard modern machines can be worked before increased breakdown, reduced life expectancy and increased maintenance costs become an issue. Economic analysis, based on current understanding, may help ascertain the breaking point and demonstrate at what level the working life expectancy of a linac is reduced with a negative cost effect however more detailed baseline data will be required. Prospective audit of breakdowns and technical incidents would be helpful to inform these assumptions.
160. In Scotland, linacs currently operate an average of 40 hours per week, thus their life expectancy is expected to be 12 years. Adopting Model B and increasing the core week to 50 hours might be expected to reduce the linac life expectancy to 10 years.

Fortunately, the current rolling programme of radiotherapy equipment replacement for Scotland is working to a 10 year replacement timetable and thus increasing the core service to 50 hours per week should not increase replacement costs already in the pipeline. However, if a 60 hours week was adopted it is possible that this may have an impact and result in the linacs needing replaced within a shorter time frame.

161. A linac maintenance issue which might relevantly be considered in this context is the provision of weekend and out of hours maintenance support from manufacturers. **At present the manufacturers provide no weekend or evening support service to enable for example parts ordering or to provide maintenance advice. The national radiotherapy equipment procurement group may wish to consider, if this service is deemed necessary, entering into discussion with the manufacturers to make some national arrangement on behalf of the Scottish service.**

Optimising Service Workloads

162. All proposed service models are based on the premise that every linac in Scotland operates with comparable workloads. The current workload and patient throughput is not similar for all linacs in Scotland and this is in part a reflection of the variation in clinical service hours, patient populations, geography, available resources and to some extent variation in clinical practice. There are however, a number of advantages of ensuring comparable workloads per linacs, not least more efficient use of resources. Other benefits include:
- a) reduced waiting times;
 - b) in some cases reduced travel times/distances for patients; and
 - c) greater choice of access for the patient.
163. There are concerns about maximising the potential capacity of all linacs in Scotland to meet demand. In the case of Highland for example, it seems likely that the available service capacity will be greater than the clinical demand from this area resulting in inefficient use of capacity. In contrast the clinical demand may exceed service capacity in other areas, such as the central belt, if workloads remain unchanged. This highlights the importance of reviewing the distribution of workloads, and making best possible use of national resources (RAPG 2003).

164. Re-distributing the radiotherapy workload will require current patient referral and service population boundaries to be reconsidered and may prompt some creative use of high capacity/low demand resources for the purposes of e.g. research and development; short-term management of service pressures to avert unnecessary waits for treatment in high pressure areas; or to establish specialist resources.
165. **It is recommended that further work is undertaken to explore how far redistribution of workloads can be taken to optimise the use of the linac capacity.**

ECONOMIC EVALUATION

166. Preliminary economic evaluation indicates that Model B, scenario c, i.e. the preferred model, is the most cost effective. Further analysis and sensitivity testing is in progress.

SERVICE MODEL RECOMMENDATIONS

167. Both models B and C present options for increasing the service capacity to achieve the required capacity of 354,000 fractions by 2015.
168. **Service Model B, scenario c will enable the required capacity (354,000 fractions) through service redesign and a smaller service expansion, 3/4 linacs.**
169. **A phased adoption of model B, scenario c service redesign is recommended as a first stage change.**
170. **This will involve:**
- **Increasing the core clinical service to a 10 hour day, 5 day week.**
 - **Reducing the days lost per annum as a result of closure for public holidays and routine maintenance to achieve 257 clinical days per annum.**
 - **Optimising the capacity of linacs in Scotland and redistributing the workload**
171. **Achieving this service redesign will enable capacity to deliver up to about 312,500 fractions per annum. Assuming incremental increases in clinical**

demand, this capacity threshold should be adequate until about 2010-2012. Therefore, there is no immediate requirement to increase the number of linacs in Scotland beyond 25.

172. As recommended (paragraphs 21, 43, 45, 68) demand and capacity projections should be reviewed on a recurrent basis in-line with new available data and emerging evidence. This should also be supported by monitoring of actual radiotherapy service demand and activity between now and the review period. It is recommended that the next review is carried out in 3 to 4 years time, to ensure adequate lead time for purchase of additional linacs and associated equipment – if it is concluded that these are required by 2010-2012 (as above).
173. If demand projections hold true, and capacity for 354,000 fractions per annum are required, up to 3/4 additional linacs will be required to enhance service Model B, scenario c. Alternatively, a 6 day working week may be considered further but does not at this stage seem feasible from a human resource perspective.
174. Assuming that an additional 3/4 linacs are indicated, the location of these linacs will require further debate. Capacity exists to house additional linacs at the Aberdeen, Dundee, Edinburgh and Glasgow cancer centres. Utilisation of this building space could provide an immediate and short-term solution but may not be the preferred permanent option and should be re-assessed as part of the review in 3-4 years time.
175. A Radiotherapy Advisory Group, reporting to the Scottish Cancer Group is being established to:
 - a. monitor clinical practice, impact of extended hours and capacity constraints
 - b. coordinate developments such as IMRT (intensity modulated radiotherapy) and IGRT (image guided radiotherapy) to ensure equitable access across Scotland

- c. **coordinate efforts to ensure that all linear accelerators have an approximately equal workload**
- d. **repeat the current review of capacity and demand in 3-4 years time to ensure adequate lead time if additional capacity is found to be required.**

176. **Immediate action is required to:**

- **review workforce shift patterns, working practices, skill mix, new roles and additional staff requirements to meet the above core service model.**

CONFIDENCE IN PROPOSED WAY FORWARD

177. The methodology adopted for projecting the required radiotherapy service capacity for Scotland 2011-2015 and the proposed combination of service redesign and modest service expansion for achieving this, has been presented and tested in a number of forum which, given the approval and support, provides a considerable degree of confidence in both the method and recommended way forward.
178. The RAPG was established with a widely representative cross-section of specialists in clinical oncology, other NHSScotland staff, Scottish Executive staff, and patients and carers. Members unanimously support the proposals. In addition, Therapy Radiographers in Scotland (TRiS) and the Scottish Radiotherapy Physics Group were involved in discussions and contributions.
179. In June 2004 the work was presented at the European Society for Therapeutic Radiology and Oncology (ESTRO) workshop in Brussels. An international community were again privy to the Scottish work through a 'Scotland in the Netherlands' event held in December 2004, Edinburgh. This brought together the most influential opinion formers in the field of clinical oncology, from the Netherlands and the UK, and the approval and support from this event has added further assurance. A senior delegation from the Department of Health and English Radiotherapy Planning Team also attended.

180. Furthermore, the work has been presented to a working group from the Department of Health, London who is conducting a similar exercise and is now revising their approach to consider shadowing the methodology presented in this report.

CHAPTER SIX

PATIENT & CARER INVOLVEMENT

181. The current radiotherapy activity planning process was enhanced by the invaluable contribution and involvement of patients and carers at all stages of discussion, providing useful insights into ‘service user’ views.
182. However, given the relatively small incremental service changes which are indicated to meet the projected clinical demand, it was agreed that a wide-ranging patient/public consultation was not warranted at this time. The opinion gleaned from such an exercise would only reflect the experience of current patients/carers and may not necessarily reflect the opinion or thoughts of a future patient generation with different profiles, contemporary culture and expectations.
183. **It is recommended that if and when more radical change is indicated and/or the next review is scheduled, in three to four years time, a comprehensive patient/public engagement process is undertaken.**
184. In the current process the following issues were considered:
- Optimising patient travel times
 - Patient accommodation and transport

OPTIMISING PATIENT TRAVEL TIMES

185. Geographical modelling (GIS) was undertaken to consider optimised patient travel times to the existing radiotherapy facilities in Scotland. Figure 9 displays the ‘catchment’ areas of the five radiotherapy facilities based on current referral routes. Referral routes are in the main determined by Health Board of residency and are not always the closest facility to the patient.
186. Optimising the patient travelling time to existing radiotherapy facilities in Scotland may result in considerable change to the populations served by the each facility (Figure 10). The most obvious change being that Dumfries and Galloway patients would be referred to Glasgow as opposed to Edinburgh as at present.

187. Implementing optimised patient travel times to radiotherapy facilities, despite the benefit to patients, is not straight forward and presents a number of difficulties arising mainly from the way in which services have developed. These include difficulties in relation to working across health board boundaries and ensuring the continuity of patient care and management when a number of other services are involved. Furthermore, oncologists have established and support oncology referrals and review clinics at a number of locations within existing boundaries. These factors should not however, deter consideration of new ways of managing radiotherapy referrals to allow greater flexibility in order to reduce travelling and associated stress for both patients and their carers.
188. Such practice will for a number of patients present more than one possible radiotherapy department to which they may be referred. All patients should be considered for treatment at any one of the Scottish cancer centres in order to ensure timely access to treatment. This may be of particular benefit for Island patients who might reasonably be referred to any of the radiotherapy facilities with minimum disruption, should transport links support it. Recent Scottish Executive initiatives to improve transport links to remote and rural communities, including the Islands, may make this option more feasible.
189. **Better cohesion between services should be explored in order to support comprehensive quality assured care packages for individual patients. Patient pathways to radiotherapy need not be fixed or dictated by any specific health board/regional boundary but rather selected to optimise the patient outcome and experience. Decisions should be based on the best available option for patients while ensuring better use of national resources, thus realising a truly patient centred service.**

Figure 4: Catchment Populations of Scottish Cancer Centres based on Current Referral Pathways

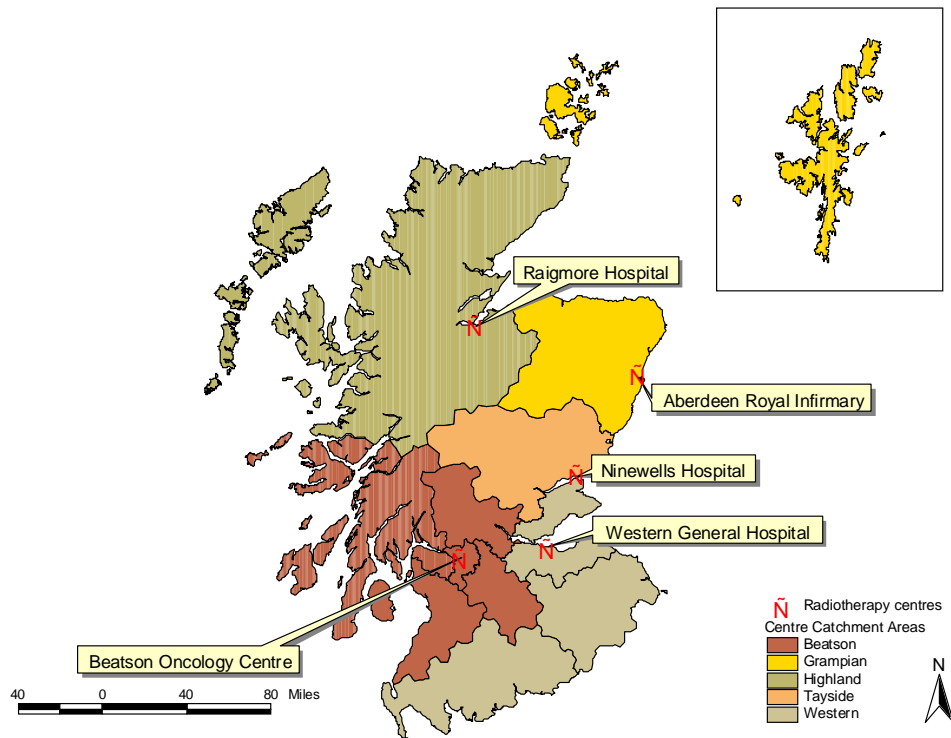
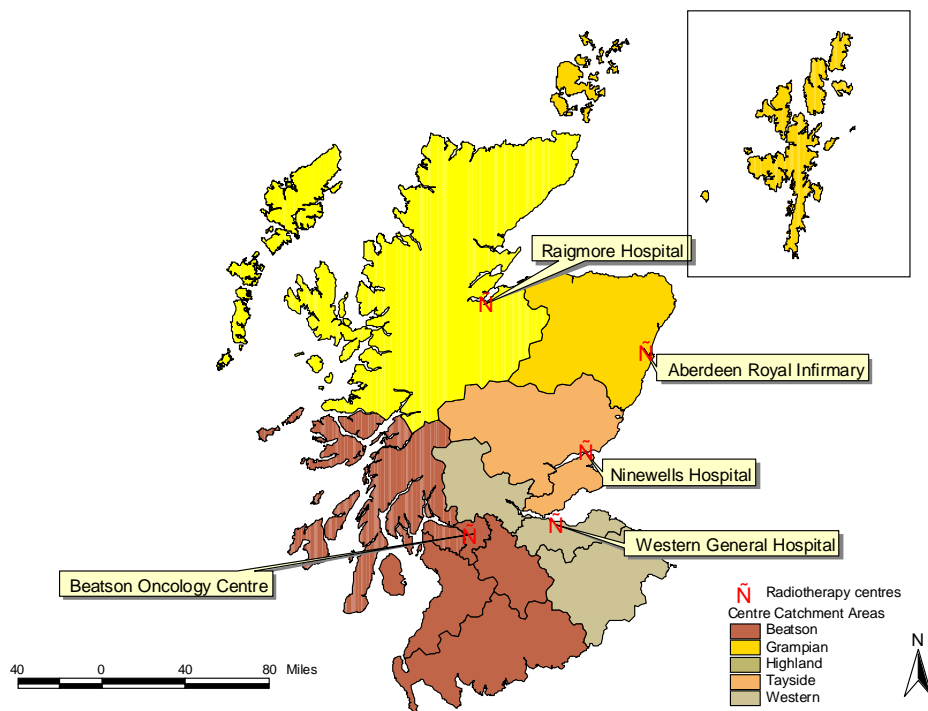


Figure 5: Catchment Populations of Scottish Cancer Centres Optimised by Patient Travelling Time



PATIENT ACCOMMODATION AND TRANSPORT

Accommodation

190. The vast majority of radiotherapy treatments are delivered on an out-patient basis. This has a major impact on patients, their relatives, carers and hospital transport services (RCR 2000).
191. Patients living a considerable distance from radiotherapy facilities, for example in the Northern or Western Isles, are normally offered some type of accommodation for the duration of their treatment. However, for patients living in closer proximity to a facility, accommodation is not routinely offered despite the recognised physical, emotional and financial costs of daily commutes for treatment (Atkinson *et al.* 2002, Roe *et al.* 2002).
192. Some patients attend daily for up to 8 weeks of treatment. The appointment itself normally takes about 10 minutes but a round trip commute to the cancer centre and a combination of waiting for appointment and transport (hospital or public) can result in a full days commitment. As the treatment progresses and side-effects, such as fatigue or nausea, become more pronounced the impact of daily commutes on the patient and carer are often exacerbated.
193. Existing accommodation facilities are barely adequate to meet the demand of patient referrals from remote areas. As a result some patients are choosing to delay the start of treatment until accommodation becomes available. For patients living less remote to radiotherapy facilities but still having to undertake a relatively strenuous daily commute e.g. more than 120 minute round trip, the option of accommodation is not normally considered.
194. **It is recommended that accommodation facilities be reviewed with a view to extending and enhancing them. When assessing the required capacity of such facilities, consideration might be given to the impact of increasing access for a greater number of patients e.g. those living relatively remote to a cancer centre. A larger proportion of patients might benefit from having access to accommodation facilities at any stage of their treatment and it might be the case that patients access this service for only one or two weeks rather than for the full duration of their**

radiotherapy. Furthermore, additional accommodation facilities may reduce the pressure on already overstretched inpatient resources.

Transport

195. The issue of patient transport is considerable. It is inevitable that increased numbers of radiotherapy patients will result in increased demand on transport services. Furthermore, the additional demands arising from an ageing and less mobile population should be considered.
196. The proposed radiotherapy core service change to a 10 hour clinical day may not immediately impact on existing patient transport arrangements, since patients requiring transport can, with appointment management, still be treated between 9am – 5pm. This however should not overshadow the continuing substantial demand and difficulties faced by radiotherapy services in relation to arranging patient transportation.
197. **It is recommended that the demand for and capacity of hospital transport services is reviewed within a context wider than radiotherapy services. This might be done in collaboration with other outpatient services. Further exploration of alternative modes of transporting patients for daily appointments is also needed.**

CHAPTER SEVEN

WORKFORCE

198. It is estimated that the capacity of radiotherapy services in Scotland will need to increase by 51% in order to meet future demands. Regardless of whether this additional capacity is met with 38 linacs working shorter hours or fewer linacs working longer hours, new ways of working and an increased workforce will be essential (Table 7).

KEY STAFF GROUPS

199. The key professional groups essential to the delivery of core radiotherapy services are clinical oncologists, radiotherapy physicists (including dosimetrists and engineers) and therapeutic radiographers (including advanced practitioners and assistants). Details of the roles and contributions of these key professional groups are found in appendix L.
200. **Administrative and nursing staff, medical oncologists, pharmacists, physiotherapists, and dieticians are but a few of the other professional groups that make up the multidisciplinary cancer team. The impact on these professional groups and to other services e.g. haematology, pathology, radiology, surgery, of any change to the radiotherapy service as well as the increased patient numbers should be considered.**

GENERAL ISSUES

201. In general the NHS is facing a workforce shortage and without careful planning this is likely to continue given that fewer people are of working age and that there is a 20% reduction in the pool of school leavers (Scottish Executive 2004).
202. The national Scottish Health Workforce Plan (Scottish Executive 2004a) identified the following strategies to address pressures:
- Offer flexible working patterns
 - Re-distribution of workload
 - Staff development
 - Widening entry gate to education

- Use of telemedicine and automation
 - Integrated workforce planning
203. Issues relating to the recruitment, training and retention of oncology staff are a recognised national concern. Currently there is an international shortage of radiation physicists and radiographers (Rostom 2000).
204. The reasons for staff shortages are complex and wide-ranging and whilst this problem can not be resolved overnight, an urgent review of staffing levels and a national approach to workforce planning needs to be embraced to ensure safe and modern delivery of radiation therapy both in the present and future health service (Abraham *et al.* 1999; Rostom 2000; RCR 1998).

CURRENT RADIOTHERAPY WORKFORCE

Clinical Oncologists

205. As at 2004, there were 40.2 WTE consultant clinical oncologists in post in Scotland and 3 WTE vacant posts. This represents a 7% vacancy rate for 2004 although this represents a fall from 12% in 2003.
206. As with most workforces, the population profile is ageing. Twenty three percent of the current workforce will retire over the next 10 years.

Radiotherapy Physicists

207. Using current recommendations from IPEM (Institute of Physics and Engineering in Medicine) an establishment of 58.5 WTE radiotherapy physicists is required for Scotland. The current establishment is 42.5 WTE, a shortfall of 16 WTE posts. Also 8 WTE posts were vacant as at December 2004 and therefore only 34.5 WTE were in post, less than 60% of the recommended level.
208. Shortfalls also exist in the establishment of dosimetrists and engineers putting additional pressure on existing staff, particularly during this very busy period of rapid equipment expansion and replacement.

209. It is estimated that about 17% of the current workforce (radiotherapy physicists, dosimetrists and engineers) will retire over the next 10 years.

Therapeutic Radiographers

210. As at 2003, the therapeutic radiography establishment for Scotland was 162.64 WTE (not including academic posts) and 32.35 of these posts were vacant.
211. Eighteen percent of the current workforce is due to retire within the next 10 years. In addition, 50% of people in Higher Education lecturing posts are due to retire. This should not be overlooked as these posts will be filled from the current clinical workforce.
212. The leaving rate from therapeutic radiography is estimated to be about 8% per annum.

ESTIMATED FUTURE RADIOTHERAPY WORKFORCE REQUIRED

213. As indicated, it is projected that the capacity of radiotherapy services in Scotland will need to increase by 51% in order to meet future demand. Regardless of how this additional capacity is achieved, a concentrated and considerable investment in the workforce is required.
214. Estimating both the numbers and skills required of the radiotherapy workforce 2011-2015 is not straightforward and although some crude workforce models exist to support planning, in the main, they do not consider the commitment to training, research, role extension, skill mix, new working practices and increased demand resulting from more complex treatments and technologies.

Clinical Oncologists

215. There is currently a debate over how many new patients a clinical oncologists should see in a year. The Royal College of Radiologists current recommendation is 315 new patients per annum (RCR 1998a) although this is being reviewed. If about 15,000 new patients are expected per annum, 2011-2015, a minimum of 47.6 WTE clinical oncologists to see this population – 10% increase on current establishment. If however, the Royal College recommends a patient workload of 250 new patients per

annum, 60 WTE clinical oncologists may be required for Scotland – nearly a 60% increase in establishment.

Radiotherapy Physicist

216. By 2007/08 there will be 25 modern linacs for Scotland. Based on IPEM workforce recommendations, with modification by current Heads of Department, this will require 58 WTE radiotherapy physicists, 38.5 WTE dosimetrists and 34.2 WTE engineers.
217. To support service redesign it is estimated that 71.5 WTE radiotherapy physicists, 48.8 WTE dosimetrists and 42.3 WTE engineers will be required. This will require non-standard working hours for engineers and dosimetrists to allow routine servicing to be carried out during non-clinical hours.
218. Assuming the projected required capacity (354,000 fractions) holds true, 3/4 additional linacs will be required to enhance the core service change. It is estimated that this will require 80.1 WTE radiotherapy physicists, 54.6 WTE dosimetrists and 47.3 WTE engineers. This represents an 88% increase from current establishment in radiotherapy physicists but a 132% increase from current actual establishment.

Therapeutic Radiographers

219. Under Agenda for Change, the contracted working week for radiographers will be increased from 35 to 37.5 hours. Assuming that current College of Radiographer staffing models are applied (Society of Radiographers 1999) it is estimated that 217.6 WTE radiographers will be required to support the core clinical service change. This will increase to about 243.2 WTE if 3 additional linacs over and above the planned 25 are commissioned. This represents a 50% increase on the current establishment but considers only core staff requirements, that is to say staff for linacs and not for the many other roles which therapeutic radiographers undertake in a clinical oncology service.
220. Changing work practices and the development of new roles such as radiotherapy assistants may reduce the required radiographer establishment for routine linac/simulator staffing. For example, a model of 3 radiographers and one assistant

per machine would require (based on proposed service redesign and 28 linacs) a radiography establishment of 182.4 WTE and about 61 WTE assistants.

221. **It is recommended that further work be undertaken to test the existing workforce models and to ascertain if they still hold true for a modern service. Further consideration to alternative staffing models should also be given.**

WORKFORCE SUPPLY

Clinical Oncologists

222. In 2004, there were 24 Specialist Registrars (SpR) in post in Scotland. The retention rate for SpRs according to recent figures is about 20% highlighting the need to do more to keep those training in Scotland.
223. **Further work is required to consider if the current SpR training opportunities and retention of trainees in Scotland will adequately meet future needs.**

Radiotherapy Physicists

224. Four medical physics training posts are available in Scotland each year. Training to become a fully qualified medical physicists takes 4 years post graduation and the sub-specialisation of medical physics which the trainee decides to embark upon is one of free choice. The demand for medical physics trainees within the NHS is great and as new opportunities arise e.g. PET, the competition to make radiotherapy an attractive career destination becomes fiercer.
225. Recently, there was some success in securing linked posts following the first two year training, this has enhanced the training experience and increased the employment opportunities for trained physicists within NHS Scotland. While it goes a short way to improving general retention of medical physics trainees to Scotland it does not address the wider training, recruitment and retention issues relating directly to radiotherapy physics and the potential impact of future service redesign/expansion.
226. **It is recommended that the medical physics training posts for Scotland be increased from 4 to 6. Funding for two additional trainees per annum will**

require about £75,000 rising to £300,000 per annum once 2 additional trainees are in each of the four years of training. Further discussion about ring-fencing the additional training posts for radiotherapy physics is required.

227. **This is still unlikely to satisfy the demand for trained radiotherapy physicists and further modelling and exploration of ways to increase the workforce need to be looked at.**
228. The case of dosimetrists and engineers is similar and currently these posts are filled by graduates with relevant degrees. Recruitment of graduates with engineering degrees to the NHS is increasingly difficult as the demands from industry and other private and public sectors is considerable.

Therapeutic Radiographers

229. In Scotland, two higher education establishments provide academic training for therapeutic radiographer (4 years BSc Hon Degree). Clinical aspects of training are supported by all five cancer centres. The undergraduate student intake has been increased in recent years to help address the national shortage of trained staff. In total, 26 undergraduate places are available per annum in Scotland and attrition from this training, despite improvement, remains high and is currently about 20%.
230. As a one off agreement the Scottish Executive HDMB provided funding for a pilot fast-track postgraduate therapeutic radiography course hosted by Queen Margaret University College, Edinburgh. This two year pilot has recruited two cohorts of 15 students with the first 15 due to graduate November 2005. Preliminary evaluation of this course suggests success with minimal attrition. Due to current funding agreements regarding postgraduate education in Scotland, this course can not be continued by the SEHD. It appears unlikely at this stage that the course will be sustained unless the Higher Education Establishment successfully negotiate continued funding through normal Higher Education funding mechanisms. Even then, recruitment to the course may prove difficult given the considerable financial burden that would be placed on the student, which is likely to add to existing financial debts from first degrees. This is an issue faced by many institutions in Scotland wishing to offer postgraduate training opportunities.

231. Assistant therapeutic radiographers are recently recognised posts and a national training programme for Health Care Assistants has been credited and is due to commence in 2005. A therapeutic radiography training element has been approved and should enable opportunity for training as a therapeutic assistant practitioner in a number of further education colleges. There are currently two fully trained assistant practitioners in post at the Aberdeen Cancer Centre and they demonstrate the benefit that can be gained from changing workforce dynamics and enhancing the skill pool through new posts.

Table 7: Current, Actual and Estimated WTE for Scottish Radiotherapy Service based on current Workforce Models

Profession	Current WTE Est.	Actual WTE Establish 2004	Estimated WTE for service redesign	Estimated WTE for service redesign + 3 additional linacs
Clinical Oncologists	43.2	40.2	60.0	60.0
Radiotherapy Physicists	42.5	34.5	73.4	79.9
Dosimetrists	41.50	29.7	48.6	52.9
Engineers	35.5	35.7	43.5	47.3
Therapeutic Radiographers	162.6 (2003)	130.3 (2003)	217.6	243.2

BALANCING THE WORKFORCE SUPPLY AND DEMAND

232. Complex modern radiotherapy is increasingly reliant on the expertise of clinical oncologists, therapeutic radiographers, radiotherapy physicists, dosimetrists and engineers to prescribe, plan and deliver quality treatment and patient care, maintain equipment to relevant standards, and develop and implement new techniques and technologies.
233. This is resulting in changing roles and new demands on existing staff. The role of a radiotherapy physicist for example, is changing considerably and advances in technology are resulting in more time consuming and work intensive planning procedures.

234. The proposed service model and subsequent service change indicated for the Scottish radiotherapy service over the next 10–15 years to achieve required capacity, is likely to need substantial increases in the workforce as demonstrated but, as importantly and possibly more challenging are the required changes to working practices, professional capacity, skill mix and role development.
235. In terms of therapeutic radiography, some of this work is already underway and the Radiography Role Development Project (NES) funded by Scottish Executive Cancer and Workforce Department monies has demonstrated huge scope for developing the radiographer role at both ends of the professional spectrum to enhance the service and improve recruitment and retention to the profession. Initiatives that support clinical leadership in promoting service change and which help transform clinical practice, ways of working and improved skill mix are strongly indicated (SOR 2003).
236. **It is recommended that:**
- **Assistant therapy radiographer posts are promoted and supported.**
 - **Advanced practitioner or consultant therapy radiographer posts are promoted and supported.**
237. **This would require funding and estimate costs are as follows:**
- Total expected cost of assistant practitioner is c£18,000 per annum. This should cover training costs and on-costs. If a minimum of one assistant per linac is achieved initially, 25 assistant practitioners would be about £450,000 per annum.
 - Consultant posts are estimated to cost £53,400 per annum including training and on-costs. The number of consultant therapeutic radiographer posts that are necessary and warranted will require further discussion with the service. Assuming one for every cancer centre would require 5 for Scotland at a cost of £267,000 per annum. This may not be justified by service needs and fewer consultant posts may be negotiated e.g. 3.
238. Within all professional groups, innovative change in skills mix is required to allow different professions to work in ways that will facilitate modern treatment pathways

and make best use of specialist skills. Professional boundaries should be more permeable since fixed boundaries inhibit seamless care and best use of available skills and resource.

239. Increasing the core pool of skilled and trained staff to support proposed service changes is a major concern and while substantial increases in both funding and flexibility of funding will allow expanded and more versatile training opportunities, any expansion will be constrained by the number of clinical training placements and impacted by the recruitment issues faced by higher education establishments to education posts.
240. **The crux of future cancer service is the workforce and is dependent on an inter-professional approach, where practitioners are valued for their flexibility as well as their specialist expertise. A culture change both within and between professional groups and service, to create an environment supportive of radical thinking and working, and which will allow mutual acknowledgement of the existence of valuable skills across the professional groups is crucial to a modern health service and will require support from the Scottish Executive and the NHS.**
241. The right balance of skills will not occur without careful planning because of the conflicts between economic forces, political pressures and professional objectives (Martinez J & Martineau T 1998). **A sustained and long-term workforce initiative is required and should be considered immediately to provide time to develop the workforce required by 2011–2015.**
242. **A partnership approach involving Unions, Colleges, Societies, Institutes and the service is strongly indicated since a number of changes and negotiations are required, including increased service hours, routine servicing at weekends, workforce structural change, and changed working practices. This is in addition to the need for increased staff numbers, increased training opportunities and improved recruitment and retention. Considerable HR support for new roles and role extension at both ends of the professional spectrum is required to improve skill mix and contribute to retention and professional development.**

RECOMMENDATIONS & CONCLUSIONS

243. Radiotherapy is a core component of modern cancer therapy and is one of the most rapidly changing treatment modalities.
244. It is widely accepted that radiotherapy will remain an essential component of cancer treatment for many years to come and that the demand for radiotherapy will continue to rise.
245. Overall, it is predicted that there will be about 31,500 new cancer cases diagnosed in Scotland per annum 2011 - 2015. Although the remit of this planning project was to 2015, beyond this, the cancer incidence in Scotland is projected to increase steadily to 34,000 cases per annum by 2020.
246. About 14,000 - 15,000 new radiotherapy patients will be referred for radiotherapy in 2011–2015 compared to 11,000 in 2003.
247. The current rate of radiotherapy use in Scotland is thought to be low in comparison to European countries and a substantial gap exists between current practice and optimal practice based on best available evidence.
248. Clinical practice and opinion about optimal fractionation schedules remains divergent across the profession with significantly variable fractionation schedules being prescribed for similar clinical indications.
249. For most cancers, a range of future fractionation schedules have been considered and provide the basis for demand estimations. This demonstrates the uncertainty about which direction clinical management will take in the future. For example, with breast cancer the possible future fractionation could be either:
- Current (25 – 27)
 - 15 fractions (START Trial)
 - 5 fractions (FAST Trial)
 - intra-operative therapy

250. It is estimated that the clinical demand for radiotherapy services in Scotland, 2011-2015 will be about 318,000 fractions per annum. This takes into account all currently unmet need. Required service capacity is estimated to be about 354,000 fractions. This includes 10% in addition to clinical demand to ensure that waiting times are not built into the system and that capacity exists to enhance the radiotherapy service provision in Scotland through development and implementation of new techniques and technologies.
251. The current service model is not adequate to achieve the required capacity 2011-2015. Options for increasing service capacity include service redesign with a smaller service expansion (3/4 linacs).
252. Service redesign alone has been shown to provide only 65% of the additional capacity required but is the preferred option for initially increasing capacity in Scotland. The recommended service redesign reflects a 10 hour treatment day, Monday to Friday and an increase to 257 clinical days per annum. This recommendation is on the understanding that the following are also approved and achieved:
- A national workforce strategy to support recruitment, training, retention and development of the necessary workforce including support for new ways of working, skill mix initiatives and development of new roles e.g. radiotherapy assistants
 - A core service change ensuring that patients receive access to the same range of services regardless of their appointment time
 - 25 linacs in operation in Scotland, including a second linac at Inverness
 - All linacs in Scotland carrying, as much as possible, comparable workloads, requiring exploration of new patient pathways/access
253. Adequate staff numbers must also be a precondition of any service change. The proposed 10 hour clinical service day will NOT require existing staff to work beyond their contract hours and should not operate on the goodwill of existing staff as has been the case to manage some previous ad-hoc extended day agreements. The new proposed core service would however require a shift system to meet the 10 hour

clinical day requirements and to ensure that routine maintenance is undertaken outside clinical hours.

254. A national workforce strategy is crucial, without which the radiotherapy service of 2011–2015 will not be able to provide the required service.
255. Immediate workforce recommendations are:
- Initiatives to support clinical leadership to promote service changes and help transform clinical practice, ways of working and improved skill mix are strongly indicated. It is recommended that:
 - > assistant therapy radiographer posts are promoted and supported.
 - > advanced practitioner or consultant therapy radiographer posts are promoted and supported.
256. This would require funding and estimated costs are as follows:
- Total expected cost of assistant practitioner is c£18,000 per annum. This should cover training costs and on-costs. If a minimum of one assistant per linac is achieved initially, 25 assistant practitioners would be about £450,000 per annum.
 - Consultant therapy radiographer posts are estimated to cost £53,400 per annum including training and on-costs. How many consultant therapeutic radiographer posts might be warranted may require further discussion. Assuming one for every cancer centre, this would require 5 for Scotland at a cost of £267,000 per annum.
257. It is recommended that the medical physics training posts for Scotland be increased from 4 to 6. Funding for two additional trainees per annum will require about £75,000 rising to £300,000 per annum once 2 additional trainees are in each of the four years of training. Further discussion about ring-fencing the additional training posts for radiotherapy physics is required.

258. In support of a fair and equal service for all, the extension of radiotherapy service hours should be matched by transition of support and ancillary services/facilities, ensuring equal provision for patients at all times. A core service change would therefore be a prerequisite.
259. Optimising patient workloads, improving service collaboration, and patient pathways are central to the debate of efficient use of existing resources and ensuring an optimal service with capacity to meet demand 2011 – 2015.
260. A smaller scale service expansion of 3/4 linacs may also be required if demand and capacity projections hold true. It is recommended that the next review is carried out in 3 to 4 years time, to ensure adequate lead time for purchase of additional linacs and associated equipment – if it is concluded that these are required by 2010-2012 (as above).
261. If the review determines that demand projections hold true and capacity for 354,000 fractions per annum is required, up to 3/4 additional linacs will be necessary to enhance the service redesign detailed above to achieve the required capacity. Alternatively, a 6 day working week may be considered.
262. Assuming that an additional 3/4 linacs are required, the location of these linacs will need further debate. Capacity exists to house additional linacs at the Aberdeen, Dundee, Edinburgh and Glasgow cancer centres. Utilisation of this building space could provide an immediate and short-term solution but may not be the preferred permanent option and should be re-assessed as part of the review in 3-4 years time.
263. Given the necessary pieces of work and issues highlighted by this review, and the recommendation for continued monitoring and a further review in 3 – 4 years time, a Radiotherapy Advisory Group has been established to monitor/review the process, review and if necessary revise demand estimations and ensure adequate time in the planning cycle for any modifications to be considered if indicated, including the planning for additional linacs should current capacity projections hold true.

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GLOSSARY

Adjuvant Therapy treatment given with, or shortly after, another treatment to enhance its effectiveness e.g. chemotherapy prior to radiotherapy but after lumpectomy for breast cancer

Age-Specific Cancer Incidence the incidence of cancer within a given age defined population

Annual Cancer Incidence the number of new cases of cancer in a defined population within a single calendar year

Audit an examination or review that establishes the extent to which a condition, process or performance conforms to predetermined standards or criteria. Assessment or review of any aspect of health care to determine its quality – provision of care, compliance, community response, completeness of records etc

Basic Treatment Equivalent a measure of radiotherapy workload which includes consideration of the complexity of treatment techniques

Benign a neoplasm which is generally slow growing and will remain localised – non malignant

Brachytherapy radiotherapy delivered using a radiation source close to the surface of the tumour. Used most commonly for gynaecological tumours

Cancer Risk the probability that an individual will develop cancer within their lifetime or by a specified age

Capacity A measure of the time which a linac is open and staffed in order to meet demand

CHART (Continuous hyper-fractionated Accelerated Radiotherapy) is a way of delivering up to 3 fractions per day over 10 continuous days. It has been shown to improve outcome for some patients with lung or head and neck cancers

Chemotherapy the use of cytotoxic drugs which interfere with the process of cell division to destroy malignant cells

Chemo-Radiation a combination of chemotherapy and radiotherapy

Co-morbidity disease(s) that coexist(s) in an individual other than a condition that is the subject of interest/study

Conformal Therapy a treatment technique which aims to shape the dose to the tumour whilst minimising dose to healthy tissue

CT (Computed Tomography) an x-ray technique using a scanner which takes a series of images across the body which can be viewed in two- or three-dimensional form

Clinical Demand the number of fractions of treatment that will be required to treat the cancer population in which radiotherapy is indicated 2011-2015

Clinical Oncologist a doctor who manages patients with cancer and who has specialist knowledge involving the use of all forms of non-surgical treatments, including radiotherapy and chemotherapy, and palliative care

Demand see Clinical Demand

Digitally Reconstructed Radiograph (DRR) a planar radiograph made by computer-projected rays through 3D CT density information

Dosimetrist staff undertaking all aspects of treatment planning, including patient immobilisation and the preparation of patient-related accessories. Dosimetrists may also undertake radiotherapy equipment dosimetry and quality control. This is a new and evolving role in radiotherapy and is being undertaken by clinical scientists, clinical technologists and radiographers

Electronic Portal Imaging (EPI) an electronic system for acquiring verification images of the geometry of treatment during radiotherapy delivery

Exposure each time the radiation beam is turned on to treat the patient from a new direction. A fraction may be made up of one to eight + exposures

External Beam Radiotherapy refers to radiotherapy treatment delivered as a series of short daily treatments in the radiotherapy department, using a linear accelerator. In the majority of cases this treatment is delivered on an outpatient basis.

Fraction The total treatment dose is generally divided into equal portions (fractions) each one representing an attendance for radiotherapy. A course of treatment may comprise anything between 1 and 36 fractions and is conventionally given on a daily basis, usually 5 days a week

Gating Gating or Respiratory Gating is a treatment delivery technique which allows the treatment of tumours at certain defined points in the respiratory cycle

Gray (Gy) a unit of measure of absorbed radiation dose

Hyper-fractionation the practice of giving more than one fraction per day, in practice rarely no more than 3 fractions per day are given

Hyperthermia Therapy means elevation of temperature. When cells or tumour tissues are subjected to elevated temperatures, a number of events follow that have important biologic consequences for cancer therapy. Hyperthermia therapy can kill tumour cells in its own right, but perhaps more importantly, it can sensitise tumour cells to other forms of therapy, including radiation and chemotherapy

Hypo-fractionation the practice of giving less than the conventional five daily fractions per week

IGRT (Image Guided Radiotherapy) uses additional imaging equipment mounted on the linac's gantry to acquire a cone-beam CT scan prior to every treatment and ensure improved treatment and planning field matching

IMRT (Intensity Modulated Radiotherapy) a treatment delivery technique that modulates the intensities of the radiation beams, as well as geometrically shaping them. IMRT provides improved dose deposition avoiding critical structures, delivering complex dose distributions designed using forward or inverse planning

Incidence the number of new cases/episodes in a defined population within a given time period

Interstitial Radiotherapy the temporary or permanent insertion of sealed radioactive sources within the body's tissues of sealed radioactive sources

Intracavity Radiotherapy the insertion of sealed radioactive sources into a body cavity e.g. uterine cavity

Intraoperative Radiotherapy (IORT) delivers a large single dose to the tumour tissue during surgery, minimising dose to healthy tissue

Intravascular Brachytherapy similar to standard brachytherapy in that radioactive sources are delivered to the treatment site. Used for treatment of coronary arteries - radioactive sources are delivered via a catheter inserted into the artery

Linear Accelerator (Linac) a treatment machine generating megavoltage x-rays or electrons

Malignant cancerous. Malignant tumours can invade and destroy surrounding tissue and have the capacity to spread

Megavoltage the word used to refer to megavoltage gamma rays or x-rays. These types of radiation are capable of penetrating several centimetres of tissue

Metastatic spread of a disease from the organ or tissue of origin to another part of the body

Mortality the number of people who have died from cancer and is usually expressed as the number of deaths each year in a specified area

Mortality Rates the mortality rate is the number of people who die from cancer per 100,000 population

MRI (Magnetic Resonance Imaging) an imaging technique based on the differences in magnetic properties of protons within living cells. It provides superior soft tissue definition of many tumours compared with CT

Multileaf Collimator (MLC) a system on a linear accelerator which uses a number of "leaves" to create an irregular shaped radiation beam. It is used to shape the beam to the tumour

Optimal or Appropriate Radiotherapy Utilisation is a measure of the proportion of incident cancer patients that should receive radiotherapy based on evidence

Palliative Radiotherapy radiotherapy given with the intention of alleviating symptom or for temporary control of tumour growth

Performance status a categorical description of a patient's ability to perform activities of daily living, usually recorded using a validated scale such as Karnowsky or WHO scales

PET (Positron Emission Tomography) section imaging using a radionuclide which is a positron emitter. It provides functional information about the tumour and its site and size

Photodynamic Therapy (PDT) is based on the concept that certain photosensitisers can be localised in tumours and subsequently activated with the appropriate wavelength (energy) of light to generate active molecular species that are toxic to cells and tissues

Quality Assurance (QA) all procedures that ensure consistency of the medical prescription and safe delivery of that prescription as regards to dose to the target volume, together with minimal dose to normal tissue, minimal exposure to personnel and adequate patient monitoring aimed at determining the end result of treatment (WHO 1988)

Radical Radiotherapy treatment intended to produce a high rate of local tumour control; it accepts a defined rate of normal tissue complications and demands a certain level of technical sophistication

Radiosensitisers chemical compounds which can enhance tumour cells to the killing effects of ionising radiation

Radiotherapy the use of ionising radiation to destroy malignant tumours while minimising the damage to normal tissue

Radiotherapy Indication a clinical situation in which radiotherapy is recommended as the treatment of choice on the basis of evidence that it has a superior clinical outcome compared to alternative clinical modalities (including no treatment), and where the patient is suitable to undergo radiotherapy based on an assessment of performance status indicators and the presence or absence of co-morbidities

Radiotherapy Physicist state registered medical physicist with expert training in radiotherapy physics

Radiotherapy Utilisation a measure of the proportion of incident cancer patients receiving radiotherapy based on current practice

Retreatment treatment of the same disease in a patient, with the same agent or procedure repeated after initial treatment, or with an additional or alternative measure or follow-up. It does not refer to the treatment of a patient with more than one treatment modality in the initial management of disease e.g. adjuvant therapy

Screening examination of people with no symptoms, to detect unsuspected disease

Simulator a diagnostic energy x-ray machine (kilovoltage x-ray tube) with geometric movements similar to those of the linear accelerator for viewing a simulated treatment. It is used for localisation of treatment areas and for verification of treatment plans prior to starting treatment

Staging a description of the extent to which a cancer has enlarged locally and spread through the body. Usually expressed by the TNM staging system

Stereotactic Radiotherapy is directed by various scanning devices to achieve precise positioning in three dimensional space

Survival the percentage of people still alive 1, 3, 5 and 10 years after they have been diagnosed with cancer. The 5 year survival rate is often quoted

Systematic Review focus on peer reviewed publications about a specific health problem and use rigorous, standardised methods for selecting and assessing articles

Therapeutic Radiographer state registered allied health professional trained to deliver radiotherapy and all aspects of patient care

TNM Staging includes a description of the primary tumour (T), nodal spread (N), and distant metastases (M). A very early stage cancer would be categorised as T1N0M0

Tomotherapy Unlike traditional radiation therapy systems which have beams projecting onto the tumor from a few different directions, tomotherapy rotates the beam source around the patient, thus allowing the beam to enter the patient from many different angles in succession

Trend a long-term movement in an ordered series e.g. a time series

Workload can be measured in a number of ways but here refers to the number of fractions per linac

ACRONYMS

CCORE	Collaboration for Cancer Outcomes Research and Evaluation
CHART	Continuous Hyper-fractionated Accelerated Radiotherapy
CNS	Central Nervous System
CRAG	Clinical Research and Audit Group
CSBS	Clinical Standards Board for Scotland
EPI	Electronic Portal Imaging
ESTRO	European Society for Therapeutic Radiology and Oncology
GIS	Geographical Information System
GROS	General Registrars Office Scotland
HDMB	Health Department Management Board
IGRT	Image Guided Radiotherapy
IMRT	Intensity Modulated Radiotherapy
IORT	Intraoperative Radiotherapy
IPEM	Institute of Physics and Engineering in Medicine
MCN	Managed Clinical Network
MDT	Multi-Disciplinary Team
MRI	Magnetic Resonance Imaging
NHL	Non-Hodgkin's Lymphoma
NHS	National Health Service
NICE	National Institute of Clinical Excellence
PET	Positron Emission Tomography
QA	Quality Assurance
RAPG	Radiotherapy Activity Planning Group
RCR	Royal College of Radiologists
SEHD	Scottish Executive Health Department
SIGN	Scottish Intercollegiate Guidelines Network
SOR	Society of Radiographers
START	Standardisation of Radiotherapy Trial
SUCA	Scottish Urological Cancer Audit
TRiS	Therapy Radiographers in Scotland
WHO	World Health Organisation
WLE	Wide Local Excision
XRT	External Beam Radiotherapy

SCOTTISH EXECUTIVE HEALTH DEPARTMENT RADIOTHERAPY ACTIVITY PLANNING STEERING GROUP

MEMBERSHIP AND REMIT

MEMBERSHIP

Cornbleet	Mike (CHAIR)	Senior Medical Officer (SEHD)
Baillie	Brian	Director of Strategic Planning, NHS Forth Valley
Black	Roger	Head of ISD Cancer Information Group
Blyth	Christine	Therapy Radiography in Scotland (TRiS)
Chalmers	Ruth	Project Manager, Radiotherapy Activity Planning (SEHD)
Dewar	John	CMO Speciality Advisor, Radiotherapy
Dickson	Iain	Lay Member
Divers	Tom	Chief Executive, NHS Greater Glasgow
Elliot	Barbara	Lay Member
Erridge	Sara	Consultant Clinical Oncology, Edinburgh
Forsyth	Lesley	Radiography Role Development Project Officer, NHS Education
Gray	Gordon	Assistant Health Care Planner, NHS Lothian
Gregor	Anna	Lead Cancer Clinician (Scotland) SEHD
Held	Sam	SCAN Patient Involvement Officer
Hutchison	Cathy	Consultant Nurse – Cancer Services, NHS Greater Glasgow
Ingram	Annie	Regional Planning & Workforce Co-ordinator, NHS Tayside
Mowbray	Russell	Lead Programme Manager – Cancer Services, NHS Greater Glasgow
Peterkin	Gordon	Medical Director, NHS Grampian
Porterfield	Elizabeth	Head of Branch – Cancer Strategies (SEHD)
Rodger	Alan	Medical Director, Beatson Oncology Centre
Strachan	Ray	Lay Member
Thomson	Evelyn	WOSCAN Manager, NHS Greater Glasgow
Thwaites	David	Radiotherapy Physics, NHS Lothian
Wallace	Andy	Lay Member
Wrench	John	Director of Public Health, NHS Highland

REMIT

In support of the initial stage of the Project, a Radiotherapy Activity Planning short-life Subgroup was set up to oversee a nationwide review of radiotherapy pathways - to ensure a patient focus throughout. Preliminary statistical and geographical modelling was undertaken using a Geographical Information System (GIS) to analyse the implications of current and future possible locations for NHS services.

The Health Department Management Board agreed at their meeting of 17 June 2003, that the Radiotherapy Activity Planning Subgroup be reconstituted, involving such others as may be needed, to act as a Steering Group to oversee the next stage of the Radiotherapy Activity Planning Project and progress the following recommendations:

- discussions begin with all interested parties (including NHS Boards, Trusts, workforce planning, relevant professional and other staff groups) as to the scope of possible changes to working practices with a view to introducing them as soon as feasible to help meet current and projected rising demand.
- detailed option appraisal should be carried out by the Cancer Branch, involving economic and further statistical input/modelling to assess the undernoted options to meet the projected level of need by 2010-2014:
 - a. a sixth cancer centre for Scotland, (either at Wishaw General Hospital, which is the preferred site for potential centralisation of cancer services within Lanarkshire, or at the Larbert site identified as the preferred option for a single acute centre for Forth Valley), and
 - b. the scope for and implications of expanding capacity at the existing five cancer centres to meet the projected level of need
- Grampian, Highland and the Island Health Boards should be formally advised to further develop their review of existing working practices and referral patterns to ensure the sustainability of radiotherapy services in particular and tertiary cancer services in general in Inverness, with a specific focus to provide appropriate capacity for patients across the North of Scotland regional cancer network area for the future. The option appraisal report (above) should also consider the North of Scotland position in the light of these further discussions/review at local level.

RADIOTHERAPY ACTIVITY PLANNING

**Report of the Radiotherapy Activity Planning Sub-Group
of the Scottish Cancer Group**

April 2003

EXECUTIVE SUMMARY AND RECOMMENDATIONS

1. Based on projections of cancer incidence and the pattern of treatment, the currently planned expansion of radiotherapy treatment equipment (to 24 linear accelerators by 2005-06) will not provide the capacity required to treat the anticipated numbers of patients requiring radiotherapy by 2010-2014, the period covered by *Cancer Scenarios*, published by SE in 2001.
2. There is currently some measure of unmet need, therefore the basic assumptions and recommendations throughout this report take this into account, arising from which it is projected that significant expansion of capacity will be required if the estimate of currently unmet need is to be provided for.
3. Although additional capacity can be derived from changes to current working practices, this on its own cannot provide all of the projected capacity required.
4. The number of further additional linear accelerators required by 2010-2014 is likely to be between 5 and 10 depending on productivity. Five additional linacs could be sited within the existing cancer centres, ten cannot. Investment on this scale implies that an additional cancer centre in Scotland may be needed to respond optimally to expected demand.
5. Placing the additional machines in the existing centres would create a centre in Edinburgh on the same scale as the new Gartnavel site for the West of Scotland Cancer Centre, but with significant problems of congestion, and no potential for any further expansion if demand increases beyond 2010-2014. Recent estimates published by WHO estimate the potential rise in the incidence of cancer throughout the world to be 50% by 2020.
6. The creation of a sixth centre within the central belt for the provision of radiotherapy and co-ordination of cancer treatment would shorten patient travel time for a significant number of patients and ease already substantial congestion at the existing centres.
7. Grampian, Highland and Island NHS Boards are, between them likely to require one additional linear accelerator. The single machine at Inverness is inherently vulnerable to severe disruption for patients in the event of machine failure, and the additional machine might logically be placed there rather than in Aberdeen. However, the current configuration of workload is insufficient to justify a second machine. If Inverness were not sustained as a viable long-term cancer centre the distances that patients in the north-west of Scotland would have to travel for radiotherapy would be severely detrimental to their care.
8. Clearly this would be a major acute/tertiary services development, and further work to assess the available options is required. There are also potentially significant capital and revenue consequences over the next 7 to 10 years. The Working Group's strong recommendation is that this will require a national centrally driven approach. It is therefore recommended that the Health Department Management Board **agree** that:
 - discussions begin with all interested parties (including NHS Boards, Trusts, workforce planning, relevant professional and other staff groups) as to the scope of possible changes to working practices with a view to introducing them as soon as feasible to help meet current and projected rising demand.

- detailed option appraisal should be carried out by the Cancer Branch, involving economic and further statistical input/modelling to assess the undernoted options to meet the projected level of need by 2010-2014:
 - a. a sixth cancer centre for Scotland, (either at Wishaw General Hospital, which is the preferred site for potential centralisation of cancer services within Lanarkshire¹, or at the Larbert site identified as the preferred option for a single acute centre for Forth Valley), and
 - b. the scope for and implications of expanding capacity at the existing five cancer centres to meet the projected level of need
 - Grampian, Highland and the Island Health Boards should be formally advised to further develop their review of existing working practices and referral patterns to ensure the sustainability of radiotherapy services in particular and tertiary cancer services in general in Inverness, with a specific focus to provide appropriate capacity for patients across the North of Scotland regional cancer network area for the future. The option appraisal report (above) should also consider the North of Scotland position in the light of these further discussions/review at local level.
9. HDMB is further invited to **confirm** that
- the current Working Party be reconstituted, involving such others as may need to be co-opted from time to time, to act as a Steering Group to oversee this exercise
 - the detailed option appraisal report should be submitted to the Board by the end of March 2004
 - the report should include recommendations on the timing, format and framework for wide ranging consultation on the future development of the *Cancer in Scotland* strategy and options for the future configuration of cancer services.
10. It is likely that additional short term resource will be required to support this work. HDMB's **approval** is sought for a short term (9-12 months) secondment of a dedicated project manager to work within the Cancer Branch (Health Planning and Quality Division). Economic and statistical support will be provided by (or arranged via) Analytical Services Division and ISD respectively. Costs will be met from the *Cancer in Scotland* centrally held monies.

Introduction

1. *Cancer in Scotland: Action for Change*² published by the Scottish Executive in July 2001 set out a wide range of issues to be taken forward by the Scottish Cancer Group (SCG), including a
 - '...rolling brief to continuously monitor the age and effectiveness of radiotherapy equipment and to make recommendations for further long-term capital investment.'and further,
 - the 'provision of CHART (Continuous Hyperfractionated Accelerated Radiotherapy) facilities in Scotland will be assessed as a priority within a strategic review of the future needs for radiotherapy delivery'.
2. To allow investment planning, implementation and associated redesign/change programmes to get well underway, this work was not among the first level priorities to be taken forward by the SCG. However, in October 2002, in the wake of, but not because of, the issues surrounding provision of services at the Beatson Oncology Centre in Glasgow, the Minister for Health and Community Care asked that this work be fast-tracked.
3. The Radiotherapy Activity Planning short-life sub-group was therefore established to oversee a nation-wide review of radiotherapy pathways and to report to the Minister by end April 2003.

Membership

4. The Sub-Group met for the first time on the 28th November 2002 (membership at Annex). The membership was kept deliberately small, as the intention (and need) was to work primarily via open meetings and visits to cancer centres and NHS Boards.
5. Following the first round of these visits in March 2003, this report outlines options and makes recommendations for further detailed work including, as required, further large scale consultation and discussion around the emerging options.

Terms of Reference

6. *Cancer in Scotland* accepted, as a starting premise, the principles underlying the Calman-Hine report³, taken forward in Scotland within the "Commissioning Cancer Services"⁴ framework that, wherever they live, patients should have equality of
 - access to cancer services
 - quality of cancer services
 - clinical outcomes
7. *Cancer Scenarios*⁵, published in 2001 and developed as an aid to planning cancer services for the next decade, predicted a 28% increase in the number of patients

diagnosed with cancer by 2010-14, but only a 9% increase in the number of deaths (based on 1995-97 registrations) . For this report, an updated dataset which includes revised projections for some cancers, notably prostate cancer, has been used. (Further details about the updated data are available directly from ISD). Approximately half of the projected increase is due to the ageing population, the other half being attributable to a projected increase in the underlying individual risks of being diagnosed with cancer. This 30% increase of patients living with cancer has clear implications for the future capacity needs for tertiary cancer services including radiotherapy facilities, demand for which has grown at 3-5% pa⁶ across the UK.

8. The projected rise in cancer incidence is consistent with the recent WHO report which predicts a rise of 50% world-wide by 2020⁷

Methods

9. At the request of the sub-group and to ensure a patient focus throughout, the Scottish Cancer Intelligence Unit (Information & Statistics Division of the Common Services Agency for the NHSScotland (ISD)) acquired expertise in the use of a Geographical Information System (GIS). This allowed the sub-group to model patient travel times to each of the five existing cancer centres, to study the impact of altering referral patterns for cancer services from one NHS Board to another, as well as to study the impact of introducing potential additional delivery sites.
10. When combined with *Cancer Scenarios*, GIS is a very powerful tool with which to analyse the implications of current and future possible locations for NHS services, in this case, radiotherapy facilities. The need to distribute the workload equitably on the basis of patient travel times and capacity of the different centres was incorporated in the model. The baseline used for the calculations in Tables 3 to 7 below is the actual number of cancer registrations receiving radiotherapy for 1999.
11. The potential uses of the modelling tools were presented at an open meeting held in Edinburgh in January 2003 to which a wide range of clinicians, managers, planners and patients were invited. Following that meeting, a detailed range of options was developed and mapped, and these were presented initially to the five current cancer centres at a series of meetings in March 2003. In the light of these visits, the options have been further refined, and agreed by the Sub-Group.
12. Certain assumptions have underpinned all of the modelling:
 - 12.1 Calculations are based on projections in *Cancer Scenarios*, and on current working practices, skill mix and competency models (where available) and on the current norm of 8 hours a day/5 days a week.* It is further assumed that the modernisation agenda will, over time, change staffing configurations and working practices and that taken together with the workforce planning initiatives the current shortages of certain professional and other staff will have been addressed over the timescale under review.

* Glasgow (Beatson Oncology Centre) currently operates 13 hours per day on most days, and has done so for several years.

- 12.2 The completion of the programme of replacement and modernisation of radiotherapy equipment funded by the Scottish Executive and currently underway across Scotland. By the time of completion (commissioning) of the next planned (4th) wave in 2005-06, Scotland will have 24 modern linear accelerators, or just slightly below 5 per million population. There have been some delays and uncertainties surrounding this phase of the programme, but for the purposes of this report it is assumed that this current radiotherapy equipment planning is completed as outlined in Table 1.

Table 1: Current provision and planned expansion of radiotherapy facilities

<i>Cancer Centre</i>	<i>Clinical Oncologists</i>			<i>Linear Accelerators</i>		
	<i>Estab-lishment</i>	<i>Actual</i>	<i>Population served/ Clinical Oncologist</i>	<i>Current</i>	<i>Planned</i>	<i>Population served/linac</i>
Aberdeen	4	4	138,223	2	3	184,298
Inverness	3	2	110,719	1	1	221,439
Dundee	5.5	5.5	71,940	2	3	131,890
Edinburgh	10.5	10.5	123,318	5	6	422,235
Glasgow	23	17.5	144,766	10	11	454,387
Total	46	39.5		20	24	

- 12.3 50% of patients with cancer will require radiotherapy at some time during their treatment. The estimate of the current situation (1999 registrations) is that approximately 30-35% are actually treated, therefore, an element of unmet need has to be incorporated in the interests of access and equity. **As shown in Table 2 below, no realistic assumptions about future working patterns will allow 50% of cancer patients to receive radiotherapy in 2010 with only 24 linear accelerators.**

- 12.4 Linear accelerator needs can be calculated in at least three ways:

- Royal College of Radiologists (RCR) guideline⁸ - 5 linacs per million population
- Updated RCR guideline⁹ - 6.6.linacs per million population by 2010 which takes some account of the rising incidence of cancer and the increasing demand for radiotherapy of 3-5% pa.
- Estimates of potential workload per linear accelerator can be made depending on working practice and variables such as throughput of patients. These can range from 219 to 907 new patients per linac per annum depending upon the assumptions made (see table 2 below). An average of 450 patients per linac has been used in Tables 3 to 7. The presently planned 24 linacs (see Table 2 below) treating 35% of the current 26,000 patients pa treat 380 new patients each on average per year. The estimates below are calculated on the basis of 450 patients/linac/year and therefore assume an efficiency increase of 19%.

Table 2: New patient workload per linear accelerator – sensitivity to varying assumptions concerning working patterns

Assuming average 17 attendances/ course and 1.4 courses/pt

<i>Patients per hour</i>	<i>Working hours/day</i>	<i>Working days/year</i>	<i>Patients/ accelerator/ yr.</i>	<i>Pts treated/yr. with 24 linacs</i>	<i>Proportion of Year 2010 caseload treated</i>
4	8	240	322	7,728	23%
4	10	240	403	9,680	34%
5	8	240	403	9,672	29%
5	10	240	504	12,096	36%
5	12	240	605	14,520	44%
5	12	360	907	21,768	65%

Assuming 25 attendances/course, ie 50% increase (CHART etc)

4	8	240	219	5,256	16%
4	10	240	274	6,582	20%
5	8	240	274	6,576	20%
5	10	240	343	8,232	25%
5	12	240	411	9,864	30%
5	12	360	617	14,808	45%

12.5 A travel time of one hour each way was taken as the cut off point for acceptability for patients, except for Highland and Grampian where, because of remoteness and rurality, a travel time of 90 mins has had to be deemed acceptable. This may be unreasonable given that many of the reasons that patients are receiving radiotherapy may make travelling for 2-3 hours per day very difficult. The Island Boards haven't been included in these travel time analyses and for the present purpose it is assumed that they will continue to travel as presently, ie Orkney and Shetland to Grampian, and Western Isles to Highland and Glasgow.

12.6 Current working practices in terms of fractionation schedule (how treatment is divided up into small doses given daily or more frequently) and indications for radiotherapy will not decrease demand significantly over the next ten years. Changes in radiotherapy practice which are likely over the next few years and which can be anticipated to impact on the productivity of a linear accelerator are hyperfractionation (delivering radiotherapy in more frequent, smaller doses in a compressed total treatment time), and intensity modulated radiotherapy (IMRT), which uses a greater number of radiation fields to deliver radiotherapy more precisely and at a higher dose only to the volume of the tumour and not to surrounding tissues. Both of these developments would involve more machine time per patient and therefore reduce the numbers of patients treated per machine.

Findings/Results

13. At present patients from Borders, Lothian, Fife and Dumfries and Galloway go to Edinburgh; patients from Highland and Western Isles to Inverness; Grampian, Orkney and Shetland to Aberdeen, Tayside and a very small part of North Fife to Dundee and those from Forth Valley, Lanarkshire, Ayrshire & Arran, Argyll & Clyde

and Glasgow go to the Beatson. This means that approximately 60% of Scottish patients are currently treated at one cancer centre.

14. Although the group are aware of the census projections of a falling Scottish population and accompanying demographic changes, the potential impact will need to be assessed, but at the moment it is thought it is unlikely to outweigh the projected rising cancer incidence due to an ageing population and increased risk factors as noted in paragraph 7 above. Therefore, using the projected incidence figures and the stated assumptions, Table 3 shows the projected numbers of linear accelerators required by 2010-2014 at each of the five existing centres. The total number of machines varies from 25 if calculated on the basis of 5 per million population, to 37 on the basis of 450 new patients per linac per annum. The former assumption is derived from a 1999 report by the RCR that does not allow for the substantial rise in incidence of cancer predicted over the next 7-10 years and beyond⁶. A figure of 6 linacs per million seems more realistic, which would give a total requirement of 30 for Scotland. However, some possible assumptions give rise to a figure of 6.6 per million population by 2010⁶, and it is worthy of note that several European countries are already planning on the basis of 7 or 8 linacs per million population^{10,11}

Table 3: Current and projected needs for linear accelerator capacity

Radiotherapy Centre	1999			2010-14			
	Radiotherapy Patients	Number of Linacs ¹	Number of Linacs ²	Radiotherapy Patients ³	Number of Linacs ¹	Number of Linacs ²	Number of Linacs ⁴
Beatson Oncology Centre	3249	7.2	12.7	7771	17.3	12.5	16.5
Raigmore Hospital	367	0.8	1.2	876	1.9	1.2	1.5
Aberdeen Royal Infirmary	881	2.0	2.8	1799	4.0	2.8	3.7
Western General Hospital	1946	4.3	6.9	4686	10.4	7.0	9.3
Ninewells Hospital	628	1.4	1.9	1343	3.0	1.9	2.5
Total	7071	15.7	25.6	16475	36.6	25.4	33.6

¹ Calculation based on 450 patients/linac

² Calculation based on the RCR guideline of 5 linacs per million of population

³ Calculation based on projected cancer patients using *Cancer Scenarios* and ratio of radiotherapy patients to cancer patients in 1999 including unmet need (50%)

⁴ Calculation based on the RCR guideline of 6.6 linacs per million of population

15. The GIS model allows an evaluation to be made of the impact of redistribution of patients as blocks by Health Board of residence in an effort to determine the most equitable distribution of work and minimal travel time to fixed sites of provision for the largest number of people. This approach underestimates the complexity of any such proposed shift, and the optimised travel times do not fit well with existing Health Board boundaries. Thus, at present patients in

northeast Fife travel to Ninewells for radiotherapy (and other tertiary services). Any proposed shift would be unlikely to persuade patients in North Queensferry to cease going to Edinburgh and start travelling to Ninewells. A further more detailed analysis based on postcode of residence being developed, but preliminary analysis suggests that this will not significantly alter the outcomes except for Fife.

16. Optimising travel times within Scotland would suggest patients from Forth Valley could travel to Edinburgh, Dumfries and Galloway to Beatson and Fife to Ninewells. The impact of these changes (table 4) shows that the West of Scotland Cancer Centre would have to grow to an unmanageable size (17 linear accelerators), with the Edinburgh Cancer Centre at 9 accelerators and Ninewells to 6, which is beyond the current physical capacity of the site (4 linacs).

Table 4: Effect of optimising patient travel time to current five centres

Radiotherapy Centre	1999			2010-14			
	Radiotherapy Patients	Number of Linacs ¹	Number of Linacs ²	Radiotherapy Patients ³	Number of Linacs ¹	Number of Linacs ²	Number of Linacs ⁴
Beatson Oncology Centre	3071	6.8	12.1	7454	16.6	11.8	15.6
Raigmore Hospital	367	0.8	1.2	876	1.9	1.2	1.5
Aberdeen Royal Infirmary	881	2.0	2.8	1799	4.0	2.8	3.7
Western General Hospital	1645	3.7	5.8	3828	8.5	6.0	7.9
Ninewells Hospital	1107	2.5	3.7	2517	5.6	3.6	4.8
Total	7071	15.8	25.6	16475	36.6	25.4	33.5

¹ Calculation based on 450 patients/linac

² Calculation based on the RCR guideline of 5 linacs per million of population

³ Calculation based on projected cancer patients using *Cancer Scenarios* and ratio of radiotherapy patients to cancer patients in 1999 including unmet need (50%)

⁴ Calculation based on the RCR guideline of 6.6 linacs per million of population

17. Since large parts of Forth Valley, Lanarkshire and Dumfries & Galloway are within 60 minutes travel time of at least two of the existing cancer centres it is possible to envisage redirecting patient flows within the travel time constraint to allow a more practical and balanced distribution. The model suggests that the optimal configuration would then see Dumfries & Galloway patients going to Glasgow, Fife and Forth Valley patients going to Dundee and Lanarkshire patients going to Edinburgh. This reduces the West of Scotland Centre to a manageable 10 linacs, but requires 9 or 10 in Edinburgh and 6 in Dundee (table 5).

18. The physical capacity to house additional accelerators exists in all the centres, with Edinburgh potentially able to accommodate an additional three, Dundee, Aberdeen and Inverness one each and Gartnavel at least one. The projections however, suggest that an additional machine will be required in the Northern region (Grampian and Highland) at either Inverness or Aberdeen but not both. There was general consensus when meeting the West of Scotland Boards that the new Cancer Centre at Gartnavel Hospital should not grow beyond the currently planned 11 accelerators, as this would mean that a new one was constantly being commissioned (each is expected to have a working life of about 10 years). The wisdom of creating an equally large centre in Edinburgh will need to be considered.

Table 5: Optimal configuration with existing centres

	1999			2010-14			
Radiotherapy Centre	Radiotherapy Patients	Number of LinAcs ¹	Number of LinAcs ²	Radiotherapy Patients ³	Number of LinAcs ¹	Number of LinAcs ²	Number of LinAcs ⁴
Beatson Oncology Centre	2383	5.3	9.3	5838	13.0	9.1	12.0
Raigmore Hospital	367	0.8	1.2	876	1.9	1.2	1.5
Aberdeen Royal Infirmary	881	2.0	2.8	1799	4.0	2.8	3.7
Western General Hospital	1971	4.4	7.2	4565	10.1	7.4	9.7
Ninewells Hospital	1469	3.3	5.1	3397	7.5	5.0	6.7
Total	7071	15.8	25.6	16475	36.5	25.5	33.6

1 Calculation based on 450 patients/linac

2 Calculation based on the RCR guideline of 5 linacs per million of population

3 Calculation based on projected cancer patients using *Cancer Scenarios* and ratio of radiotherapy patients to cancer patients in 1999 including unmet need (50%)

4 Calculation based on the RCR guideline of 6.6 linacs per million of population

19. The Cancer Centre in Inverness appears highly vulnerable with a single linear accelerator. Although this machine is relatively new and is leased, any machine failure causes severe disruption to treatments with detriment to quality of care and outcome as well as anxiety for patients. The Centre has a funded third consultant oncologist post which remains unfilled after at least two rounds of advertising, and without a third consultant and/or an additional machine cannot engage in training specialist registrars. Should either of the two current consultant oncologists be unable, for any reason, to continue the service would be very difficult to sustain. On a population basis and with the current catchment area, however, the argument for a second machine is difficult to justify. The travel times for patients in the north-west and Islands would be prohibitive if services were not available in Inverness.

20. The model suggests that an additional machine will be required either in Aberdeen or Inverness but not both, and agreement needs to be reached between Grampian and Highland Health Boards as to the most appropriate location for this as well as the patient areas that should go to each Centre regardless of Health Board boundaries. For example, the area around Elgin is equidistant from Inverness and Aberdeen but is within the Grampian Board area.
21. Consideration should be given to expanding the hostel capacity in Inverness to allow patients to come from further afield without requiring a hospital bed. Such accommodation is widely used, for example, in Scandinavia with great success.
22. **Based on cancer incidence projections and the models above, it is clear that the existing 5 centres cannot be configured to accommodate the number of linear accelerators projected to be required by 2010-2014.**
23. The option of a sixth centre has also therefore been explored, with the GIS model employed to consider the impact of several different locations. Possible hospital sites investigated included: Golden Jubilee Hospital, Inverclyde, Ayr, Kirkcaldy, Perth and Stornoway. Each was rejected on grounds of insufficient catchment area, proximity to existing centres or insufficient impact on travel times for many patients. Developing a stand-alone radiotherapy centre was not considered in detail as the interdependence of clinical services makes this highly inefficient.
24. The illustrative examples most worthy of further consideration are Wishaw Hospital in Lanarkshire and the recently vacated site of the Royal National Hospital at Larbert in Forth Valley (which is the preferred option for the single acute site in the Forth Valley Acute Services Review). Wishaw Hospital may emerge as the favoured site for centralisation of cancer services within Lanarkshire, which may increase the logic of co-siting radiotherapy capacity there.
25. It is immediately apparent that any development of radiotherapy services on a sixth site would be on a much larger scale than a stand-alone, single accelerator 'satellite' model. After shuffling Health Board populations within the GIS model in many ways, the two example sites considered would each require to have four linear accelerators.
26. Assuming the Wishaw site to have a catchment area that includes Lanarkshire and Dumfries and Galloway with Forth Valley patients continuing to be treated at the West of Scotland Centre the configuration required is presented at Table 6.
27. For the Larbert site, the catchment area would include Lanarkshire and Forth Valley, with Dumfries and Galloway going to Glasgow (Table 7). However as current transport infrastructure favours an East/West direction of travel rather than North/South work would need to be done to ensure transport links were available between Lanarkshire and Forth Valley, particularly from the south. It is assumed that if single site development at Larbert goes ahead appropriate roads and other transport infrastructure will go hand in hand with the development.

28. Detailed analysis has not been carried out of the feasibility of either of these sites, or any other, becoming a sixth cancer centre in Scotland, nor would such analysis be appropriate until or unless such a possibility is considered worthy of further discussion and thereafter appropriate consultation.

Table 6: Optimal configuration of linacs if Wishaw were the 6th site

Radiotherapy Centre	1999			2010-14			
	Radiotherapy Patients	Number of Linacs ¹	Number of Linacs ²	Radiotherapy Patients ³	Number of Linacs ¹	Number of Linacs ²	Number of Linacs ⁴
Wishaw General Hospital	872	1.9	3.5	2179	4.8	3.5	4.6
Beatson Oncology Centre	2561	5.7	9.9	6155	13.7	9.7	12.9
Raigmore Hospital	367	0.8	1.2	876	1.9	1.2	1.5
Aberdeen Royal Infirmary	881	2.0	2.8	1799	4.0	2.8	3.7
Western General Hospital	1283	2.9	4.4	2949	6.6	4.6	6.0
Ninewells Hospital	1107	2.5	3.7	2517	5.6	3.6	4.8
Total	7071	15.8	25.5	16475	36.6	25.4	33.5

1 Calculation based on 450 patients/linac

2 Calculation based on the RCR guideline of 5 linacs per million of population

3 Calculation based on projected cancer patients using *Cancer Scenarios* and ratio of radiotherapy patients to cancer patients in 1999 including unmet need (50%)

4 Calculation based on the RCR guideline of 6.6 linacs per million of population

Table 7: Optimal configuration if Larbert were the preferred 6th site

Radiotherapy Centre	1999			2010-14			
	Radiotherapy Patients	Number of Linacs ¹	Number of Linacs ²	Radiotherapy Patients ³	Number of Linacs ¹	Number of Linacs ²	Number of Linacs ⁴
Larbert	1050	2.3	4.2	2495	5.5	4.2	5.5
Beatson Oncology Centre	2383	5.3	9.3	5838	13.0	9.1	12.0
Raigmore Hospital	367	0.8	1.2	876	1.9	1.2	1.5
Aberdeen Royal Infirmary	881	2.0	2.8	1799	4.0	2.8	3.7
Western General Hospital	1283	2.9	4.4	2949	6.6	4.6	6.0
Ninewells Hospital	1107	2.5	3.7	2517	5.6	3.6	4.8
Total	7071	15.8	25.6	16475	36.6	25.5	33.5

¹ Calculation based on 450 patients/linac

² Calculation based on the RCR guideline of 5 linacs per million of population

³ Calculation based on projected cancer patients using *Cancer Scenarios* and ratio of radiotherapy patients to cancer patients in 1999 including unmet need (50%)

⁴ Calculation based on the RCR guideline of 6.6 linacs per million of population

RECOMMENDATIONS

29. Clearly this would be a major acute/tertiary services development, and further work to assess the available options is required. There are also potentially significant capital and revenue consequences over the next 7 to 10 years. The Working Group's strong recommendation is that this will require a national centrally driven approach. It is therefore recommended that the Health Department Management Board **agree** that:
- discussions begin with all interested parties (including NHS Boards, Trusts, workforce planning, relevant professional and other staff groups) as to the scope of possible changes to working practices with a view to introducing them as soon as feasible to help meet current and projected rising demand.
 - detailed option appraisal should be carried out by the Cancer Branch, involving economic and further statistical input/modelling to assess the undernoted options to meet the projected level of need by 2010-2014:
 - a. a sixth cancer centre for Scotland, (either at Wishaw General Hospital, which is the preferred site for potential centralisation of cancer services within Lanarkshire¹², or at the Larbert site identified as the preferred option for a single acute centre for Forth Valley), and
 - b. the scope for and implications of expanding capacity at the existing five cancer centres to meet the projected level of need
 - Grampian, Highland and the Island Health Boards should be formally advised to further develop their review of existing working practices and referral patterns to ensure the sustainability of radiotherapy services in particular and tertiary cancer services in general in Inverness, with a specific focus to provide appropriate capacity for patients across the North of Scotland regional cancer network area for the future. The option appraisal report (above) should also consider the North of Scotland position in the light of these further discussions/review at local level.
30. HDMB is further invited to **confirm** that
- the current Working Party be reconstituted, involving such others as may need to be co-opted from time to time, to act as a Steering Group to oversee this exercise
 - the detailed option appraisal report should be submitted to the Board by the end of March 2004
 - the report should include recommendations on the timing, format and framework for wide ranging consultation on the future development of the *Cancer in Scotland* strategy and options for the future configuration of cancer services.
31. It is likely that additional short term resource will be required to support this work. HDMB's **approval** is sought for a short term (9-12 months) secondment of a dedicated project manager to work within the Cancer Branch (Health Planning and Quality Division). Economic and statistical support will be provided by (or arranged via) Analytical Services Division and ISD respectively. Costs will be met from the *Cancer in Scotland* centrally held monies.

ACKNOWLEDGEMENTS

The sub-group gratefully acknowledges the expertise and cheerful assistance of Jillian Campbell and Mette Tranter of the Scottish Cancer Intelligence Unit (with the latter on secondment from Lothian Health), without whom none of the geographical modelling would have been possible.

MEMBERSHIP OF THE RADIOTHERAPY ACTIVITY PLANNING SUB-GROUP

Dr M A Cornbleet, SEHD (Chair)

Mrs J Birrell (SEHD)

Mr R Black (ISD)

Mr I Dickson (Patient)

Mr T Divers (GGHB)

Mrs B Elliott (Carer)

Dr A Gregor (Lothian HB)

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Dr J Wrench (Highland HB)

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- ⁸ COIN Guideline, Royal College of Radiologists, London 1999
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- ¹⁰ Postma TJB, Terpstra S. Long range healthcare capacity planning in the Netherlands: the case of radiotherapy. Eur J Health Econom (2002) 3, 251-260
- ¹¹ Performance of different radiotherapy workload models. Barbera L; Jackson LD, Schulze MK et al, Int J Radiat Oncol Biol Phys 2003 Mar15;55(4):1143-9

RADIOTHERAPY – A MULTI STEP TREATMENT PROCESS

Radiotherapy is a cancer specific treatment and is rarely used to manage or treat other diseases. In Scotland, only about 1% of the radiotherapy delivered per annum is for the treatment or management of non-malignant disease.

It is widely accepted that radiotherapy will remain an essential component of cancer treatment for many years to come and that the demand will continue to rise as a result of both increasing cancer incidence and changing clinical indications and practice. The main radiotherapy activity planning report (2005) focuses on the need for increased radiotherapy service capacity in relation to the treatment delivery stage. However, radiotherapy is a complex multi-step process and a number of vital planning steps and stages are required between the decision to treat with radiotherapy and the first actual treatment appointment.

In some cases, this multi-step process involves several patient appointments and considerable treatment planning time involving co-ordinated presence of different professional groups, including the prescribing consultant who may spend a substantial amount of time at clinics away from the base centre. If additional devices, for example beam directional shells (BDS) are required, the patient may also need to attend for up to three additional appointments, over and above planning appointments, so that impressions and fittings can take place. Given the time required to let cast impressions set etc, it is not feasible to undertake all this work in one appointment or indeed one day.

The number of stages and steps between decision to treat with radiotherapy and 1st radiotherapy treatment appointment, and the time allocated to all these planning steps and process, varies considerably and is dependent on the complexity of treatments, timeous availability of all staff required, service capacity at the various stages of the radiotherapy process and capacity in other necessary services. The performance status of the patient can also be an influencing factor.

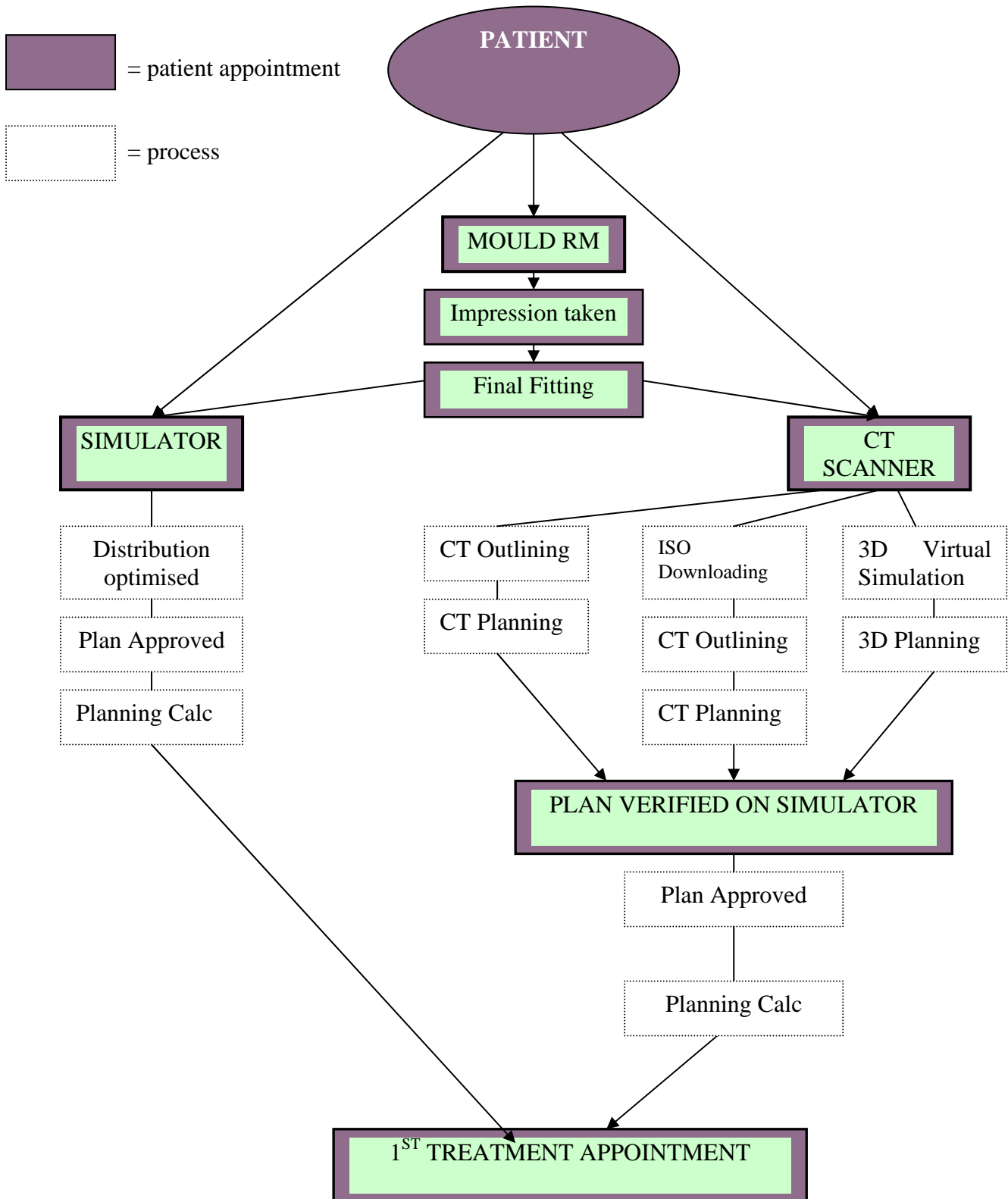
Therefore, timely patient progression from decision to treat to start of radiotherapy treatment will depend on adequate capacity in a number areas, both within the radiotherapy service and within services external to radiotherapy e.g. CT scanning facilities.

There is opportunity within the existing systems, through change management, to accelerate the progression through the planning stages to first radiotherapy treatment. Combined patient appointments, if possible, can reduce the burden for both the patient and the service. Furthermore, role extension opportunities within the existing workforce may reduce the need for particular patient appointments to be co-ordinated with the availability of certain staff group. For example, the plan verification on simulator appointment may be adequately carried out by trained radiographers thus reducing the need to align these appointments with consultant availability.

Diagram 1 presents a simplified patient pathway through the radiotherapy service from decision to treat with radiotherapy to the first radiotherapy treatment. The Royal College of Radiologists (1993) recommends that this should take no longer than 4 weeks for radical treatments and no longer than 2 weeks for palliative treatments.

March 2005

Diagram 1: Patient Path through Radiotherapy Service



RADIOTHERAPY HORIZON SCANNING WORKING GROUP

Membership and Remit

Erridge	Sara (CHAIR)	Senior Lecturer in Radiation Oncology & Honorary Consultant Clinical Oncology, Edinburgh
Brawn	Diane	Superintendent Radiographer, Inverness
Brunton	Fraser	Head of Radiotherapy Physics, Glasgow
Colligan	Steven	Head of Radiotherapy Physics, Inverness
Dewar	John	Consultant Clinical Oncology, Dundee
Dodds	David	Consultant Clinical Oncology, Glasgow
Junor	Liz	Consultant Clinical Oncology, Edinburgh
Milne	Una	Superintendent Radiographer, Dundee
Rampling	Roy	Professor of Clinical Oncology, Glasgow
Redgwell	Nicola	Superintendent Radiographer, Aberdeen
Redpath	Tony	Head of Radiotherapy Physics, Edinburgh

Remit

The Working Subgroup will be accountable to the Radiotherapy Activity Planning Steering Group. Its remit will be to agree and present a consensus view, where possible, about the future of Radiation Oncology in Scotland 2010-2014, in response to advances in both therapeutic and other technologies, including the impact on service capacity. It is recognised that it is difficult to predict future practice, particularly in the field of radiation technology where change is rapid. However, in order to obtain a reasoned Scottish consensus, members will be expected to confer with the wider oncology workforce and NHS colleagues to ensure that a comprehensive and inclusive view is obtained. Regional and NHS Board support should be provided to ensure that this is achieved to the highest level possible.

The Working Group will produce a written report by the end of August 2004 for approval and inclusion in the Interim Report to be submitted to the Health Department Management Board by end September 2004.

OPTIMAL RADIOTHERAPY UTILISATION MODELLING - METHODOLOGY

Radiotherapy Utilisation Modelling is an attempt to try to establish the proportion of cancer patients within a population who should receive radiotherapy based on best available evidence. For a number of years it has been widely accepted across the commonwealth that about 50% of cancer patients should receive radiotherapy. However, in reality radiotherapy utilisation does and will vary across the countries as each has a different case-mix of cancer types, stage of cancer at presentation and co-morbid diseases, all of which independent of resource availability, impact on treatment delivery.

In an attempt to accurately quantify the requirement for radiotherapy, Professor William MacKillop and his team at the Queen's Cancer Research Institute, Kingston, Ontario devised a technique of establishing radiotherapy indications; defined as 'a set of clinical parameters that suggest that radiotherapy is necessary, expedient or advisable'. They conducted a systematic review of the literature, including published guidelines, such as, Scottish Intercollegiate Guidelines (SIGN), Cancer Care Ontario Clinical Practice Guidelines, National Cancer Institute PDQ guidelines etc and from this established evidence based clinical scenarios where radiotherapy is indicated. Then, using population data the proportion of cases in a cancer population matching these scenarios was applied to calculate optimal radiotherapy utilisation.

In 2001, the Australian Department of Health and Ageing funded the Collaboration for Cancer Outcomes Research and Evaluation (CCORE) of the Liverpool Health Service to carry out a project titled *Radiotherapy in cancer care: estimating the optimal utilisation from a review of evidence-based guidelines*. This group, chaired by Professor Michael Barton, conducted a systematic review of the radiotherapy indications for all cancer sites. Any indications for radiotherapy identified in clinical practice guidelines or other literature was included in the analysis. These were then entered into a software programme (TreeAgeTM) and for each cancer radiotherapy utilisation trees were constructed. Then using, wherever possible, Australian population data optimal utilisation rates for all cancer sites were calculate. A full report has been published and is available at <http://www.ncci.org.au/pdf/radiotherapyreport.pdf>

The Radiotherapy Activity Planning Group for Scotland gratefully acknowledge the permission of Professor Barton and Dr Delaney from CCORE, to use their radiotherapy utilisation trees to calculate the optimal radiotherapy utilisation for Scotland.

In order to achieve radiotherapy indications that would more accurately reflect Scotland and provide a sounder basis for forward planning for the Scottish Radiotherapy Service 2011-2015, the evidence base applied to the modelling was altered if there was a widely different approach to cancer management. In brief this is because interpretation of data and clinical practice varies around the world and highest priority evidence applied by the CCORE group was at times at variance with clinical practice in Scotland. One example is the use of post-operative radiotherapy for localised stomach and pancreatic cancer. While this may be standard practice in Australia, it is rarely practiced in Scotland mainly as a result of different surgical practice and interpretation of the evidence.

Once completed, the Scottish Radiotherapy Utilisation trees were circulated to site-specialist Clinical Oncologists to obtain their agreement that they accurately reflected optimal clinical practice based on the current clinical community and national consensus views on currently available evidence.

Once the indications for radiotherapy were established, data from the Scottish Cancer Registry and National and Regional Audits were used to calculate the proportions of patients within each category. Scottish data was not available for all cancer types and in these cases the Northern and Yorkshire Cancer Registry and Information Service database (<http://www.nycris.org.uk>) was searched to obtain comparable data for a UK population. Failing this, the data used in the original Australian report were used.

The data which are required for this process are

- data on distribution of the various pathological subtypes
- data on the stage distribution of the different cancer sites
- data on surgical clearance
- patient fitness and co-morbid diseases
- presence or absence of focal symptoms

Data was obtained from the following Scottish Cancer Audits.

1. Breast: South East Scotland Cancer Network (SCAN) breast cancer audit 2003. SCAN includes patients from Borders, Dumfries and Galloway, Fife and Lothian and covers a population of 1.4 million, 27% of the Scottish population. It is a mixed urban and rural population. All patients with breast cancer are referred to a specialist breast cancer surgeon and so the audit case ascertainment is high. In accordance with SCAN clinical guidelines all patients see a Clinical Oncologist pre-operatively to assess their suitability for breast conservation, therefore the rate of mastectomy for 'social' reasons e.g. travelling, is low. Data on tumour stage (including number of lymph nodes involved) and type of surgery were used.
2. Lung: SCAN lung cancer audit 2002-2003. The case ascertainment is not as complete as the Breast cancer audit with about 80% (800 out of 1000 cases) of the population being identified. However, as all surgery, radiotherapy and chemotherapy is delivered by clinician's participating in this audit it is unlikely that any patient receiving treatment for their lung cancer would have been missed. The 'missing cases' have been distributed according to the same proportions as the known cases. Data on tumour stage and performance status were used. The respiratory physician making the diagnosis enters the latter data onto the registration form.
3. Urological cancers : Scottish Urological Cancer Audit 1999 – 2002. This was a large national Audit (in preparation for publication), which looked at a case distribution and treatment of Urological Cancers across Scotland, including bladder, kidney, penis, prostate, renal pelvis & ureter and testis.
4. Head and Neck: Scottish Audit of Head and Neck Cancers 1999-2002 . This was a large national Audit (in preparation for publication), which looked at the case distribution and treatment of head and neck cancer across Scotland. The case distribution was used. In addition to these data, other data on the suitability for local resection was obtained from 2003 SCAN audit data.

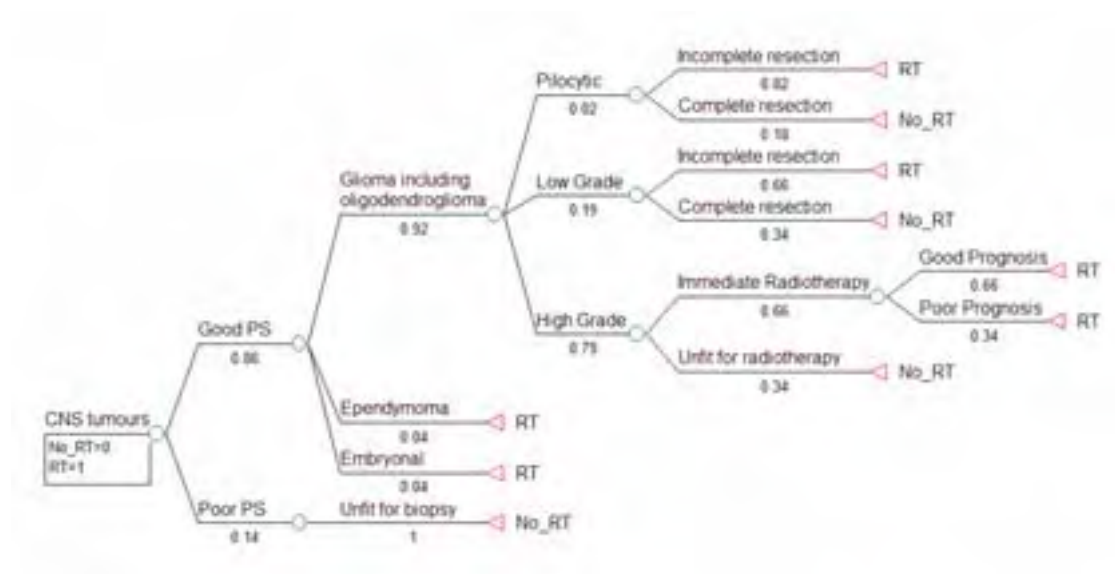
5. Gynaecological Cancers: Edinburgh Cancer Centre database 2001. In this year all patients with pathologically confirmed gynaecological invasive cancer from the SCAN region were discussed at the multi-disciplinary meeting and their details entered onto the Cancer Centre database (subsequently only those seen at the Cancer Centre have been entered). As the 'trigger' for discussion was the pathological diagnosis of cancer, no cases should have been missed. Data on stage was used.
6. CNS: 1999 CRAG audit. This was commenced as a Scottish National audit, but unfortunately Greater Glasgow had to stop collecting data but the data still covers over half the Scottish population. This audit looked at the management of patients presenting with a CT scan, which suggested a malignant brain lesion. The data on biopsy rate and case distribution were used.
7. Upper Gastro-intestinal: Scottish Audit of Upper Gastrointestinal Audit and Oesophageal Cancers (SAGO) 1997-2000. This was a large national Audit including Stomach, Pancreas, Oesophagus, Gall bladder.
8. Melanoma data is collected nationally and was supplied via personal correspondence
9. Colorectal : SCAN 2002 Colorectal Cancer Audit. This identifies all patients referred to colorectal surgeons and oncologists. This primarily collects data according to Duke's stage and the data on TNM have only recently been collected but are available for 74% of rectal cancer cases. The 'missing cases' have been distributed according to the same proportions as the known cases.

In the Scottish modelling we primarily looked at radiotherapy use in the initial phase following diagnosis. From the audit of treatments performed in 2003 it can be seen that radical treatments consume in excess of 80% of the fractions. However, in order to enable comparison with International figures, using the relapse figures from the Australian data, the rate of deferred radiotherapy has also been calculated.

**Horizon Scanning Group of the Radiotherapy Activity Planning Group
November 2004**

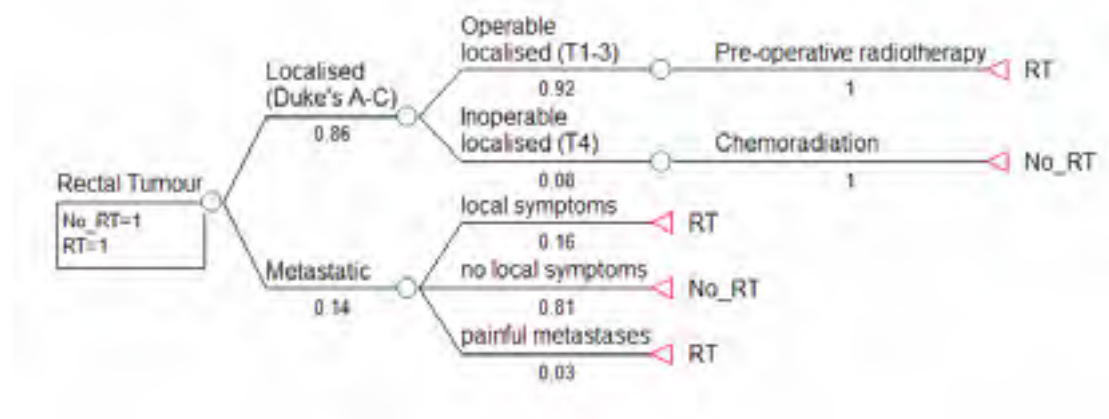
CLINICAL DECISION TREES

CNS

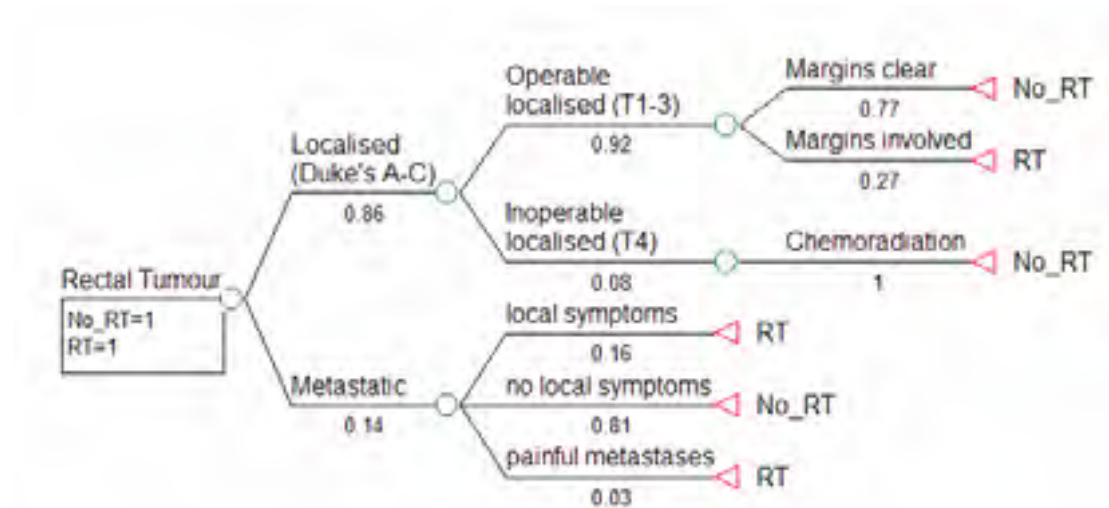


RECTAL CANCER

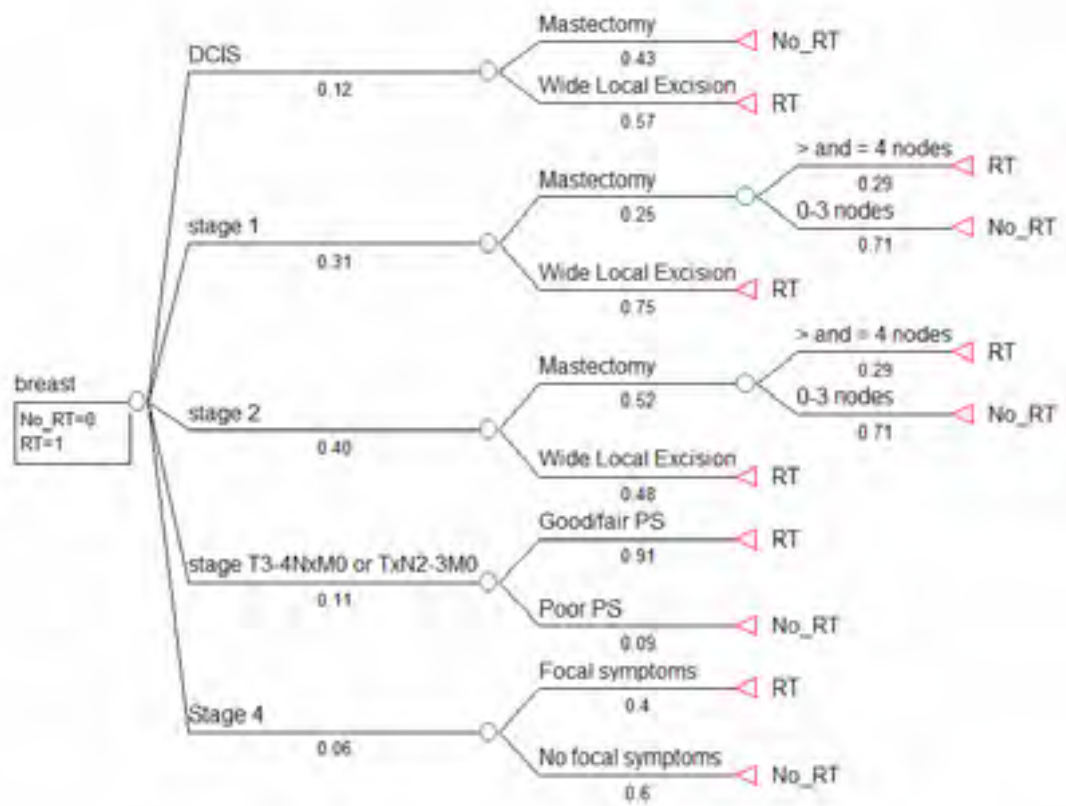
Pre-operative radiotherapy



No pre-operative radiotherapy

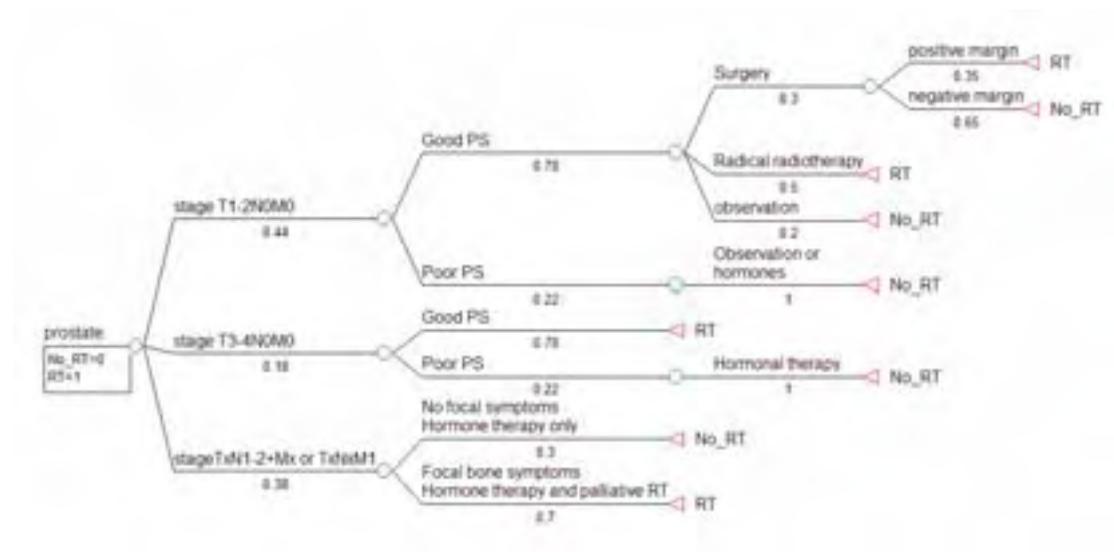


BREAST CANCER

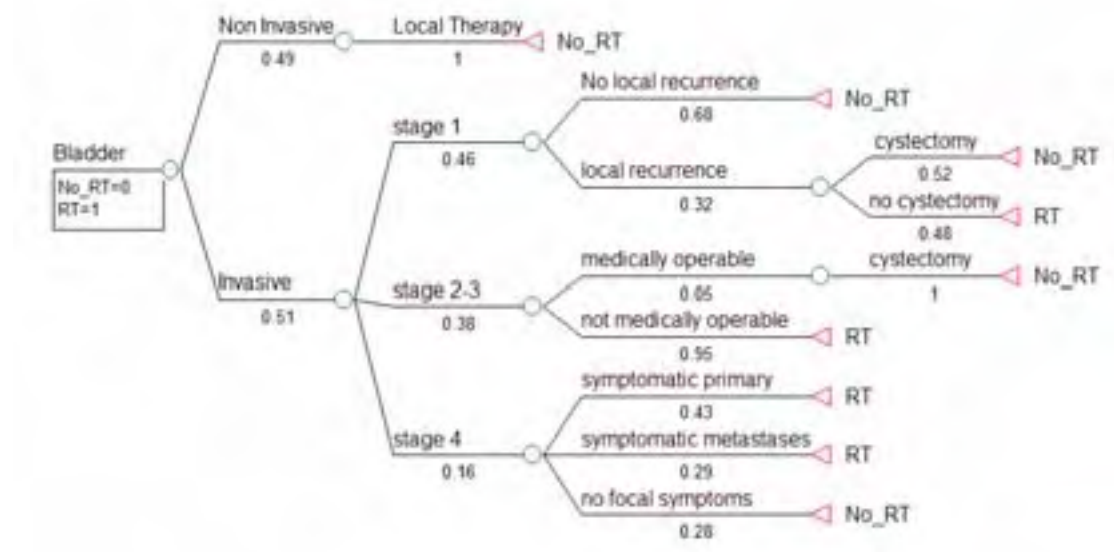


UROLOGICAL CANCERS

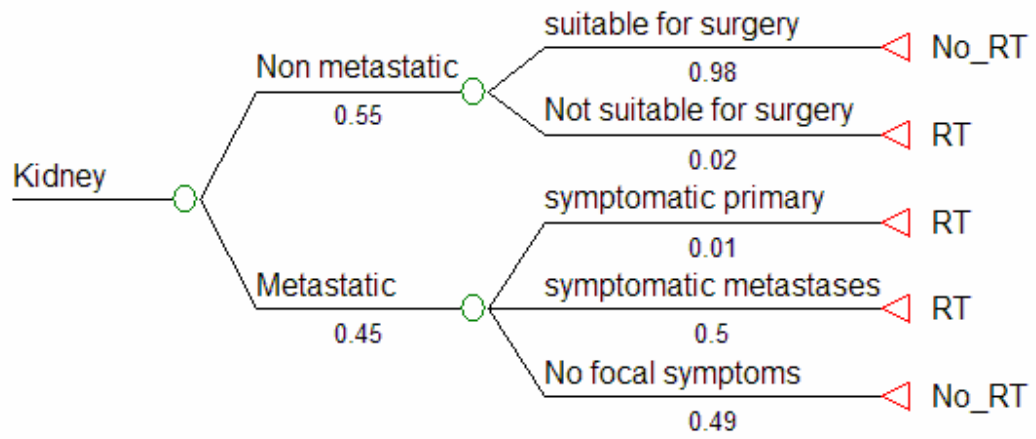
PROSTATE CANCER



BLADDER CANCER

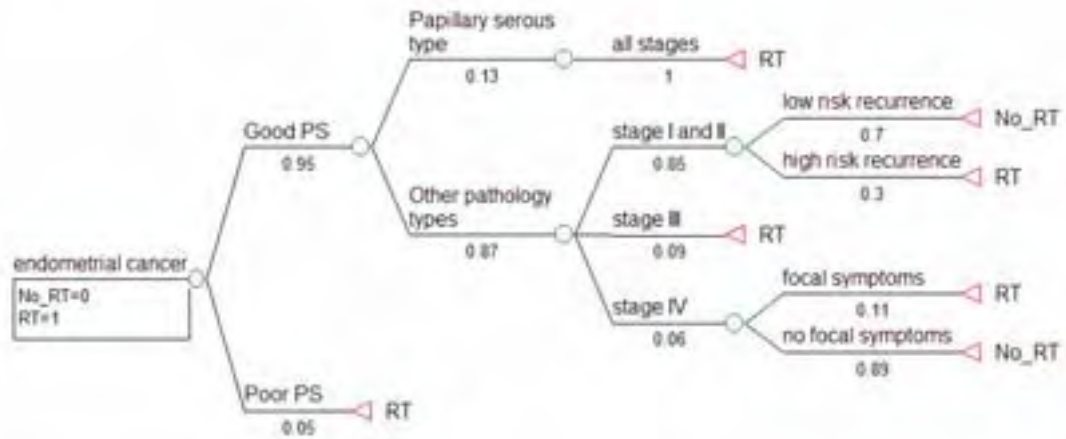


RENAL CANCER

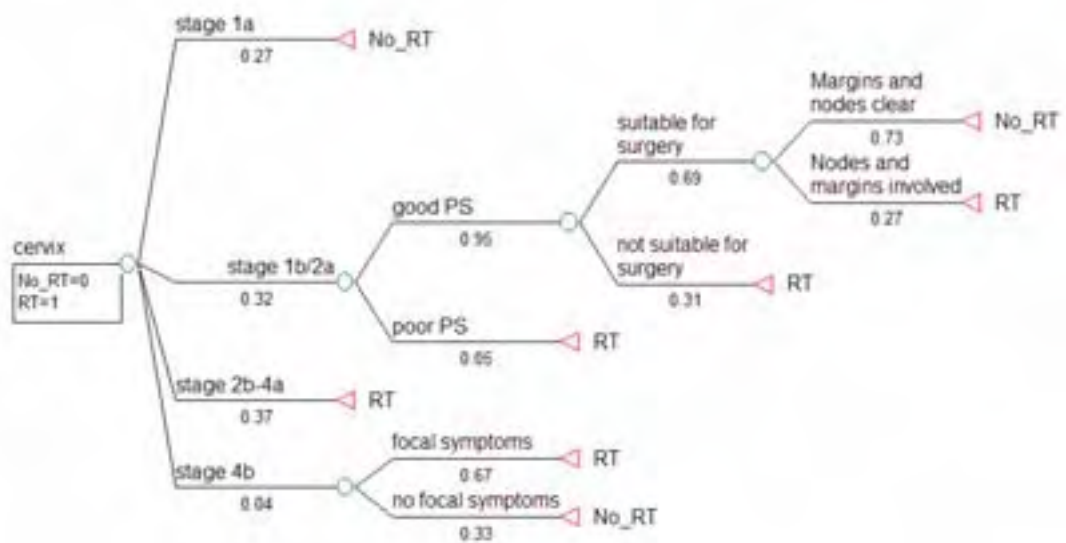


GYNAECOLOGICAL CANCER

ENDOMETRIAL CANCER

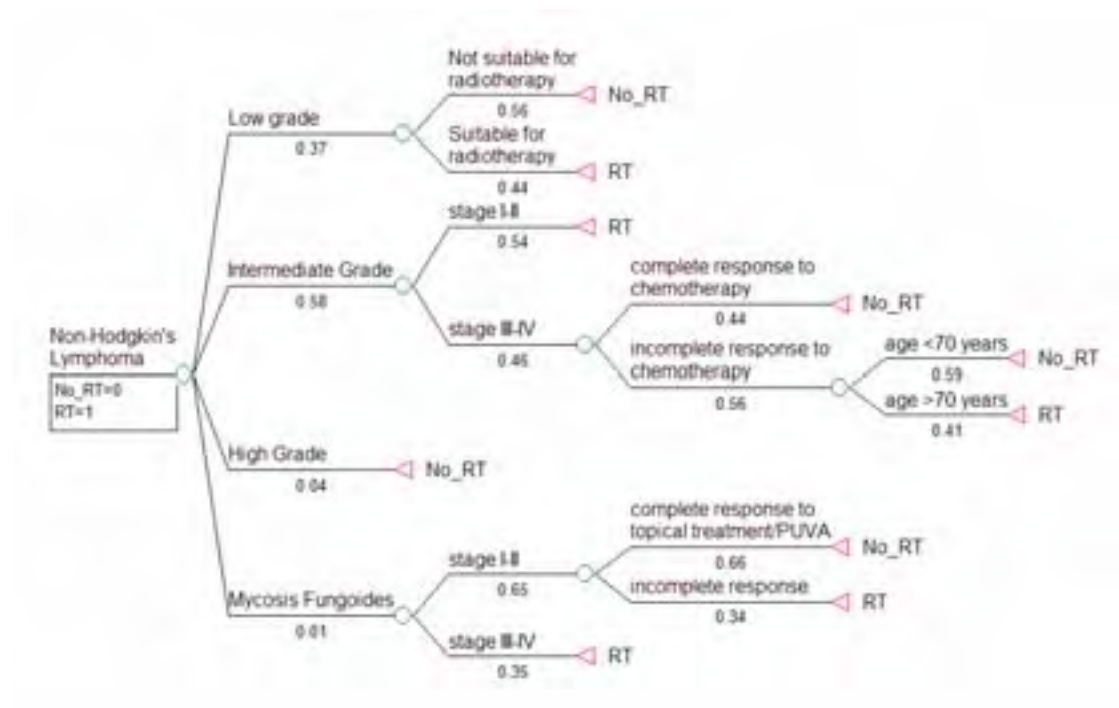


CERVIX CANCER

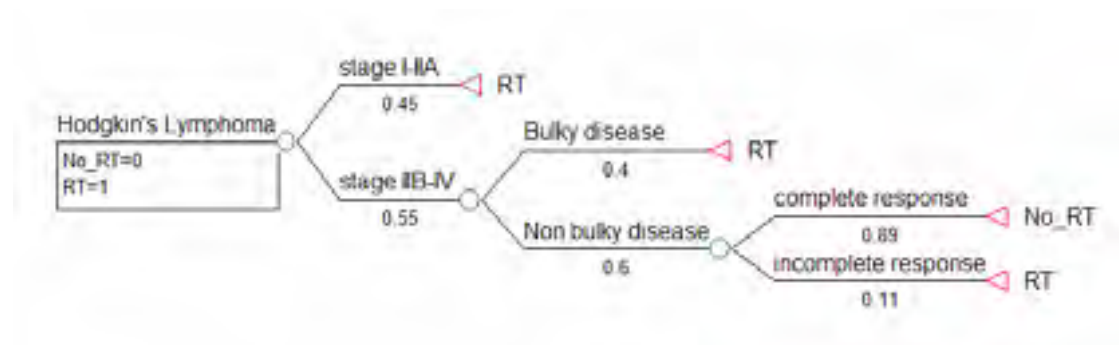


LYMPHOMA

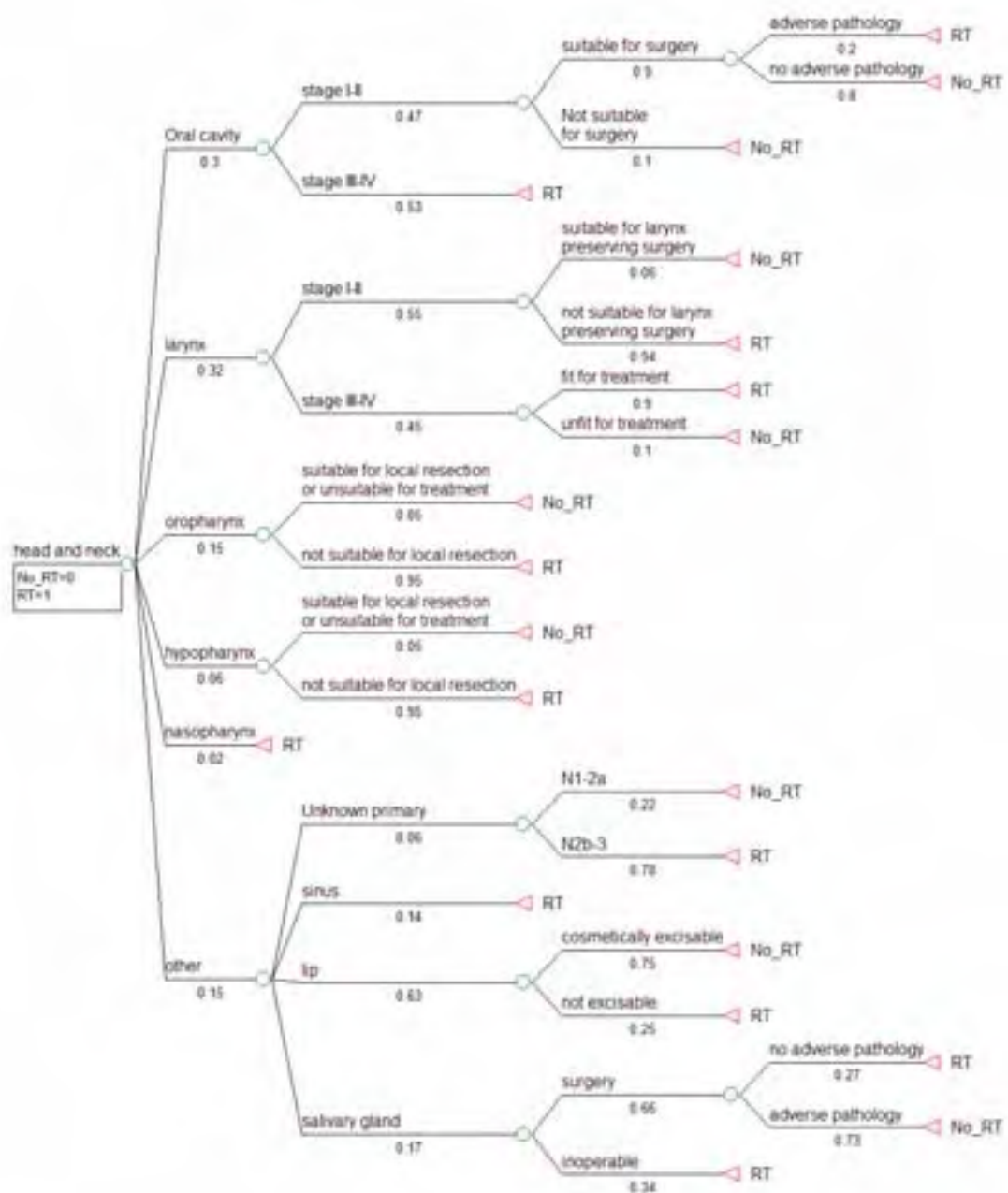
NON-HODGKIN'S LYMPHOMA



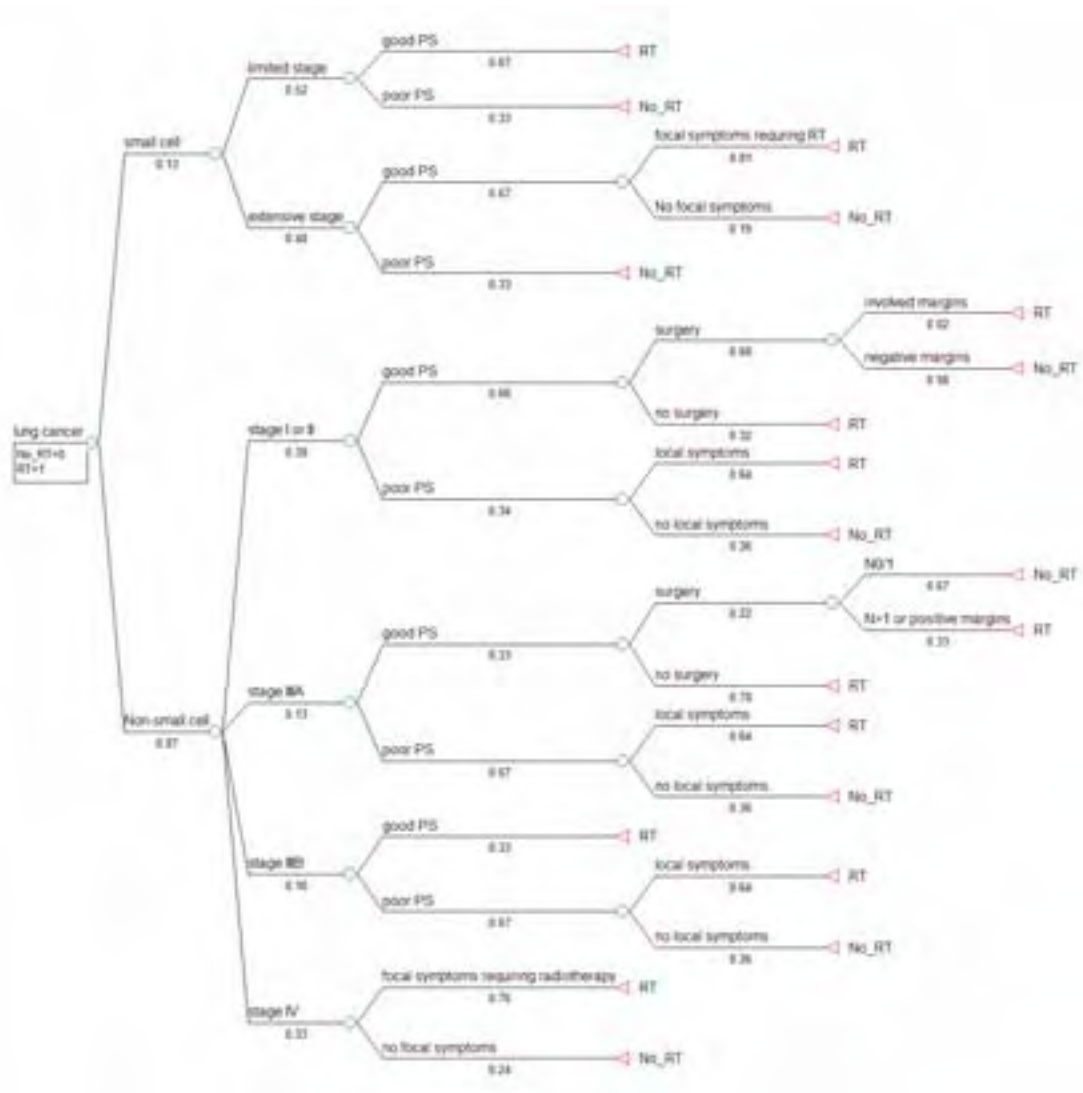
HODGKIN'S DISEASE



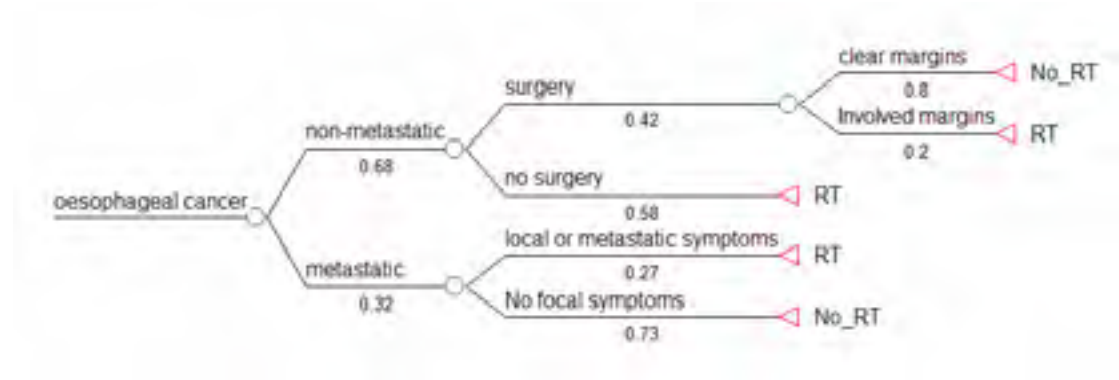
HEAD AND NECK



LUNG CANCER



OESOPHAGEAL CANCER



SCOTTISH RADIOTHERAPY MODELLING BY CANCER TYPE

*CNS Tumours**SUMMARY*

Optimal radiotherapy indication for CNS cancers is 60.7 – 81.9%. The total fractions required 2011 – 2015 to optimally treat the future incident population with an indication for radiotherapy is 6090 - 8010 fractions.

CNS Tumours

CNS tumours constitute about one and half percent of cancers registered in Scotland per annum with an average of 396 cases per annum, 1996 - 2000. In 2003, CNS tumours were the primary cause of death in 187 men and 144 women.

The incidence of CNS Tumours is projected to increase by 15.4% between now and 2011 – 2015 to an average annual incidence of 413.

CURRENT RADIOTHERAPY UTILISATION

Scotland

In 1998-1999 a National Audit was performed looking at the investigations and treatment received. Unfortunately the Greater Glasgow region had to withdraw from this audit, but data collection continued in Lothian, Borders, Fife, Tayside, Grampian and Highlands and Islands. This audit identified 324 patients with a CT scan or MRI suggesting a solitary supra-tentorial intra-cerebral tumour. Of these 261 underwent a biopsy. Of these cases, 156 had a malignant glioma (GBM, anaplastic astrocytoma or anaplastic oligodendroglioma), 33 had low-grade glioma, 7 embryonal tumours, 5 cerebral lymphomas, 42 metastases and 18 benign conditions/non-diagnostic.

In the 156 proven high-grade glioma, the rate of use of radiotherapy varied from 59% to 94% between centres, but this appeared to reflect a lower biopsy rate in the hospital with higher radiotherapy utilisation. The fractionation varied between centres with 60Gy in 30 fractions being delivered in 62%, 71% and 25% of patients. The first two centres delivered 30Gy in 6 fractions to the remaining patients and the third centre used 45Gy in 20 fractions.

Sweden

In the 12-week prospective audit of radiotherapy, CNS tumours represented 2.1% of the treatments delivered. The mean number of fractions used was 23.8, median 28 with a dose ranging from 20-66Gy. Brain tumours represent 2.7% of cancers in Sweden, therefore based on these figures 37% of brain tumours received radiotherapy.

Ontario data

A review was performed of all cases of glioblastoma multiforme (grade IV glioma) registered in Ontario 1982-1994 (Paszat IJORBP 2002). Of the 3279 cases identified, 50% received surgery and radiotherapy, 37.2% surgery only, 5.3% radiotherapy without surgery and 7.5% no treatment. The mean number of fractions received was 24 (median 25)

OPTIMAL RADIOTHERAPY UTILISATION

Australia

This calculated that 92% of patients with brain tumours should receive radiotherapy. This figure was based upon data from the South Australian Hospital Registry where 94% of patients underwent biopsy and therefore were defined as having 'good performance status'. Of these 70% had a high-grade glioma and the algorithm suggested that all such patients should receive radiotherapy. Obviously, this was not the case in the 1998 Scottish audit.

Scotland (Table J1)

Using data from the CRAG audit when only 80% of patients were fit enough to undergo biopsy and assuming that all such patient should be fit enough to have radiotherapy, then the optimal radiotherapy utilisation rate for intrinsic CNS patients in Scotland is estimated as between 60.7 – 81.9%.

POTENTIAL CHANGES TO UTILISATION

Suggestions of conditions where radiotherapy may not be used as frequently were

- i) oligodendrogliomas, there are proposed trials to look at using chemotherapy first line and deferring radiotherapy
- ii) other chemo-sensitive tumours such as cerebral lymphoma, germ cell tumours and embryonal tumours
- iii) hormonal secreting pituitary adenomas, where new more effective medical therapies are becoming available
- iv) meningioma and pituitary adenoma where improved surgical techniques may remove the need for adjuvant radiotherapy
- v) single fraction stereotactic radiosurgery may replace fractionated treatment for some meningiomas
- vi) intra-operative radiotherapy, this is a highly experimental technique in which a single treatment is delivered at time of surgery, this might replace fractionated radiotherapy for some intra-cranial lesions

Suggestions of conditions where radiotherapy will be used more frequently were

- i) Meningiomas – there is an increasing body of evidence that radiotherapy is successful in both the primary and adjuvant setting and with more sophisticated planning techniques the toxicity can be minimised.
- ii) Brain metastases – stereotactic radiosurgery will be used more, particularly for patients with solitary lesions.

TREATMENT/FRACTIONATION FOR CNS TUMOURS

Current Fractionation

High grade glioma

Good performance status– 60Gy in 30 fractions (all centres)

Poor performance status– 30Gy in 6 fractions (three centres) and one occasionally uses 30Gy in 10 fractions.

Two of the centres occasionally use 45Gy in 20 fractions for patients who are borderline between these two categories.

Low grade glioma

Radiotherapy is only recommended as part of the immediate management in a minority of these patients. For those receiving radiotherapy, the dose varies from 45Gy in 25 fractions, 50.4Gy in 28 fractions to 54Gy in 30 fractions.

Meningioma

As with low-grade glioma, only a minority of patients receive radiotherapy either as primary definite treatment or adjuvant post-operative treatment following incomplete resection or due more aggressive pathology. One centre does not irradiate meningioma, whereas the other centres use between 50-60Gy in 28 to 30 fractions.

Embryonal lesions

This is a rather varied group of tumours including tumours such as medulloblastoma and PNET. One of the centres uses a 25 fraction treatment, one 30 fractions to primary, two 32 fractions for craniospinal treatment.

Pituitary lesions

Three centres use 45Gy in 25 fractions and one 45Gy in 20 fractions.

Changes to fractionation that should be considered in 2004

Three centres felt no need to change the current fractionation schedules for any of the sites. One felt that hyper-fractionated treatment with 68 twice-daily fractions should be considered for embryonal lesions, as per the SIOP PNET 4 study. It was calculated that a total of 5950 fractions will be required for the treatment of incident CNS population with an indication for radiotherapy 2011 – 2015 (Table J2).

Changes to the fractionation schedules in the next ten years

- i) Meningioma – the use of IMRT and stereotactic radiotherapy may allow a change to shorter fractionation schedules
- ii) Hyper-fractionated schedules may be adopted for medulloblastoma.

Changes in techniques over the next ten years

- i) 3D-CRT for all good performance status patients with high grade glioma and all patients with low-grade tumours or benign diseases
- ii) IMRT will be used to treat low-grade lesions such as meningioma and some low-grade intrinsic brain tumours.

Table G1: Optimal radiotherapy use in intrinsic CNS lesions

CNS tumours 359 incident cases per annum - 1996 - 2000	Good PS 0.86 ¹ 308	Glioma including oligo- dendroglioma ² 0.92 ³ 283	Pilocytic 0.02 ³ 5	Incomplete resection 0.18 ³ 1		Radiotherapy 1
				Complete resection 0.82 ³ 5		No Radiotherapy 5
			Low grade 0.19 ³ 54	Incomplete resection 0.66 ³ 36		Radiotherapy 36
					High risk 0.5 ³ 9	Radiotherapy 9
				Complete resection 0.34 ³ 18	Low risk 0.5 ³ 9	No radiotherapy 9
			High grade 0.79 ³ 224	Immediate RT 0.66 ^{1,4} 148	Radiotherapy Good prognosis 0.66 ⁴ 98 (148 ⁴)	
					Radiotherapy Poor prognosis 0.33 ⁴ 50 (76 ⁴)	
					Unfit for RT 0.33 ^{1,4} 76 No radiotherapy 76 (0 ⁴)	
	Ependymoma 0.04 ³ 12					Immediate Radiotherapy 12
	Embryonal 0.04 ³ 12					Immediate Radiotherapy 12
Poor PS 0.14 ¹ 50	Unfit for biopsy 1.00 50				No radiotherapy 50	

¹ In the CRAG audit 1998-1999 of all patients presenting with a high-grade enhancing lesion, only 80% were fit enough to undergo biopsy which is lower than in Australia. According to Australian model 69% of biopsy proven cases were high-grade glioma therefore if this ratio is applied to the poorer Scottish performance data then 86% of patients have a good performance status (31% low grade+ (80% of 69%))

² Australian model separates oligodendroglioma from glioma, this is artificial with an increasing diagnosis of oligodendroglial components of tumours

³ Figures from Australian model

⁴ In CRAG audit approximately two-thirds of patients with biopsy proven glioma received radiotherapy and two-thirds of these received long-course radiotherapy. In the Australian model it was assumed that all patients fit enough for biopsy should receive radiotherapy, using these guidelines then all 224 patients with high grade glioma should receive radiotherapy (148 thirty fractions and 76 six fractions), this would then be an optimal radiotherapy utilisation of 79.9%.

Table G2: Current and future fractionation requirements

	Number of patients based on 1996 - 2000 model	Current fractionation (2003/04)	Optimal total # needed in 2004	Predicted number of cases in 2011 - 2015 (15.4% increase)	Predicted fractionation 2011 - 2015	Total Fractions required 2011 - 2015
Low grade glioma incl pilocytic	46	28 ¹	1288	53	28	1486
High grade glioma good prognosis	98 -1498	30	2940 - 4440	113- 171	30	3390 - 5130
High grade glioma poor prognosis	50-76	6	300- 56	58-88	6	348-528
Ependymoma	12	30	360	14	30	420
Embryonal	12	32	384	14	32 ²	448
Total	218–294 (60.7 - 81.9%)		5272- 6818			6090 - 8010

¹For the purposes of this calculation the most commonly used fractionation schedules have been used.

²One centre felt hyper-fractionation might be used, but this would only constitute a couple of patients

Colorectal Cancer

SUMMARY

Optimal radiotherapy indication for rectal cancer is 27.8 – 88.7%. The total fractions required 2011 – 2015 to optimally treat the future incident population with an indication for radiotherapy is 8991 - 9931 fractions.

Optimal radiotherapy indication for colon cancers is 1%. The total fractions required 2011 – 2015 to optimally treat the future incident population with an indication for radiotherapy is 145 - 290 fractions.

Colorectal Cancer

An average of 3462 colorectal cancers were diagnosed per annum in Scotland, 1996 – 2000. Incidence is higher in males than in females. In 2003, colorectal cancers were the primary cause of death in 830 men and 752 women.

The incidence of colorectal cancers is projected to increase by 29% between now and 2011 - 2015 to an average annual incidence of 4467.

ROLE OF RADIO THERAPY

The majority of colorectal cancer is colonic rather than the rectal, and the indication for radiotherapy is primarily in the loco-regional treatment as a component of primary therapy of rectal cancer.

The management of rectal cancer is in a state of flux at present, which makes predictions for the future difficult. Issues include:

- 1) *Screening* – pilot studies have demonstrated that this could be highly effective at detecting colorectal cancers at an earlier stage where radiotherapy may not be required.
- 2) *Improved surgical techniques* - the wide-spread adoption of Total Mesorectal Excision (TME) as the surgical standard for operable rectal cancer has raised the question about routine use of short-course pre-operative radiotherapy for all operable rectal cancers. With this operation the risk of a local recurrence is 3 - 5%, therefore giving every patient radiotherapy may cause unnecessary morbidity. This question of pre-operative radiotherapy is currently being explored in the NCRN CR07 study.

CURRENT RADIO THERAPY UTILISATION

POPULATION-BASED STUDIES

France

The management of 683 patients diagnosed in France with rectal cancer in 1995 was examined (Phelip 2004). 46.8% received adjuvant radiotherapy, but this rate varied greatly between regions (21 to 70%). In the majority of cases (72.4%) this was delivered pre-operatively.

Netherlands

All patients diagnosed with rectal and recto-sigmoid cancer in South-east Netherlands from 1980 to 2000 for included in the study (Martijn 2003). 3635 cases were identified and 31% had radiotherapy combined with surgery. The use of radiotherapy combined with surgery increased over the two decades from 26% to 40%. There was also a marked shift to pre-operative treatment; 1% pre-operative and 25% post-operative in 1980-89 and 35% pre-operative and 4% post-operative in 1990-2000.

Sweden

In the prospective audit, 56% of cases of rectal cancer received radiotherapy and 6% of colon cases. 80% of the rectal cases were treatments with curative intent, 95% combined with surgery, the median number of fractions was 5.0 with a mean of 8.3, suggesting a high use of the Swedish pre-operative schedule of 25Gy in 5 fractions.

California

Patients with Stage III colon cancer and Stage II and III rectal cancer registered in the Californian Cancer Registry during 1996 and 1997 were identified (Ayanian 2003) and the factors affecting the delivery of radiotherapy and chemotherapy examined. Of the 534 patients with rectal cancer, 64.8% had score 0 on the Charlson co-morbidity score (Charlson 1987), 19.3% 1 and 15.9% ≥ 2 . Around 64% received radiotherapy (figure not given in paper) with older age, Black race, lower income, unmarried, more co-morbid disease, smaller hospital and no radiotherapy department within the hospital all predicted for lower utilisation.

OPTIMAL RADIOTHERAPY UTILISATION

Ontario

This model suggested that 20.9% of cases should receive early radiotherapy with 2.7% receiving treatment during the later phases of their illness. This figure was based on the data that 91.1% of cases were fit to receive treatment and of these 71.1% had colon cancer. Of patients with colon cancer, 3% would require immediate radiotherapy for positive surgical margins and a further 3.8% would need radiotherapy for metastatic disease. For the rectal cancer patients, 60% would need radiotherapy as part of their definitive local therapy and 10.5% for palliative treatment for loco-regional or metastatic disease.

Australian

The modelling for rectal cancer suggested that 61% of patients should receive radiotherapy, primarily to local disease.

Scotland

The Australian model was developed before the widespread adoption of TME so does not comply with standard management of rectal cancer in Scotland. As discussed the management of this condition is debated and will be influenced by on-going clinical trials, therefore two trees have been constructed to fit with the two scenarios (Table J3 and J4 respectively).

The data on TNM and Duke's stage comes from the SCAN colorectal audit of cases diagnosed in Edinburgh. Of the 87 patients with rectal cancer, 74% had T stage recorded. For the model the unstaged patients were distributed at the same ratios so that 8% had T1, 14% T2, 57% T3 and 8% T4. Similarly 76% of patients had a Duke's stage allocated, and if the unstaged patients are redistributed then 15% had Stage Duke's A, 33% Duke's B, 38% Duke's C and 14% Duke's D. This method probably underestimates advanced cases as these are more likely to be unstaged.

Of the 87 patients 22% had short-course pre-operative radiotherapy, 6% pre-operative chemo-radiation, 1% post-operative radiotherapy, 55% surgery without radiotherapy. 11% palliative radiotherapy with or without surgery, and 5% received neither surgery nor radiotherapy. Based on this utilisation, currently 4676 fractions would be used to treat rectal cancer per annum in Scotland.

Table G3: Routine use of pre-operative radiotherapy for all patients with ‘operable’ (T1-3) cancer

Rectal Tumours 1183 incident cases per annum 1996-2000	Localised (Dukes A-C) 0.86 ¹ 1017	Operable localised (T1-3) 0.92 ¹ 936	Pre-operative radiotherapy 936		
		Inoperable localised (T4) 0.08 ¹ 81	Chemoradiation 81		
	Metastatic (Duke's D) 0.14 ¹ 166	local symptoms 0.16 ² 27		Local radiotherapy 27	palliative
		no local symptoms 0.81 ² 134		No radiotherapy 134	
		Painful metastases 0.03 ² 5		Palliative radiotherapy 5	

¹ from SCAN 2003 audit of cases diagnosed in Edinburgh

² from Australian model

Table G4: No routine pre-operative radiotherapy, selective post operative radiotherapy to patients with positive margins.

Rectal Tumours 1183 incident cases per annum 1996-2000	Localised (Dukes A-C) 0.86 1017	Operable localised (T1-3) 0.92 ¹ 936	Margins clear 0.77 ³ 720	No radiotherapy 720
			Margins involved 0.23 ³	Post-operative radiotherapy 216
		Inoperable localised (T4) 0.08 ¹ 81	Chemoradiation 81	
	Metastatic (Duke’s D) 0.14 166	local symptoms 0.16 ² 27	Local palliative radiotherapy 27	
		no local symptoms 0.81 ² 134	No radiotherapy 134	
		Painful metastases 0.03 ² 5	Palliative radiotherapy 5	

³ From Dutch TME trial

TREATMENT/FRACTIONATION FOR RECTAL CANCERS

Current fractionation

- 1) 5 fractions (short course) for localised disease operable disease
- 2) 25 fractions, with chemotherapy, (long course) for locally advanced in-operable disease
- 3) 20-25 fractions were used for post-operative treatment for those patients who had not received pre-operative therapy but the circumferential margins were involved
- 4) 20-25 fractions were used for some good performance patients with metastatic cancer but local symptoms
- 5) 10-12 fractions were used for patients with a poor performance status but local symptoms.

How will fractionation change?

There were no major changes in the fractionation predicted other than some patients currently receiving short-course treatment might receive long-course 25-fraction chemo-radiation in the future

What patients will be treated with a more sophisticated technique?

The role of more complex techniques such as IMRT, has not been evaluated in rectal cancer. However, a UK randomised trial looking at the role of IMRT in pelvic nodal irradiation is proposed. Potentially IMRT could allow sparing of small bowel and bladder and thereby reduce toxicity. Whether or not all patients receiving high dose radiotherapy for rectal cancer, or just those receiving post-operative radiotherapy when there is more small bowel within the radiotherapy volume, is uncertain.

How will the groups of patients receiving radiotherapy change?

As discussed above, at the current time this is difficult to predict until the results of currently recruiting trials are available. Also, the use of MRI to more accurately assess operability may influence the numbers of patients receiving short course of long course radiotherapy.

Estimated fractions required 2011 – 2015

Fractions were calculated based on the two scenarios (Table J5 and J6):

Table G5: Fractions required for optimal radiotherapy utilisation where all operable patients pre-operative radiotherapy

Indication	Number in model	Fractionation in 2004	Fractions required in 2004	Number in 2015 (29% increase)	Fractionation in 2015	Fractions required in 2015
Operable short course radiotherapy	936	5	4680	1207	5	6035
Locally advanced Chemoradiation	81	25	2025	104	25	2600
Local palliation	27	10	270	35	10	350
Palliation to metastases	5	1-5	5-25	6	1	6
Total	1049 (88.7%)		6980-7000			8991

Table G6: Fractions required for optimal radiotherapy utilisation where no pre-operative radiotherapy is indicated

Indication	Number in model	Fractionation in 2004	Fractions required in 2004	Number in 2015 (29% increase)	Fractionation in 2015	Fractions required in 2015
Post-operative radiotherapy	216	20-25	4320-5400	279	25	6975
Locally advanced Chemoradiation	81	25	2025	104	25	2600
Local palliation	27	10	270	35	10	350
Palliation to metastases	5	1-5	5-25	6	1	6
Total	329 (27.8%)		6620-7720			9931

OPTIMAL RADIOTHERAPY UTILISATION FOR COLON CANCER

Colon Cancer 2072 incident cases per annum 1996-2000	Duke's A-C 0.77 ¹ 1595	Resection clear margin 0.88 ²		No radiotherapy 1404
		Resection local invasion 0.12 ^{2,3}		Post operative radiotherapy 191-0 ³
	Duke's D 0.23 ¹ 477	No focal symptoms 0.97 ²		No radiotherapy 462
		Brain metastases 0.01 ² 5		Palliative radiotherapy 5
		Bone metastases 0.02 ² 10		Palliative radiotherapy 10

¹ SCAN Colorectal audit 2002

² from Australian model

³ In Scotland, post-operative radiotherapy after colon cancer is rarely used except for caecal tumours, no cases received post-operative RT246 in 2002 audit.

Fractions required for optimal radiotherapy utilisation for colon cancer

	Number in model	Current fractionation	Fractions required in 2004	Number in 2015 (29% increase)	Fractionation 2015	Fractions required in 2015
Post- operative radiotherapy	0-191	20-25	0-4775	0-246	25	0-6150
Palliative radiotherapy brain	5	5	25	6	5	30
Palliative radiotherapy bone	10	1-5	10-50	13	1-5	13-65
Total	15-206 (0.7- 9.9%)		35-4850			43-6245

Breast Cancer

SUMMARY

Radiotherapy indication for breast cancer is 70%. The range of fractions required 2011 - 2015 to optimally treat the future incident population with an indication for radiotherapy is 40,290 – 66,090 fractions.

Breast Cancer

Breast cancer is the most commonly occurring cancer in women accounting for 27.4% of all female cancers. An average of 3550 cancers were diagnosed per annum in Scotland, 1996 – 2000. In 2003 there were 1,138 deaths from breast cancer. Mortality fell by 18.8% over the 10-year period from 1993 to 2002 (estimated by Poisson regression).

The incidence of breast cancer is projected to increase by 23.4% between now and 2011 – 2015 to an average annual incidence of 4380 cases.

ROLE OF RADIOTHERAPY IN BREAST CANCER

Radiotherapy has a key role in the treatment of breast cancer. COIN guidelines for the non-surgical management of breast cancer recommend the following role for radiotherapy:

RADIOTHERAPY	Recommendation
Primary	Surgery remains the mainstay for most patients with operable breast cancer and primary radical radiotherapy is only recommended when other methods have failed or are not possible.
Chest wall	XRT should be given to the chest wall after mastectomy in patients considered to be at high risk of local recurrence.
Adjuvant	Radiotherapy after breast conserving surgery significantly reduces the risk of local recurrence and should normally be given. Radiotherapy to the breast should normally be given after wide local excision of invasive breast cancer
Breast Boost	After complete local excision, there is uncertainty regarding the need for breast boost radiotherapy. Results of EORTC trial awaited.
Axillary	After axillary clearance the axilla should not normally be irradiated unless there is evidence of extracapsular extension into the axillary fat. After axillary sampling the axilla should only be irradiated if node positive, and further surgical dissection is not possible.

Internationally there is a trend towards increasing utilisation of radiotherapy in the management of breast cancer. Dewar *et al.* (1999) reported on changes in treatment and workload in the years 1987 and 1993 reporting that the use of postoperative radiotherapy increased by 72% (from 34% to 49%).

If intra-operative therapy proves to be as effective as external beam radiotherapy then it will have a marked impact on the demand for radiotherapy services. The extent to which this treatment will be used is unclear, but if all T1N0 patients are eligible then 23 % of all breast cancer patients will be suitable for intra-operative therapy.

CURRENT RADIOTHERAPY UTILISATION

POPULATION BASED STUDIES

Sweden

In the 12-week prospective audit performed in Sweden in 2001, 81% of the cases of breast cancer received radiotherapy, and breast treatments accounted for 24% of all treatments delivered. 68% of the breast treat treatments were with curative intent with a median of 25 fractions.

Germany

The initial treatment of 8661 women registered in six German Cancer Registries was examined (Engel 2003) and demonstrated that the rate of breast conservation varied from 39.7% to 57.7% of patients and between 80.6 and 85% of these patients received radiotherapy. Of the women undergoing mastectomy 10.4 to 32.2% had radiotherapy. Between 2.9 and 5.7% of women presented with metastatic cancer.

British Columbia

The management of all breast cancer cases presenting in 1995 was examined by Hislop et al. 2563 cases were identified, but 3% were excluded as diagnosed outside the province, 1% as death certificate only diagnosis and 2% as a synchronous other primary (Hislop 2003). A random sample of 50% of cases was then selected for detailed analysis. In situ carcinoma (DCIS) was present in 13.1%, metastatic disease in 3.5%, 42.8% node negative and 40.6% node-positive invasive cancer. Of the patients with in-situ disease, 14.5% received breast conservation and radiotherapy and the remaining cases were treated either with conservation and no radiotherapy or by mastectomy. Of the patients with metastatic cancer at presentation 22.5% had a mastectomy and 12.5% local excision but only one case (2.5%) had local radiotherapy. Of the cases with invasive non-metastatic cancer 40.4% had breast conservation and radiotherapy, 8.0% conservation but no radiotherapy and 48.3% mastectomy (with or without radiotherapy), 3.3% had no local surgery.

A second study was performed to look at the impact of new trial data on the use of radiotherapy in node-positive cases from 1995 to 2000 (Chua 2004). When two cohorts of patients (cohort 1 1995-1997 and cohort 2 1998-2000) were examined, the rate of breast conservation was 45% in the early group and 48% in the second. In both groups 98% received post-operative radiotherapy. The remaining patients underwent a mastectomy and 50% in the first and 66% in the second cohort received post-operative radiotherapy.

This rate of post-mastectomy radiotherapy in BC will be much higher than that in Scotland; the Canadians perform a Level II clearance and the Scottish surgeons a more radical level III clearance. The role of nodal irradiation following more radical surgery is less firmly established.

Ontario

In a technique identical to that described above for lung cancer, the Kingston team looked at radiotherapy utilisation in Ontario (Foroudi 2003, ASTRO oral presentation). The use of initial radiotherapy was 55.5% (range 54.7-56.2%) with 76.2% (75.7-77%) post-lumpectomy patients receiving radiotherapy and 25.7% (24.6-26.8%) post-mastectomy cases. For the benchmark counties (see above) the rates were higher 63.7%, 84.3% and 36% respectively, the latter rate exceeding the rate predicted in the model (see below).

OPTIMAL RADIOTHERAPY UTILISATION

Ontario

This model suggested that 39.1% of women with in-situ carcinoma should receive radiotherapy, for those with Stage I disease 58.4% should receive radiotherapy in the initial phase with a further 10.2% needing it later (Foroudi 2002). For Stage II disease the figures were 73.2% and 8.2% and Stage III 91.4 and 3.9% respectively. Of the cases presenting with metastatic disease 11.8 should receive immediate radiotherapy with a further 51.9% receiving radiotherapy later. Therefore if 15% of cases present with in situ disease, 42% with Stage I disease, 31.6% Stage II, 6.9% Stage III and 4.3% metastatic disease, a total of 57.3% will need radiotherapy in the initial phase and a further 9.1% later.

Australian

This modelling suggested that 83% of breast cancer cases should receive radiotherapy (Delaney 2003). This figure was based on 13% in situ, 77% Stage I or II, 7% Stage III and 3% Stage IV at presentation. Of the patients presenting with in situ disease two-thirds would be treated with breast-conservation and all would receive radiotherapy. For those women with localised invasive cancer 81% would have breast conservation and all would receive radiotherapy, as would 18% of patients undergoing a mastectomy.

Scotland

Applying the Australian model to a Scottish population, it was concluded that 70.0% of all breast cancer patients have an indication for radiotherapy (Table J7).

TREATMENT/FRACTIONATION FOR BREAST CANCER

It is estimated that between **40,290 and 69,090** fractions of radiotherapy will be required to treat the incident breast cancer population with an indication for radiotherapy 2011 – 2015 (Table J8).

How will fractionation change?

A major Breast Radiotherapy trial (START) has recently completed and is due to report early 2005. This trial considered a reduction in fractions for post-operative adjuvant radiotherapy from 25 to 15. As the result of the trial is yet unknown, both fractionation schedules have been modelled giving a significant range of total fractions that may be required 2011 – 2015.

Another trial (FAST) is currently recruiting and is randomising patients between five and twenty five fractions of radiotherapy. The outcomes under investigation are local control and cosmesis.

Table G7: Optimal radiotherapy use in Breast Cancer

Breast Cancer Average annual incidence Scotland 1996 – 2000 3550	DCIS 0.12 ¹ 426	Mastectomy 0.43 ¹ 183		No radiotherapy 183
		WLE 0.57 ¹ 243		Radiotherapy 243
	Stage I ¹ 0.31 ¹ 1101	Mastectomy ¹ 0.25 ¹ 275	≥ 4 nodes ¹ 0.29 ¹ 80	Radiotherapy 80
			0-3 nodes ¹ 0.71 ¹ 195	No radiotherapy 195
		WLE ¹ 0.75 ¹ 826		Radiotherapy 826
	Stage II ¹ 0.4 ¹ 1420	Mastectomy ¹ 0.52 ¹ 738	≥ 4 nodes 0.29 ¹ 214	Radiotherapy 214
			0-3 nodes 0.71 ¹ 524	No radiotherapy 524
		WLE ¹ 0.48 ¹ 682		Radiotherapy 682
	Stage T3- 4NxM0 or TxN2-3M0 ¹ 0.11 ¹ 391	Good PFS 0.91 ² 355		Radiotherapy 355
		Poor PFS 0.09 ² 35		No radiotherapy 35
	Stage IV ¹ 0.06 ¹ 213	Focal symptoms 0.4 ² 85		Palliative radiotherapy 85
		No focal symptoms 0.6 ² 128		No radiotherapy 128

¹Data from SCAN 2003 breast cancer audit

² Data from Australian report

Table G8: Current and future fractionation requirements for Breast Cancer

	Number in 2001 model	Fractionation in 2004	Fractions required in 2004	Number cases in 2015 (23.37% increase)	Fractionation in 2015	Fractions required in 2015
DCIS & WLE	243	20	4860	300	20	6000
Stage I & WLE	826	20-27	16,520 – 22,302	1019	5-25 ¹	5095 - 25,475
Stage I & mastectomy & ≥ 4 nodes	80	20	1600	99	20	1980
Stage II & WLE	682	20-27	13,640 – 18,414	842	15-25	12,630 – 21,050
Stage II & mastectomy & ≥ 4 nodes	214	20	4280	264	20	5280
Stage T3-4NxM0 or TxN2-3M0 Good PFS	356	20	7120	439	20	8780
Stage IV focal symptoms	85	5	425	105	5	525
TOTAL	2486 (70.0 %)		48,445 – 59,001	3068		40,290 - 69,090

¹ Intra-operative radiotherapy, which is at the early stages of clinical evaluation, may potentially replace external beam radiotherapy for these patients

Urological Cancers

SUMMARY

Optimal radiotherapy indication for prostate cancer is 61.4%. The range of fractions required 2011 – 2015 to optimally treat the future incident population with radiotherapy is 30,930 – 39,426.

Optimal radiotherapy indication for bladder cancer of the is 28.2%. The range of fractions required 2011 – 2015 to optimally treat the future incident population with radiotherapy is 11,005 – 13,025.

Optimal radiotherapy indication for renal cancer is 24.0% The total fractions required 2011 – 2015 to optimally treat the future incident population with radiotherapy is 1060 fractions.

Optimal radiotherapy indication for testicular cancer is 46.0%. The total fractions required 2011-2015 to optimally treat the future incident population with radiotherapy is 0 – 1710 fractions.

Prostate Cancer

An average of 2012 prostate cancers were diagnosed per annum in Scotland, 1996 – 2000. In 2003, prostate cancers were the primary cause of death in 786 men.

The incidence of prostate cancer is projected to increase by 35% between now and 2011 - 2015 to an average annual incidence of 2716.

CURRENT RADIOTHERAPY UTILISATION

POPULATION-BASED STUDIES

Scotland

A retrospective audit of all prostate cancer cases diagnosed in 1988 and 1993 was conducted and demonstrated that 6% of men in the first cohort received radical radiotherapy, and 9% in the second (Howard 1999).

France

The management of all cases diagnosed in 1995 in five French cancer registries was examined by Bauvin *et al.* (Bauvin 2003). Of the 1000 cases identified, 23% presented with T1, 35% T2, 18% T3 or T4 N+ and 17% metastatic disease. The stage was unknown in 7%. 18.2% of patients received radical radiotherapy, 21% radical prostatectomy (3.0% of total cohort with post-operative radiotherapy), 37% hormone treatment and 22.9% 'watchful waiting'. The utilisation of radical radiotherapy varied from 11.7% to 34.2%, with the lowest rate in the area with the highest rate of prostatectomy.

Sweden

In the prospective audit, 51% of cases of prostate cancer received radiotherapy, 45% with curative intent, with the majority of the other treatments delivered to bone metastases. A median number of thirty fractions were delivered when the treatment was with curative intent.

OPTIMAL RADIOTHERAPY UTILISATION

Ontario

The Canadian modelling divided patients into low, medium and high risk (Foroudi 2003). Low risk was defined as PSA ≤ 10 , Gleason score ≤ 6 and T2a or less, high risk was PSA >20 , Gleason score >8 and Stage T3a or greater. For patients with low risk disease, if 31% have a short life expectancy, 25% prefer watchful waiting and 21% undergo prostatectomy then the initial use of radiotherapy would be 23.6% with a further 20.3% receiving radiotherapy later. For medium risk disease if 51% do not receive immediate treatment and 14.5% undergo a prostatectomy then the early use of radiotherapy is 39.6% with a further 29.1% receiving radiotherapy later. For high-risk disease, 33.5% have initial radiotherapy, with the remainder treated with hormones, and a further 45.5% requiring treatment later. Therefore taking the cohort as a whole, 32.2% should receive initial radiotherapy and 29% later.

Australia

The Australian model suggested that 60% of patients should receive radiotherapy.

Scotland

The optimal radiotherapy indication for prostate cancer in Scotland was calculated as 61.4 (Table J9)

Table G9: Optimal radiotherapy use in prostate cancer

Prostate cancer 2012 cases per annum 1996 - 2000	T1-2 N0 M0 0.44 ¹ 885	Good PS .0.78 ² 690	Surgery 0.3 ² (164-218)207	Positive margins 0.35 ² 72	Post-operative radiotherapy 72
				Negative margins 0.65 ² 135	No radiotherapy 135
			Radical radiotherapy 0.50 ² 345		Radical radiotherapy 345
			Observation 0.2 ² 138		No radiotherapy ³ 138
		Poor PS .0.22 ² 195	Observation or hormones 1.0 ² 195		No radiotherapy ³ 195
	T3-4 N0 M0 0.18 ¹ 362	Good PS 0.78 ² 282	Radical radiotherapy 1.00 ² 282		Radical radiotherapy 282
		Poor PFS .0.22 ²	Hormonal therapy 1.00 ² 80		No radiotherapy ³ 80
	Tx N1-2 Mx or Tx Nx M1 0.38 ¹ 765	No focal symptoms Hormone therapy only 0.3 ² 230			No radiotherapy ³ 230
		Focal bone symptoms hormone therapy and palliative radiotherapy 0.7 ² 536			Palliative radiotherapy to bone 536

¹Stage from Scottish data, edited to distribute unstaged

²Data from Australian model

³During initial management, radiotherapy may be required at time of progression

TREATMENT/FRACTIONATION FOR PROSTATE CANCER

Current fractionation for prostate cancer varies considerably across the country and ranges from 20 to 41 fractions. The total fractions required to optimally treat a future population is between 30,930 – 39,426 (Table J10).

Table G10: Current and future optimal fractions required for prostate cancer

	Patient Numbers needing RT in 2001 model	Current fractionation	Fractions required in 2004	Numbers predicted in 2015 (35% increase)	Fractionation in 2015	Fractions required 2015
T1-2N0 post-operative RT	72	20-41	1440 - 2952	97	32-41	3104 - 3977
T1-2N0M0 good PS radical radiotherapy	345	20-41	6900 – 14,145	466	32-41	14,912 – 19,106
T3-4N0M0 good PS radical radiotherapy	282	20-41	5640 – 11,562	381	32-41	12,192 – 15,621
Palliative radiotherapy to metastases	536	1	536	722	1	722
TOTAL	1235(61.4%)		14,516 – 29,195	1666		30,930 – 39,426

Bladder Cancer

An average of 1507 bladder cancers were diagnosed per annum in Scotland, 1996 – 2000. In 2002, bladder cancer was the primary cause of death in 277 men and 180 women.

The incidence of bladder cancer is projected to increase by 22% between now and 2011 - 2015 to an average annual incidence of 1839.

CURRENT RADIOTHERAPY UTILISATION POPULATION-BASED STUDIES

Canada

Two Canadian studies have been published; one from Alberta and the second from Ontario. In the first study of the 285 patients diagnosed with muscle invasive bladder cancer between 1984 and 1993, 26% received radical radiotherapy, 8% post-operative and 2% pre-operative radiotherapy. Whereas in Ontario, of the 20,906 cases of invasive bladder cancer diagnosed between 1982 and 1994, 6.6% received radical radiotherapy.

Sweden

In the Swedish prospective audit, it was estimated that 17% of the cases of bladder cancer received radiotherapy.

OPTIMAL RADIOTHERAPY UTILISATION

Australia

The Australian model suggests that 58% of patients should receive radiotherapy, though the majority of these will be palliative treatment at time of recurrence.

Scotland

For the cancers we have looked at radiotherapy as part of the initial management, this is more complicated for bladder cancer as a number of patients will be managed with local therapy for some months or years before proceeding with radical radiotherapy. Optimal radiotherapy indication for bladder cancer of the was calculated to be 28.2% (Table J11).

POTENTIAL CHANGES TO UTILISATION

Predicting the future of radiotherapy use in the treatment of bladder cancer is made difficult since improving surgical techniques have led some to question the role of radical radiotherapy. Some recent studies suggest that radiotherapy may have a more effective role if given pre-operatively. It is hoped that new studies being considered will clarify the role of radiotherapy.

Table G11: Optimal radiotherapy use in bladder cancer

Bladder cancer 1507 cases per annum 1996 - 2000	Non invasive 0.49 ¹ 739		Local therapy 1.0 ² 739		No radiotherapy ³ 739
	Invasive 0.51 ¹ 769	Stage I 0.46 ² 354	no local recurrence 0.68 ² 241		No radiotherapy 241
			local recurrence 0.32 ² 113	cystectomy 0.52 ² 59	No radiotherapy 59
				not suitable for cystectomy 0.48 ² 54	Radical radiotherapy 54
		Stage II-III 0.38 ² 292	medically operable 0.05 ² 15	cystectomy 15	No radiotherapy 15
			not medically operable 0.95 ² 277		Radical Radiotherapy 277
		Stage IV 0.16 ² 123	symptomatic primary 0.43 ² 53		Palliative radiotherapy 53
			symptomatic metastases 0.34 ² 42		Palliative radiotherapy 42
			no focal symptoms 0.33 ² 41		No radiotherapy 41

¹ From Scottish Cancer Registry

² From Australian model

³ A proportion of these will require radiotherapy at some point when their disease becomes invasive but this may be some years after the initial diagnosis.

TREATMENT/FRACTIONATION FOR BLADDER CANCERS

The range of fractions required 2011 – 2015 to optimally treat the future incident population with radiotherapy is 11,005 – 13,025 (Table J12).

Table G12: Current and future optimal fractions required for bladder cancer

	Number in 2000 model	Fractions in 2004	Fractions required in 2004	Number predicted in 2015 (22.% increase)	Fractionation in 2015 ¹	Fractions required in 2015
Stage I radical radiotherapy	54	20-25	1080 – 1350	66	25-30	1650 – 1980
Stage II-III radical radiotherapy	277	20-25	5540 – 6925	338	25-30	8450 – 10,140
Stage IV local palliative radiotherapy	53	10	530	65	10	650
Stage IV palliative radiotherapy to metastases	42	1-10	42 – 420	51	5	255
TOTAL	426 (28.2%)		7192 - 9225	520		11,005 – 13,025

Renal Cancer

An average of 545 renal cancers were diagnosed per annum in Scotland, 1996 – 2000. In 2002, renal cancer was the primary cause of death in 166 men and 128 women.

The incidence of renal cancer is projected to increase by 50.8% between now and 2011 - 2015 to an average annual incidence of 822.

CURRENT RADIOTHERAPY UTILISATION

POPULATION-BASED STUDIES

No specific population-based studies could be identified, though in the Swedish prospective audit 63% of cases received radiotherapy. This possibly reflects multiple courses of palliative radiotherapy in long-term survivors.

OPTIMAL RADIOTHERAPY UTILISATION

Australia

In the Australian model, it was estimated that 28% of cases should receive radiotherapy, with 17% receiving radiotherapy as part of their initial management.

Scotland

Optimal radiotherapy indication for renal cancer was calculated as 24.0% (Table J13).

Table G13: Optimal radiotherapy use in renal cancer

Renal cancer cases average 1996-2000 545	Non metastatic 0.55 ¹ 300	Suitable for surgery 0.98 ² 294	No radiotherapy ³ 294
		Not suitable for surgery 0.02 ² 6	Palliative radiotherapy 6
	Metastatic 0.45 ¹ 245	Symptomatic primary 0.01 ² 3	Palliative radiotherapy 3
		Symptomatic metastases 0.5 ² 122	Palliative radiotherapy 122
		No focal symptoms 0.49 ² 120	No radiotherapy 120

¹ From Scottish National SAGO audit

² Figures from Australian model

³ Occasionally some patients receive post-operative radiotherapy to tumour bed.

TREATMENT/FRACTIONATION FOR RENAL CANCER

The total fractions required 2011 – 2015 to optimally treat the future incident population with radiotherapy is 1060 fractions (Table J14).

Table G14: Current and future optimal fractions required for renal cancer

	Number in 2000 model	Fractionation in 2004	Fractions needed in 2004	Predicted number in 2015 (50.8% increase)	Fractionation in 2015	Fractions needed in 2015
Palliative radiotherapy to primary	9	10	90	14	10	140
Palliative radiotherapy to metastases	122	1-10	122-1220	184	5	920
Total	131 (24%)		212-1310			1060

Testicular Cancer

An average of 195 testicular cancers were diagnosed per annum in Scotland, 1996 – 2000. In 2003, testicular cancer was the primary cause of death in 13 men.

The incidence of renal cancer is projected to increase by 35% between now and 2011 - 2015 to an average annual incidence of 263.

CURRENT RADIOTHERAPY UTILISATION

POPULATION-BASED STUDIES

In the Swedish audit 48% of patients received radiotherapy, 92% with curative intent.

OPTIMAL RADIOTHERAPY UTILISATION

Australia

In the Australian model 49% of patients should receive radiotherapy

Scotland

In Scotland it is still standard practice for all patients with Stage I seminoma to be offered radiotherapy. This may however change with the publication of preliminary results of a trial suggesting that a short course of chemotherapy may be equally effective.

Based on the Australian distribution of pathological types and stage if adjuvant radiotherapy for seminoma is no longer indicated the optimal radiotherapy rate would drop from 46% to 1%, with only a few patients would require radiotherapy to residual disease following chemotherapy or palliative radiotherapy for brain metastases.

TREATMENT/FRACTIONATION FOR TESTICULAR CANCER

The current fractionation for adjuvant treatment is 15 fractions, and based on this 1350 fractions are currently required for testicular cancer. With the increase in patients by 2015, if adjuvant radiotherapy is still used then 1830 fractions will be required. However if only palliative radiotherapy is used, with an average of 5 fractions per course then only 15 fractions would be needed.

Testicular cancer 195 cases per annum 1996 - 2000	Seminoma 0.56 ¹ 109	Stage I 0.83 ¹ 90		Adjuvant radiotherapy 90 (0 ²)
		Stage II-III 0.16 ¹ 17		No radiotherapy 17
		Stage IV 0.01 ¹ 1	Brain metastases 0.06	Palliative radiotherapy 0
			No brain metastases 0.94	No radiotherapy 1
	Non seminomatous tumours 0.44 ¹¹ 86	Stage I-III 0.99 ¹		No radiotherapy 85
		Stage IV 0.01 ¹ 1	Brain metastases 0.06	Palliative radiotherapy 0
			No brain metastases 0.94	No radiotherapy 1

¹ From Australian report

² Adjuvant radiotherapy may be replaced by a short course of chemotherapy

Indication	Number from model	Fractionation in 2004	Fractions needed in 2004	Predicted number in 2015 (35% increase)	Fractionation in 2015	Fractions needed in 2015
Adjuvant radiotherapy	90	15	1350	122	0-15	0-1830
Total	90 (46%)		1350			0-1830

Gynaecological Cancers

SUMMARY

Radiotherapy indication for corpus uterine cancer is 46.3%. The range of fractions required 2011 – 2015 to optimally treat the future incident population with radiotherapy is 5810 – 5825.

Radiotherapy indication for cancer of the cervix is 56.0%. The total fractions required 2011 – 2015 to optimally treat the future incident population with radiotherapy is 3185.

Radiotherapy indication for ovarian cancer is 4.0%. The total fractions required 2011 – 2015 to optimally treat the future incident population with radiotherapy is 160 fractions.

Corpus Uteri

An average of 441 cases of corpus uteri cancer of, were diagnosed per annum in Scotland, 1996 – 2000. In 2003 it was the primary cause of death in 96 women.

The incidence of cancer of corpus uteri is projected to increase by 23% between now and 2011 – 2015 to an average annual incidence of 542 cases.

CURRENT RADIOTHERAPY UTILISATION

POPULATION BASED STUDIES

In the 2001 Swedish audit, 64% of cases received radiotherapy, 89% with curative intent. 91% of treatments were combined with surgery. The only other data on utilisation of radiotherapy in endometrial cancer is available on two web-sites. In the SEER database 23% and in NYCRIS in 1999 28% of patients with endometrial cancer received radiotherapy.

OPTIMAL RADIOTHERAPY UTILISATION

Australia

The Australian modelling (Delaney 2004) suggests that 46% of patients should receive radiotherapy.

Scotland

There is some discrepancy in the recommended practice between Australian and Scotland; primarily the use of radical lymphadenectomy. In the UK there is an on-going study (ASTEC) examining this and the role of post-operative radiotherapy. In Scotland few surgeons would routinely perform this operation. In Edinburgh all cases of pathologically confirmed gynaecological cancers from the South East Scotland Cancer Network are discussed in the Multi-disciplinary meeting. In 2001 116 cases of endometrial cancer were discussed, 70.7% received surgery alone, 25.8% surgery and external beam radiotherapy and 3.5% radiotherapy alone.

Optimal radiotherapy indication for corpus uterine cancer was calculated as 46.3% (Table J15).

Table G15: Optimal radiotherapy use in cancer of the corpus uteri

Endometrial cancer average of 441 cases per annum 1996 to 2001	Good performance status 0.95 ¹ 419	Papillary serous type 0.13 ¹ 54	Any stage 54	Post-operative radiotherapy 54		
		Other pathology types 0.87 ¹ 365	Stage I and II 0.85 ² 310	Low risk recurrence 0.7 ³ 217	No radiotherapy 217	
				High risk recurrence 0.3 93	Post-operative radiotherapy 93	
			Stage III 0.09 ² 33		Post-operative or radical radiotherapy 33	
			Stage IV 0.06 ² 22	Focal symptoms 0.11 ⁵ 2	Palliative radiotherapy 2	
		No focal symptoms 0.89 20		No radiotherapy 20		
	Poor performance status 0.05 ^{1,4} 22					Local Palliative radiotherapy 22

¹ Figures from Australian model

² Figures from Edinburgh Cancer Centre Gynaecology Multi-disciplinary Meeting 2001 where all pathologically confirmed cases were discussed

³ Figures from Australian review but in 2001, of the patients discussed in Edinburgh, 22% of Stage I and 24% of Stage II endometrial cancer cases were felt to require external beam radiotherapy. If these figures are substituted then only 69 patients would receive post-operative radiotherapy.

⁴ In Edinburgh 3.5% of cases received RT alone, suggesting poor performance status.

⁵ In Edinburgh 29% of Stage IV receive radiotherapy

TREATMENT/FRACTIONATION FOR CORPUS UTERI

The range if fractions required 2011 – 2015 to optimally treat the future incident population in Scotland with radiotherapy is 5810 – 5825 (Table J16).

Table G16: Current and future optimal fractions required for corpus uteri

Indication for radiotherapy	Number in 2001 model	Fractions used in 2004	Fractions required in 2004	Increase in cases predicted (23% increase)	Fractions predicted in 2015	Fractions required in 2015
Papillary serous type	54	20-25	1080-1350	66	25	1650
High risk stage I or II	93	20-25	1860 - 2325	114	25	2850
Stage III	33	20-25	660-825	41	25	1025
Stage IV focal symptoms	2	5-10	10 - 20	3	5-10	15 – 30
Poor performance any stage	22	10	220	27	10	270
Total	204 (46.3%) ¹		3830 - 4740	251		5810 - 5825

¹ If a 22.2% RT utilisation for Stage I and II is used then optimal use of radiotherapy would be 40.8% and a total of 3510 to 4140 fractions required

Cervix Cancer

An average of 347 cases of cancer of the cervix were diagnosed per annum in Scotland, 1996 – 2000. In 2003 it was the primary cause of death in 120 women.

The incidence of cancer of the cervix projected to decrease by 32.7% between now and 2011 – 2015 to an average annual incidence of 234 cases.

CURRENT RADIOTHERAPY UTILISATION

POPULATION-BASED STUDIES

Netherlands

This study looked at the management of 1176 cases registered in the cancer registries in South-east of The Netherlands between 1986 and 1996 (de Rijke 2002). 20% presented with Stage IA disease, 36% IB, 11% IIA, 12% IIB 10% III, 3% IVA and 4% IVB. The stage was unknown in 3% of cases. 52% of cases were 49-years old or younger, 29% 50-69 and 19% aged 70 or older. The Stage IA patients 87% were treated with surgery, Stage IB and IIA radiotherapy was the sole treatment for 8% of the youngest group, 25% for the 50-69 year olds and 64% for the eldest group. Radiotherapy was combined with surgery for 27,33 and 25% respectively. For the patients with locally advanced disease (IIB-IVA) radiotherapy alone was used for 73% <49 years, 86% 50-69 and 76% aged >70. Some patients in this group did not receive potentially curative therapy (12.5% >70, 6% 50-69, 0% <49). Of the patients with metastatic disease, 69% received some type of anti-cancer therapy.

Sweden

In the audit, 83% of cases received radiotherapy and 89% of treatments were with curative intent. 65.7% of treatments were radical radiotherapy without surgery. The median number of fractions used was 26.

Scotland

In Edinburgh, all pathologically confirmed invasive cervical cancers are discussed at the Gynaecological Multi-disciplinary meeting. In 2001, 74 cases were discussed. Of these 42% received surgery alone, 15% surgery and radiotherapy, 39% radiotherapy alone and 4% no treatment.

OPTIMAL RADIOTHERAPY UTILISATION

Australia

The Australian model predicted that 58% of cervix cancer cases should receive radiotherapy (Delaney 2004). This suggested that 52.9% of patients would undergo surgery, 10.3% radical radiotherapy for Stage I or IIA disease. 16.1% of the surgical patients (8.5% whole cohort) would require post-operative radiotherapy. Of the patient with more advanced disease, the 26% with Stage IIB-IVA disease would all receive radiotherapy as would the 9% with metastatic disease and 1.7% with more localised disease but poor performance status. Therefore 55.5% of patients would require radiotherapy as a component of their initial management and 2.5% later on for recurrent or metastatic disease.

Scotland

Radiotherapy indication for cancer of the cervix was calculated as 56.0% (Table J17).

Table G17: Optimal radiotherapy use in cancer of the cervix

Cervix cancer average annual cases 1996 to 2000 347	Stage IA 0.27 ¹ 94	Surgery only 1.0 ² 94			No radiotherapy 94
	Stage IB or IIA 0.32 ¹ 111	Good performance status 0.95 ² 105	Suitable for surgery 0.69 ² 72	Margins and nodes clear 0.73 ² 53	No radiotherapy 53
				Nodes or margins involved 0.27 ² 19	Post-operative radiotherapy 19
			Not suitable for surgery 0.31 ² 33		Radical radiotherapy 33
		Poor performance status 0.05 ² 6			Radical radiotherapy 6
	Stage IIB-IVA 0.37 ¹ 128				Radical radiotherapy 128
	Stage IVB 0.04 ¹ 14	Focal symptoms 0.67 ¹			Palliative radiotherapy 9
		No focal symptoms 0.33 ¹			No radiotherapy 5

¹ Data from Edinburgh Cancer Centre, 2001.

² Figures from Australian model

TREATMENT/FRACTIONATION FOR CANCER OF THE CERVIX

The total fractions required 2011 – 2015 to optimally treat the future incident population with cancer of the cervix in Scotland is 3185 (Table J18).

Table G18: Current and future optimal fractions required for treatment of cancer of the cervix

Indication for radiotherapy	Number in 2001 model	Fractionation used in 2004	Fractions required in 2004	Number predicted in 2015 (32.7% decrease)	Fractionation used in 2015	Fractions required in 2015
Post-operative Stage I or IIA	19	20-25	380 – 475	13	25	325
Primary radical treatment Stage IIB-IVA	167	20-25	3340 - 4175	1127	25	2800
Palliative radiotherapy Stage IV B	9	10	90	6	10	60
Total	195 (56.1)		3810 – 4740	131		3185

Ovarian Cancer

Though ovarian cancer represents the 10th commonest cancer, there are few indications for radiotherapy. In the past total abdominal radiotherapy was used but with the advent of more effective chemotherapy, radiotherapy is used in the main for palliative treatment of metastasis and involved lymph nodes. The Australian modelling suggests that 4% of ovarian cancer cases will receive radiotherapy. In the five years 1995-2000 there was an average of 635 cases per annum, so with an average of 5 fractions per course radiotherapy for ovarian cancer required 125 fractions per annum. With an increase of 26.4% in the annual incidence then the fractions required in 2015 would be 160.

Vulval and Vaginal cancers

These are rare tumours with an average of 91 vulval and 25 cases of vaginal cancer per annum in Scotland in the five years 1996 to 2001. The Australian model suggests that 34% of vulval and 100% of vaginal cancer should receive radiotherapy. Based on these figures 56 cases should receive radiotherapy. Both cancer sites are generally treated with 25 fractions with, or without chemotherapy. It is unlikely that this fractionation will change, therefore with a 19% increase (using overall increase in incidence of cancer in Scotland) the number of patients requiring radiotherapy in 2015 will be 67 cases and there will be a requirement for 1675 fractions per annum.

Haematological Cancers

SUMMARY

Radiotherapy indication for Non-Hodgkin's Lymphoma is 54.4%. The total fractions required 2011 - 2015 to optimally treat the future incident population with an indication for radiotherapy is 9090 – 12,555 fractions.

Radiotherapy indication for Hodgkin's Lymphoma is 71.4%. The total fractions required 2011 - 2015 to optimally treat the future incident population with an indication for radiotherapy is 1440 fractions.

Radiotherapy indication for Leukaemia is 4%. The total fractions required 2011 - 2015 to optimally treat the future incident population with an indication for radiotherapy is 320 fractions.

Radiotherapy indication for Myeloma 33.1%. The total fractions required 2011 - 2015 to optimally treat the future incident population with an indication for radiotherapy is 595 fractions.

Non-Hodgkin's Lymphoma

An average of 831 Non-Hodgkin Lymphomas (NHL) were diagnosed per annum in Scotland, 1996 – 2000. In 2003, it was the primary cause of death in 206 men and 211 women.

The incidence of Non-Hodgkin's Lymphoma is projected to increase by 50.4% to the period 2011 to 2015 with a projected average annual incidence of 1250 cases.

ROLE OF RADIOTHERAPY IN NON-HODGKIN'S LYMPHOMA

Radiotherapy is used in the primary management of localised NHL either as sole modality or in conjunction with chemotherapy. There is also a major role for radiotherapy in the palliation of local symptoms for patients with advanced disease.

CURRENT RADIOTHERAPY UTILISATION

POPULATION BASED STUDIES

Sweden

A Swedish audit reported that 39% of Non-Hodgkin's Lymphoma's received radiotherapy. SEER, NYCRIS and NCDB all report similar radiotherapy utilisation rates of 24-26%.

Australia

The South Australian Cancer Registry reports an actual radiotherapy utilisation rate of only 19% for patients diagnosed with Non-Hodgkin's Lymphoma. A greater proportion of patients diagnosed with high grade NHL (20%) than intermediate (22%) or low grade (12%) received radiotherapy.

OPTIMAL RADIOTHERAPY UTILISATION

In the Australian model 64% of patients with NHL should be treated with radiotherapy. The indications included radiotherapy for high-grade lymphoma and stage 3-4 intermediate grade lymphomas with bulk disease. These indications are not commonly followed in Scotland and have therefore been removed from the analysis below (Table J19)

Table G19: Optimal radiotherapy use in Non-Hodgkin's Lymphoma

NHL average number of cases 1996- 2000 831	Low grade 0.37 ¹ 308	Not suitable for radiotherapy 0.56 ² 172			No radiotherapy 172
		Suitable for Radiotherapy 0.44 ² 136			Radiotherapy 136
	Intermediate grade 0.58 ¹ 482	Stage I-II 0.54 ² 260			Radiotherapy 260
		Stage III-IV 0.46 ² 222	Complete response to chemotherapy 0.44 ² 103 98		No radiotherapy 98
			Incomplete response 0.56 ² 124	Age <70 0.59 ² 73	No radiotherapy 73
				Age >70 0.41 ² 51	Radiotherapy 51
	High grade 0.04 ¹ 33				No radiotherapy 33
	Mycosis fungoides 0.01 ¹ 8	Stage I-II 0.65 ² 5	Complete response to topical treatments/PUVA 0.66 ² 3		No radiotherapy 3
			Incomplete response 0.34 ² 2		Radiotherapy 2
		Stage III-IV 0.35 ² 3			

¹ Figures from SCAN and WOSCAN 2002

² Figures taken from Australian model

TREATMENT/FRACTIONATION FOR NON-HODGKIN'S LYMPHOMA

It is estimated as between 10305-12505 fractions of radiotherapy will be required to treat the incident NHL population with an indication for radiotherapy 2011 – 2015.

How will fractionation change?

Current radiation dose for high grade and low grade NHL is 30-40Gy in 15-20#. High grade NHL is much more common and tends to receive 40Gy. A current British trial (BNLI) is looking at reducing dose for low-grade lymphomas from 40Gy/20# to 15 fractions. As the results of this trial are unknown, both fractionation schedules have been modelled.

Table G20: Current and future optimal fractions required for NHL

Indication	Number in 2000 model	Fractionation in 2004	Fractions required in 2004	Predicted number in 2015 (50.4% increase)	Fractionation in 2015	Fractions required in 2015
Low grade suitable for RT	136	5-20	2040-2720	205	10-15	2050 - 3075
Stage I-II intermediate grade	260	15-20	3900-5200	391	15-20	5865 - 7820
Stage III-IV incomplete response aged >70	51	15-20	765-1020	77	15-20	1155-1540
Mycoses Stage I-II incomplete response to topical therapy	2	15-20 (total skin electrons)	30-40	3	15	45
Mycoses Stage III-IV	3	15-20 (total skin electrons)	45-60	5	15	75
Total	452 (54.4%)		6780-9040	681		9090 – 12,555

Hodgkin's Disease

An average of 125 Hodgkin's Disease were diagnosed per annum in Scotland, 1996 – 2000. In 2003, it was the primary cause of death in 12 men and 10 women.

The incidence of Hodgkin's Disease is projected to increase by 6.8% to the period 2011 to 2015 with a projected average annual incidence of 134 cases.

ROLE OF RADIOTHERAPY IN HODGKIN'S DISEASE

Currently radiotherapy is recommended for stage 1-2a disease with radical intent. Dose and fractionation is between 35-30Gy in 15-20 fractions depending on whether combined modality treatment is used. A current trial is addressing the use of PET with chemotherapy in this group of patients to see if radiotherapy can be omitted but this has only just started and therefore the impact on radiotherapy services is uncertain until this trial reports.

In advanced stage Hodgkin's, radiotherapy is indicated on completion of chemotherapy for 'bulk' disease or to treat residual masses evident from CT. The first indication has not been common practice in the UK, although is standard in other parts of the world. The second indication is likely to reduce RT usage if PET scanning confirms negative after chemotherapy.

CURRENT RADIOTHERAPY UTILISATION

POPULATION BASED STUDIES

Sweden

In the Swedish prospective audit, 47% were treated with radiotherapy and in the USA, the SEER 44-48% of patients were treated with radiotherapy. The South Australian Cancer Registry reports on utilisation rates for the population treated as part of their primary course of care. It reports that 47% of patients diagnosed with Hodgkin's Disease were treated with radiotherapy. Only 55% of patients with stage 1-2 were treated with radiotherapy.

North Yorkshire

NYCRIS report that 44-48% are treated with radiotherapy.

OPTIMAL RADIOTHERAPY UTILISATION

Australia

The Australian model suggests that 75% of patients diagnosed with lymphoma should receive radiotherapy. It includes all patients diagnosed with early stage Hodgkin's Disease. The NCDB only report on actual utilisation for patients treated with stage I-II Hodgkin's Disease, only 78% of patients with stage I-II disease are treated with radiotherapy.

Table G21: Optimal radiotherapy use for Hodgkin's Disease

Hodgkin's lymphoma 126 cases per annum 1996-2000	Stage I and IIA 0.45 ¹			Radiotherapy 57
	Stage IIB-IV 0.55 ¹ 69	Bulky disease 0.4 ¹ 28		Radiotherapy ³ 28
		Non bulky disease 0.6 ¹ 41	Complete response 0.89 ^{1,2} 36	No radiotherapy 36
			Not complete response 0.11 ^{1,2} 5	Radiotherapy 5

¹ Figures from Australian model

² After standard treatment or if necessary high dose chemotherapy

³ These patients may not require radiotherapy if the PET trial is positive

TREATMENT/FRACTIONATION FOR HODGKIN'S LYMPHOMA

It is estimated **1425** fractions of radiotherapy will be required to treat Hodgkin's patients with an indication for radiotherapy 2011 – 2015 (Table J22).

Table G22: Current and future optimal fractions required for HD

Indication	Number in 2000 model	Fractionation in 2004	Fractions required in 2004	Number predicted in 2015 (6.8% increase)	Fractionation in 2015	Fractions required in 2015
Stage I- IIA	57	15-20	855 - 1140	61	15	915
Bulky Stage II- IV	28	15-20	420-560	30	15	450
Stage II- IV non bulky not complete response	5	15-20	75-100	5	15	75
Total	90 (71.4%)		1350 - 1800	96		1440

Leukaemia

An average of 599 leukaemias were diagnosed per annum in Scotland, 1996 – 2000. In 2003, it was the primary cause of death in 190 men and 177 women.

The incidence of Leukaemia is projected to increase by 32% to the period 2011 to 2015 with a projected average annual incidence of 791 cases.

ROLE OF RADIOTHERAPY IN LEUKAEMIA

Radiotherapy is only used for total body irradiation (TBI) for the preparation for bone-marrow transplant or for treatment of relapses in ‘sanctuary sites’ (brain and testes) therefore the Australian modelling suggested that only 4% of leukaemia patients required radiotherapy. In the Swedish audit, 8% of patients received radiotherapy.

In the years 1996-2000 there were 599 cases per annum, so based on a 4% radiotherapy utilisation 24 patients would require radiotherapy. Fractionation schedules vary but taking an average of 10 fractions, 240 are required per annum. However, it should be noted that TBI is a very complicated treatment and takes about four times as long per fraction as a normal radiotherapy treatment.

Of the projected 791 projected patients per annum 2011 -2015, it is estimated that 32 patients will require radiotherapy with a total of 320 fractions.

Myeloma

In 2001 306 myeloms were diagnosed in Scotland. In 2003, it was the primary cause of death in 105 men and 127 women.

ROLE OF RADIOTHERAPY IN MYELOMA

Generally radiotherapy is used for palliation of bone metastases, with patients sometimes requiring repeated treatments.

CURRENT RADIOTHERAPY UTILISATION

POPULATION BASED STUDIES

Sweden

A Swedish audit reported that 106 patients received radiotherapy, which would have represented 82% of the new cases diagnosed during this time but in reality probably reflects re-treatment of previously diagnosed patients.

OPTIMAL RADIOTHERAPY UTILISATION

Australia

In the Australian model 385 of patients required radiotherapy, 33% within the initial phases of their treatment.

TREATMENT/FRACTIONATION FOR MYELOMA

It is estimated **595** fractions of radiotherapy will be required to treat the incident myeloma population with an indication for radiotherapy 2011 – 2015.

For this document we have looked at the radiotherapy requirement during the initial phase of cancer management therefore, for an average of 303 patients per annum for 1996-2000, 100 would require radiotherapy during this time. With an average of 5 fractions per course myeloma treatment requires 500 fractions per annum. The increase in myeloma has not been specifically modelled by with a general increase in 19% of all cancers, the numbers should increase to 360 by 2015 and consequently 119 patients will require radiotherapy using 595 fractions.

Head & Neck

SUMMARY

Radiotherapy indication for head and neck cancers is 78.6%. The total fractions required 2011 - 2015 to optimally treat the future incident population with an indication for radiotherapy is 34,370 fractions.

Head & Neck

An average of 1000 head and neck cancers were diagnosed per annum in Scotland, 1996 – 2000. Incidence is higher in males than in females. In 2003, head and neck cancers were the primary cause of death in 252 men and 113 women.

The incidence of head and neck cancers is projected to increase by 24.9% between now and 2011 - 2015 to an average annual incidence of 1249.

ROLE OF RADIOTHERAPY

Radiotherapy plays a key role in the treatment and cure of many head and neck tumours and is also a very effective treatment for palliation of symptoms in advanced disease. The recent Scottish Audit of Head and Neck Cancers 1999 - 2002, reported that 91.6% of radiotherapy head and neck patients recorded in the audit were treated radically and 7.4% were treated palliatively.

In recent years, a number of clinical trials have suggested that hyper-fractionation and treatment acceleration leads to better results than those achieved through conventional fractionation. The strategy for combining modified fractionation with chemotherapy remains inadequately tested but 'conventional' fractionation alone can no longer be regarded as 'state of the art' except, perhaps, for very early tumours.

Furthermore, it is anticipated that sophisticated CT planning, conformal radiotherapy and IMRT will be used in nearly all radical treatments 2011 -2015. MRI is seen as essential and MRI/CT Fusion necessary for all oropharyngeal, hypopharyngeal, nasopharyngeal and sinus tumours.

Some early (T1) laryngeal tumours are in the future likely to be amenable to surgery alone. At present they receive short fractionation external beam radiotherapy.

CURRENT RADIOTHERAPY UTILISATION

POPULATION-BASED STUDIES

Sweden

All patients with larynx, nasopharynx, sinus and oropharynx cancers received radiotherapy; 94% of oral cavity, 60% salivary gland, 39% hypopharynx, 22% lip cancers. Ninety percent of head and neck treatments were delivered with curative intent and of these 42% were combined with surgery. The median number of fractions per course was 34.

Ontario and SEER

Groome et al (2001) looked at the management of 3295 cases of glottic cancer diagnosed in Ontario, Canada 1982-1995 and 3921 diagnosed in the SEER regions (USA) from 1988-1994. Eight one percent in Ontario and 85% in SEER had localised disease. There were more T1 cases in the SEER regions (69.1%) versus 56.4% in Ontario. In Canada, 6.7% underwent surgery without radiotherapy and 26.7% surgery and post-operative radiotherapy. In comparison, the SEER figures reported 19.3% for surgery alone and 38.5% for surgery with post-operative radiotherapy. In Ontario, 57.4% received radiotherapy alone and 35.6% from the SEER database.

Scotland

The Scottish Audit of Head and Neck Cancers 1999 -2002, reported a 64% radiotherapy utilisation rate for head and neck cancers in Scotland. The Scottish Cancer registry reported a 55.3 radiotherapy utilisation rate.

Five radical radiotherapy treatment schedules were in use across Scotland (1999 -2002) ranging from 50Gy in 20# to 66Gy in 33#. Management to compensate for gaps in treatment was poor.

OPTIMAL RADIOTHERAPY UTILISATION

Australia

The Australian model suggests that 78% of head and neck patients should receive radiotherapy.

Scotland

Applying Scottish data to the model, it was determined that radiotherapy is indicated in 78.6% of all head and neck cancers as part of the initial management of disease (66% of oral cavity, 92% Larynx, 95% Oropharynx, 95% hypopharynx and 100% nasopharynx). See table J23.

TREATMENT/FRACTIONATION FOR HEAD AND NECK CANCERS

Based on 1996 - 2000 incident population 26,724 fractions would be required in 2004 to treat those head and neck patients with an indication for radiotherapy using current optimal radiotherapy. Applying the projected 24.9% increase in incidence of head and neck cancer to 2011 – 2015, a calculated 34,370 fractions of radiotherapy will be required to treat the incident head and neck cancer population with an indication for radiotherapy. This accommodates for proposed increased fractionation for most sites and clinical scenarios (Table J24).

G23: Optimal radiotherapy use for Head and Neck Cancers

Head and Neck cancer <

¹Data from CRAG audit

² Data from SCAN 2003 head and neck audit

³ Data from Australian publication

Table G24: Current and future optimal fractions required for Head and Neck Cancers

	Numbers in 2000 model	Current fractionation	Fractions required in 2004	Predicted numbers in 2015 (24.9% increase)	Fractionation in 2015	Fractions required in 2015
Oral cavity Stage I-II primary radical / post-operative radiotherapy	39	34	1326	49	35	1715
Oral cavity Stage III- IV Radical /Post op radiotherapy	159	34	5406	199	35	6965
Stage I and II larynx radical / post-op radiotherapy	165	34	5610	206	35	7210
Stage III and IV larynx radical /post- operative radiotherapy	130	34	4420	162	35	5670
Oropharynx Radical /post op radiotherapy	143	34	4862	179	35	6265
Hypopharynx Radical /post op radiotherapy	57	34	1938	71	35	2485
Nasopharynx Radical radiotherapy	20	34	680	25	35	875
Unknown primary Radical radiotherapy	7	34	238	9	35	315
Sinus Radical radiotherapy	21	34	714	26	35	910
Lip Radical radiotherapy	24	34	816	30	35	1050
Salivary gland Post-operative radiotherapy	12	34	408	15	35	525
Salivary gland Radical radiotherapy	9	34	306	11	35	385
Total	786 (78.6%)		26,724	982		34,370

Lung Cancer

SUMMARY

Radiotherapy indication for lung cancer is 62.8%. The range of fractions required 2011 - 2015 to optimally treat the future incident population with an indication for radiotherapy is – between 34,698 and 41,382 fractions.

Lung Cancer

An average of 4671 lung cancers were diagnosed per annum in Scotland, 1996 - 2000. The incidence of lung cancer in men has been falling over the last ten-year period but has been increasing in women. In 2003, it was the primary cause of death in 2186 men and 1707 women in Scotland.

The incidence of lung cancer is projected to decrease by 9.6% to the period 2011 to 2015 with a projected average annual incidence of 4224 cases.

ROLE OF RADIOTHERAPY

Radiotherapy plays a significant role in the treatment of lung cancer. Survival from lung cancer remains poor and given the relatively high incidence, there is a national priority to improve outcome. Radiation dose escalation either by means of altered fractionation (e.g. CHART) or through increased radio-sensitisation using concurrent chemotherapy, provide opportunities to improve outcome. Currently few departments have the capacity or workforce to support the delivery of hyper-fractionated regimes, such as CHART.

The role of radiotherapy in the treatment and management of lung cancer is expected to change considerably over the next ten year period. Recent data on adjuvant chemotherapy for post-operative patients makes the role of radiotherapy in this group even more uncertain. Therefore, patients with incompletely resected disease are likely to continue to receive treatment but those with positive mediastinal nodes may just receive chemotherapy.

It is anticipated that a significant proportion (20 – 50%) of patients receiving radical or post-operative radiotherapy could also benefit from more complex techniques such as gating and IMRT.

Given the changing possibilities of radiotherapy use, a number of clinical scenarios were identified where the use of the radiotherapy is likely to increase. These include:

- Stage 1 and II – patients with poor lung function will increasingly be offered radical radiotherapy – either 20 or 36 fractions or hypo-fractionated stereotactic radiotherapy.
- Stage IIIB NSCLC –currently treated with chemotherapy or high dose palliative treatment will increasingly be treated radically with chemo-radiation with up to 36 fractions
- PCI for Stage III adenocarcinomas patients (10 fractions)
- Extensive stage small cell – increasing use of consolidation radiotherapy and PCI (total of 35 fractions (25 chest and 10 head))
- Mesothelioma - post-operative radiotherapy following extra-pleural pneumonectomy (30-35 fractions with IMRT)

CURRENT RADIOTHERAPY UTILISATION

Scotland

An audit was performed of all patients diagnosed with lung cancer in 1995 (Gregor 2001, Erridge 2002). Of the 4465 cases on the cancer registry, information on management could be identified on 3855. Of these patients, 37.7% received radiotherapy within the first six-months of diagnosis and 2.7% of the cohort received radiotherapy with a potentially curative dose. Of the patients with confirmed NSCLC 40.3% received thoracic radiotherapy, 18.4% those with confirmed SCLC and 20.7% with a clinical only diagnosis.

Other United Kingdom studies

i) Cartman and colleagues examined the management of patients entered into the Yorkshire Cancer Registry between 1986 and 1994 (Cartman 2001). Only 49.4% of all cases received any active therapy, with radiotherapy delivered to 35.9% of all lung cancers. This rate varied greatly between the districts (21.9 to 42.6%). Of the cases with confirmed NSCLC 44.8% received radiotherapy and 28.3% of SCLC cases.

ii) A similar analysis was performed of Thames Cancer Registry lung cancer cases from 1995-1999 (Jack 2003). In this study 40,540 patients were identified and after 'death certificate only' cases were excluded, the variation of treatment across 26 health boards was examined. The rate of any active treatment varied from 15-42% with the radiotherapy utilisation rate varying from 8-30% of cases.

European studies

i) In 2001, a twelve-week prospective audit of radiotherapy was conducted in Sweden (Moller 2001), which demonstrated that 71% of the expected cohort of lung cancer patients received radiotherapy, 25% of cases with curative intent. Half of the 480 treatments were delivered to the thorax and the rest to metastases, primarily in bone (56% of metastases treated). The median number of fractions to the primary was 20 with a range of 1-65. The dose delivered ranged from 10-65Gy with a median dose of 44Gy.

ii) The use of radiotherapy in Ireland was examined by Mahmud et al identified 7286 cases recorded from 1994-1998 in the National Cancer Registry (Mahmud 2003). Of the 7218 on whom data could be obtained, 51.4% received any treatment and 26.6% radiotherapy.

iii) The variations in treatment between three regions of France demonstrated that 50.9% received radiotherapy but the rate varied from 73% to 39.5% (Grosclaude 1995).

North America

i) The Queen's Cancer research Institute in Kingston Ontario performed an analysis of the use of radiotherapy for lung cancer in Ontario and the SEER regions of USA between 1992 and 1996 (Barbera 2003). SEER registries collect data from fifteen regions of US with representative population. 80.3% of the population had microscopically confirmed lung cancer in Ontario compared with 91.7% of the SEER cases. The ratio of NSCLC:SCLC was 83:17 in both cohorts. The radiotherapy utilisation in the initial phase of the diagnosis (up to one year) in Ontario was 32.5% with 39.9% of the confirmed NSCLC receiving radiotherapy and 40.3% of the SCLC cases. The rate between the different counties with the 'benchmark regions', defined as those with radiotherapy centres without large waiting lists in close proximity and a fully functioning multi-disciplinary lung cancer team. In these benchmark communities the radiotherapy utilisation rate was 41.3%, pathologically confirmed NSCLC

49.3% and SCLC 47%, which compared favourably with evidence-based estimates (see below).

The SEER data demonstrated a radiotherapy utilisation of 44.2%, 48.1% for NSCLC and 42.2% for SCLC. In fact, many of the US regions had radiotherapy rates higher than the evidence based estimate (maximum 62%)

ii) The management of lung cancer in British Columbia in 1995 demonstrated that of the 2080 patients, 33% received no treatment. Of the patients with pathologically confirmed NSCLC or no pathological confirmation 4.9% received radiotherapy with curative intent and 33.1% palliative radiotherapy (Erridge oral presentation WLCC 2003) and 33.1% of SCLC cases (Laskin 2004).

Australia

i) Richardson et al looked at the management of all lung cancer patients diagnosed in the state Victoria in 1993. Of the 868 patients (82% eligible cases) 44% of patients received radiotherapy

ii) Vinod et al, looked at the patterns of care of patients diagnosed with lung cancer in New South Wales in 1993 and 1996 (Vinod 2003). They found 56% of patients received radiotherapy

OPTIMAL RADIOTHERAPY UTILISATION

Ontario

Tyldesley et al modelled the need for radiotherapy for lung cancer (Tyldesley 2001). Using published guidelines they identified 16 indications for radiotherapy in the initial phase of management and 8 at later stages. Using data from the Ontario Cancer registry and the SEER registries they estimated the number of patients in each treatment group. Though information on stage could be obtained they used data on the distribution of performance status from a cohort of patients in Southend (Brown 1996). They estimated that 45.9% of patients with NSCLC needed radiotherapy in the initial phase of their illness (defined as first four months) and 18.3% later, for those cases with SCLC 45.4% and 8.2% later.

Australia

The Australian model estimated that 76% of lung cancer cases should receive radiotherapy. Though the algorithm is similar to the standard management in Scotland, the percentage of patients with good performance status is higher than a Scottish population, for example for Stage I or II NSCLC, they estimate that 90% would undergo potentially curative therapy (surgery or radiotherapy), in the 1995 Scottish audit only 44.1% of patients with localised disease were treated with curative intent.

Scotland

Applying the Australian model to a Scottish population, it was concluded that 62.8% of all lung cancer have an indication for radiotherapy (Table J25).

TREATMENT/FRACTIONATION FOR LUNG CANCER

It is estimated that between **34,698** and **40,667** fractions of radiotherapy will be required to treat the incident lung cancer population with an indication for radiotherapy optimally 2011 – 2015 (Table J26).

How will fractionation change?

1) Radical Radiotherapy for Stage 1 and II – there were a wide range of opinions on how the fractionation would change, some consultants feeling the fractionation would increase from 20 to either hyper-fractionated or a longer daily fractionation of up to 35 fractions. Whereas others felt that CHART would no longer be used. Exactly how the fractionation will alter depends on the result of on-going trial of radiosensitizers with 20 fractions (GRIN) and the dose escalation studies, which are using 39 fractions (with 9 fractions twice-daily). At the other end of the scale, the other option is stereotactic radiotherapy using up to five fractions.

2) Radical radiotherapy for Stage III (with or without chemotherapy) – similarly there were a wide range of opinions in the change in fractionation, which depends on the results of on-going trials. Some felt more fractions would be used, up to 36, maybe with hyper-fractionation, whereas others felt the number would reduce, for example to 24 which was used in an EORTC chemo-radiation study.

3) Post-operative radiotherapy – all consultants felt that if this continues, it was likely to become chemo-radiation with more protracted fractionation of 25-28 fractions.

4) Limited stage SCLC – all consultants felt that this was likely to change, either to a hyper-fractionated technique of 35 fractions twice daily or increase to 25 fractions once-daily.

What patients will be treated with a more sophisticated technique?

1) All consultants felt that IMRT would be used to treat NSCLC in difficult locations (up to 40% patients) e.g. para-spinal, Pancoast's, limited stage SCLC receiving concurrent chemoradiation (up to 50%) and also post-operative treatment of mesothelioma.

2) Some form of system to allow for respiratory movement (4D or gating) will be used on patients with Stage 1 and II and for some stage III patients

3) T1N0 may be treated with extra-cranial stereotactic using hypo-fractionated schedule

4) CT –PET fusion will be used to plan all radical patients.

Table G25 Application of Scottish Data to Australian Model for Lung Cancer

LUNG CANCER	Small cell 0.13 ¹ 607	Limited stage 0.52 ¹ 316	Good PFS 0.67 ² 212			Radiotherapy to chest and PCI 212
			Poor PFS 0.33 ² 104			No radiotherapy 104
		Extensive stage 0.48 ¹ 291	Good PFS 0.67 ² 195	Focal symptoms requiring radiotherapy 0.81 ³ 158		Palliative radiotherapy 158
				No focal symptoms 0.19 ³ 37		No radiotherapy 37
			Poor PFS 0.33 ² 96			No radiotherapy 96
		Non small cell 0.87 ¹ 4064	Stage 1- II 0.38 ¹ 1544	Good PFS 0.66 ¹ 1019	Surgery 0.68 ³ 693	Involved margins 0.02 ³ 14
	Clear margins 0.98 ³ 679					No radiotherapy 679
	No surgery 0.32 ³ 326				Radical radiotherapy 326	
	Poor PFS 0.34 ¹ 525			Local symptoms 0.64 ⁴ 336		Palliative radiotherapy 336
				No local symptoms 0.36 ⁴ 159		No radiotherapy 189
	Stage IIIA 0.13 ^{1,3} 528			Good PFS 0.33 ¹ 174	Surgery 0.22 ³ 38	N0/1 0.67 ³ 26
			N>1 or positive margins 0.68 ³ 13			Post operative radiotherapy 13
			No surgery 0.78 ³ 136		Radical radiotherapy 136	
			Poor PFS 0.67 ¹ 354	Local symptoms 0.64 ⁴ 227		Palliative radiotherapy 227
				No local symptoms 0.36 ⁴ 127		No radiotherapy 127
			Stage IIIB ^{1,3} 0.16 650	Good PFS 0.33 ¹ 215		
	Poor PFS 0.67 ¹ 434			Local symptoms 0.64 ⁴ 279		Palliative radiotherapy 279
				No local symptoms 0.36 ⁴ 155		No radiotherapy 155
	Stage IV 0.33 ¹ 1341		Focal Symptoms requiring radiotherapy 0.76 ⁴ 1019			Palliative radiotherapy 1019
			No focal symptoms 0.24 ⁴ 322			No radiotherapy 322

¹ Data from 1995 Scottish National Lung Cancer Audit (Gregor 2001, Erridge 2002)

² Data from SCAN audit 2002-2003

³ Data from Australian model

⁴ In Scottish audit 64.1% patients with NSCLC had symptomatic local disease

Table G26: Current and future optimal fractions required for lung cancer

Indication	Number of cases in 2002 model		Fractions required in 2002	Numbers of cases in 2015 (9.6% decrease)	Fractions required in 2015	Fractions required in 2015
Good PFS L-SCLC	212	15-20 +10 (PCI)	3180 – 4240 (2120)	192	25-35 +10 (PCI)	4800 – 6720 (1920)
Good PFS E-SCLC	158	5	790	143	5	715
Stage I-II Post op RT	14	20	280	13	25-28	325 – 364
Stage I-II Good PFS Radical RT	326	36 (CHART)	11736	295	36-39	10620 – 11505
Stage I-II Poor PFS palliative RT	336	1-5	336 – 1680	304	5	1520
Stage III A Post op RT	13	20	260	12	25-28	300 – 336
Stage III A Good PFS Radical RT	136	20-30 ^{1,2}	2720 – 4080	123	24-36	2952 – 4428
Stage IIIA Poor PFS palliative RT	227	1-5	227 - 1135	205	5	1025
Stage IIIB Good PFS radical RT	215	20-30 ^{1,2}	4300 – 6450	194	24-36	4656 – 6984
Stage IIIB Poor PFS palliative RT	279	1-5	279 – 1395	252	5	1260
Stage IV focal symptoms palliative RT	1019	1-5	1019 – 5095	921	5	4605
TOTAL	2935 (62.8%)		27,247 – 39,261	2654		34,698 – 41,382

¹ Some of this group are treated with CHART without chemotherapy as they are not suitable for chemotherapy, but in general most patients receive either concomitant chemoradiation with 30 factions or neo-adjuvant chemotherapy 20 fractions of radiotherapy

² Not all these patients have tumours suitable for radical radiotherapy because of the location of the primary and nodes does not allow safe delivery of this treatment. There are no data on the proportion of patients in whom this is the case. These patients receive 13 fractions of radiotherapy.

³ These take into account changes in smoking and the Scottish population. No account has been made of the potential impact of on-going International studies into lung cancer screening using spiral CT scanning. If these trials demonstrate screening to be beneficial there potentially will be an increase in the number of early stage cancers requiring radical radiotherapy.

Upper GI Tumours

SUMMARY

Radiotherapy indication for oesophageal cancer is 53.9%. The range of fractions required 2011 - 2015 to optimally treat the future incident population with radiotherapy is 10670 - 13705 fractions.

Radiotherapy indication for stomach cancer is 13.4%. The total fractions required 2011 - 2015 to optimally treat the future incident population with radiotherapy is 2625 fractions.

Radiotherapy indication for pancreatic cancer is 41.9%. The total fractions required 2011 - 2015 to optimally treat the future incident population with radiotherapy is 6575 fractions.

Oesophageal Cancer

An average of 781 oesophageal cancers were diagnosed per annum in Scotland, 1996 - 2000. Incidence of oesophageal cancer is higher in males than in females and in 2003, it was the primary cause of death in 501 men and 275 women in Scotland.

The incidence of oesophageal cancer is projected to increase by 44% to the period 2011 to 2015 with a projected average annual incidence of 1126 cases.

ROLE OF RADIOTHERAPY IN OESOPHAGEAL CANCER

Radical radiotherapy is applicable to a small proportion of patients with localised/locally advanced (T2-T3, N1) tumours of limited length in the middle and upper thirds of the oesophagus. There has never been a randomised trial of surgery versus radiotherapy and one seems unlikely. Radical radiotherapy is usually combined with chemotherapy unless there is contraindication to the use of chemotherapy. The role of pre-operative radiotherapy or chemo-radiation remains controversial.

CURRENT RADIOTHERAPY UTILISATION

POPULATION BASED STUDIES

Nottingham, UK

From a series of 496 patients diagnosed from 1982-1985 in the Nottingham area, 13% received radiotherapy (Oliver 1992).

NYCRIS

In 1999, the Northern and Yorkshire Cancer Registry (NYCRIS) recorded that 31% of oesophageal cancers received radiotherapy.

Scotland

A Scottish Audit of Gastric and Oesophageal Cancer (SAGOC) (2002) included 3293 patients diagnosed between 1997 and 2000. 8.4% of oesophageal patients received radiotherapy as a single modality treatment and 5.3% received concomitant chemotherapy and radiotherapy. The rate of radiotherapy utilisation varied widely between the Health Boards from 7% to 22.6%

OPTIMAL RADIOTHERAPY UTILISATION

Australia

The Australian modelling concluded that 46% of patients with oesophageal cancer should receive radiotherapy as part of curative management and a further 27% for palliative therapy either for local or metastatic disease. In this model, radiotherapy was indicated for all patients with positive margins following resection and for all patients with localised disease in whom surgery could not be performed.

Scotland

Applying the model to a Scottish population was made difficult by the lack of stage data available (66% of patients recorded in the SAGOC audit were unstaged). The US National Cancer Database identified that 32% of patients present with metastatic disease. Therefore,

these figures have been used to model the optimal radiotherapy utilisation for Scotland. It was calculated that 53.9% of oesophageal patients in Scotland should have an indication for radiotherapy in the initial management of disease (Table J27).

The radical radiotherapy rate used in the model is much higher than that actually delivered in Scotland as the model assumes that all patients with localised disease are fit for radical radiotherapy, which is not the case. The SAGOC audit reported that 40% of patients at the time of presentation had severe co-existing medical conditions and 25% had a significant reduction in their WHO performance status likely to limit their treatment options. If only 15% received radical radiotherapy, this would be 116 patients per annum. As a result to the radiotherapy indication would be 23.6%.

TREATMENT/FRACTIONATION FOR OESOPHAGEAL CANCER

Based on 1996 - 2000 incident population, 7400 to 9505 fractions would be required in 2004 to treatment oesophageal patients with an indication based on current optimal fractionation. Applying the projected 44% increase in incidence of oesophageal cancer to 2011 – 2015, a calculated 10670 – 13705 fractions of radiotherapy will be required to treat the incident oesophageal cancer population with an indication for radiotherapy optimally 2011 – 2015 (Table J28)

No projected change to fractionation was applied for oesophageal cancer. It is acknowledged that there a lot of work going on in relation to chemo radiation and pre/post operative surgical options for radiotherapy. Results of these trials are likely to report within the time of this project given the relatively poor survival of oesophageal cancer.

Table G27: Application of Scottish Data to Australian Model for Oesophageal Cancer

Oesophageal cancer About 781 cases diagnosed per annum 1996 – 2000	Non metastatic 0.68 ¹ 531	Surgery 0.42 ¹ 223	Clear margins 0.8 ¹ 178	No radiotherapy 178
			Involved margins 0.2 ¹ 45	Radical Radiotherapy 45
	Metastatic 0.32 ¹ 250	No surgery 0.58 ¹ 308		Radical radiotherapy 308
		Local or metastatic symptoms 0.27 ¹ 68		Palliative radiotherapy 68
		No focal symptoms 0.73 ¹ 183		No radiotherapy 183

¹ figures from Australian model

Table G28: Current and future optimal fractions required for oesophageal cancer

	Number in 1996 - 2000 model	Fractions in 2004	Fractions required in 2004	Number predicted 2011 - 2015 (44% increase ¹)	Fractions in 2015	Total fractions required 2011 - 2015
Post-operative radiotherapy	45	20-25	900 - 1125	65	20-25	1300 – 1625
Radical radiotherapy	308	20-25	6160 - 7700	444	20-25	8880 – 11100
Palliative radiotherapy	68	5-10	340-680	98	5-10	490 – 980
Total	421 (53.9%)		7400 - 9505	607		10670 - 13705

¹ This assumes the increase is in oesophageal cancer at all sites, and in fact the predicted increase is in oesophageal junction tumours where radiotherapy plays a lesser role.

Stomach Cancer

An average of 965 stomach cancers were diagnosed per annum in Scotland, 1996 – 2000. In 2003, stomach cancer was the primary cause of death in 370 men and 209 women.

The incidence of stomach cancer is projected to decrease by 18.5% between now and 2011 – 2015, to an average annual incidence of 786 cases.

ROLE OF RADIOTHERAPY IN STOMACH CANCER

Currently in Scotland, radiotherapy is primarily only used in the palliative management of metastatic stomach cancer. However, data from the USA has suggested that there may be a role for post-operative adjuvant chemo-radiotherapy (Macdonald 2001). These data are controversial, particularly with regard to the type of surgery performed in the trial.

There is a proposed UK national trial to examine the role of post-operative chemo-radiation following the more extensive surgery performed in the UK. This would use 25 fractions per course.

CURRENT RADIOTHERAPY UTILISATION

POPULATION STUDIES

NYCRIS

From the NYCRIS database (1999), 4% of stomach cancers received radiotherapy.

Scotland

From the SAGOC Audit (2002), 4.2% of gastric cancers received radiotherapy alone. Only one case of combined chemotherapy and radiotherapy treatment was recorded.

OPTIMAL RADIOTHERAPY UTILISATION

Australia

The Australian model suggested that 68% of patients presenting with stomach cancer have an indication for radiotherapy. The Australian model advocated post-operative adjuvant chemo-radiotherapy, which is not standard practice in Scotland.

Scotland

Applying Scottish data to the Australian model was not straightforward as the model advocated post-operative adjuvant chemo-radiotherapy, which is not standard practice in Scotland. The evidence base supporting this treatment indication is debated in Scotland and it is unlikely that treatment will progress towards this due to limited long-term survival benefits.

If however, post-operative adjuvant chemo-radiotherapy was used in Scotland, a radiotherapy indication and estimate of the total fractions required can be crudely calculated based on crude data available from the SAGOC audit:

In the SAGOC audit, 16.7% of patients with gastric or gastro-oesophageal cancer underwent a resection. Of the gastric cancers, 19.6% were T1 in whom radiotherapy is not indicated according to the Australian model. Therefore, if 786 cases of stomach cancer are projected

per annum for 2011 – 2015, approximately 131 of these will undergo resection based on SAGOC data and approx 80% (105 patients) will have an indication for post-operative adjuvant chemo-radiotherapy. This gives a crude radiotherapy indication of 13.4% for Scotland.

TREATMENT/FRACTIONATION FOR STOMACH CANCER

Fractionation for post-operative adjuvant chemo-radiotherapy is 25 fractions per course. Therefore if this treatment proves to be beneficial, about 2625 fractions will be required 2011 – 2015.

Pancreatic Cancer

An average of 633 pancreatic cancers were diagnosed per annum in Scotland, 1996 – 2000. In 2003, pancreatic cancer was the primary cause of death in 297 men and 344 women.

The incidence of pancreatic cancer is projected to increase by 20.2% between now and 2011 – 2015 to an average annual incidence of 761 cases.

ROLE OF RADIOTHERAPY IN PANCREATIC CANCER

As with gastric cancer, there is currently little role for radiotherapy other than in the palliative setting. However, some patients with localised inoperable pancreatic cancer receive high dose local palliative chemo-radiation with 25 fractions for optimal local control and pain relief. The role for post-operative adjuvant radiotherapy is highly controversial. Australian modelling indicated that this treatment should be given, but in light of conflicting studies this is not standard practice in the UK. If post-operative radiotherapy was proven to be effective, it would play only a small role as more than 80% of patients currently present with advanced and un-resectable disease (Takhar et al. 2004).

CURRENT RADIOTHERAPY UTILISATION

NYCRIS

From the NYCRIS database (1999), 4% of pancreatic cancers received radiotherapy and 6% in the Swedish audit.

OPTIMAL RADIOTHERAPY UTILISATION

Australia

The Australian model suggested that 57% of patients presenting with pancreatic cancer have an indication for radiotherapy.

Scotland

If the Australian model is changed, then the 36% of patients who present with inoperable localised disease and the 14% with symptomatic metastatic disease might benefit from radiotherapy.

TREATMENT/FRACTIONATION FOR PANCREATIC CANCER

From 1996 to 2000 the average annual incidence of pancreatic cancer in Scotland was 633 cases. So based on the adapted Australian model, 203 patients would require 5075 fractions for optimal local control and 79 palliative radiotherapy, which at 5 fractions per course would mean a total of 5470 fraction per annum to treat pancreatic cancer. Few cases in Scotland with locally advanced disease are fit enough for chemo-radiation.

There is a predicted 20.2% increase in the incidence of pancreatic cancer to 2015, so by this time, 244 would require local aggressive therapy and 95 palliative radiotherapy, a total of 6575 fractions per annum.

Melanoma

SUMMARY

Radiotherapy indication for melanoma cancer is 15.7%. The range of fractions required 2011 - 2015 to optimally treat the future incident population with radiotherapy is 3085 - 3850 fractions.

Melanoma

An average of 662 cases of melanoma were diagnosed per annum in Scotland, 1996 – 2000. In 2003, melanoma was the primary cause of death in 78 men and 68 women.

The incidence of melanoma is projected to increase by 52% between now and 2011 – 2015 to an average annual incidence of 1005 cases.

ROLE OF RADIOTHERAPY IN MELANOMA

Currently in Scotland radiotherapy is only routinely used for adjuvant radiotherapy for some high-risk head and neck melanomas and in the palliative setting, for intra-cerebral, nodal and bone metastases.

CURRENT RADIOTHERAPY UTILISATION

In the Swedish audit 23% of cases received radiotherapy, 13% with curative intent with the remaining treatments delivered for loco-regional relapse or to metastatic disease (77.5% of treatments).

OPTIMAL RADIOTHERAPY UTILISATION

Though melanoma is currently rarely treated with radiotherapy in Scotland, with palliative treatments constituting the main indication, the Australian model suggested that 23% of cases should be receiving treatment, 18% in the initial phase of their illness (Delaney 2004). This rate is based on a very different approach, with a much higher utilisation of adjuvant radiotherapy. There are clinical trials examining the role of adjuvant radiotherapy currently recruiting. In addition, a particularly aggressive type of melanoma, desmoplastic melanoma, for which radiotherapy is indicated are seen much less frequently in Scotland than Australia.

In light of the comments above, the tree has been simplified and desmoplastic melanoma removed. Based on this model 15.7% of cases should receive radiotherapy.

TREATMENT/FRACTIONATION FOR MELANOMA

For optimal treatment of radiotherapy in 2004 2035 fractions would be needed and by 2015 3850.

Table G29: Application of Scottish Data to Australian Model for Melanoma

Melanoma 662 average number cases in 1996-2000	Cutaneous 0.91 ¹ 602	Stage I- III 0.99 ¹ 596	Head and neck 0.17 ³ 101	Deep lesion or ≥4 nodes, high risk recurrence 0.17 ³ 17	Adjuvant radiotherapy 17
				Shallow lesion and <4 nodes Low risk recurrence 0.83 84	No radiotherapy 84
			Non head and neck 0.83 ¹ 495	≥4 nodes 0.13 ¹ 64	Adjuvant radiotherapy 64
				node negative or 1-3 nodes 0.87 ¹ 431	No radiotherapy 431
		Stage IV 0.01 ³ 6	Focal symptoms (brain, bone, nodal) 0.51 ¹ 3		Palliative radiotherapy 3
			No focal symptoms 0.49 ¹ 3		No radiotherapy 3
			Mucosal 0.03 ¹ 20	Adjuvant post-operative radiotherapy 20	
			Ocular 0.06 ¹ 40	No external beam photon radiotherapy 40	

¹ From Australian model

² Risk of deep (pT4) = 0.16 of head and neck melanoma + risk node positive and >4 nodes (0.36 x 0.36)

³ Data from on-going Scottish National Melanoma audit

Table G30: Current and future optimal fractions required for melanoma

Indication for radiotherapy	Numbers in 2000 model	Current fractionation	Fractions required in 2004	Number predicted in 2015 (52% increase)	Fractionation in 2015	Fractions required in 2015
High risk head and neck or mucosal adjuvant radiotherapy	37	20	740	56	25	1400
≥4 nodes non head and neck, adjuvant radiotherapy	64	20	1280	97	25	2425
Palliative radiotherapy for focal symptoms	3	5	15	5	5	25
Total	104 (15.7%)		2035			3850

RETROSPECTIVE AUDIT OF RADIOTHERAPY ACTIVITY SCOTLAND 2003

Background

In order to support the Radiotherapy Activity Planning work, a retrospective audit was undertaken of radiotherapy delivered in the five Scottish Cancer Centres (2003).

Methodology

Bearing in mind the variations in data routinely collected by each radiotherapy department, a basic response template was drafted and approved by the horizon scanning group specially for this exercise (appendix H1). The group acknowledged and accepted that the level of detail requested in the template might result in some incomplete returns. Radiotherapy departments were asked to complete the template for all radiotherapy courses administered to the identified tumour sites in 2003, and highlight any difficulties or caveats in their returns.

Main Outcome Measures

The main outcome measures of the audit were to establish the current fractionation in Scotland, range of fractions delivered to similar tumour sites, and to establish base-line activity data against which demand projections might be compared; thus providing some measure of the service increase/decrease that might be required by 2011-2015.

Results

A total of 165,841.5 fractions were delivered for the treatment sites identified in the response template. In addition, the actual total number of fractions delivered by each radiotherapy facility (2003) was provided and is presented in Table 1. The total number of fractions delivered in Scotland 2003 was 175,954.

Table 1: Fractions of radiotherapy delivered in Scotland 2003

Scottish Cancer Centre	Total Fractions (Audit)	Total Fractions (Actual)
Aberdeen	18,176	21,507
Dundee	14,612	15,402
Edinburgh	37,732	41,506
Glasgow	83,646	88,263
Inverness	9276	9276
All Scotland	163,442	175,954

In all, 11,932 courses of radiotherapy were delivered/patients treated in Scotland 2003. It should be noted that some departments record patients per annum while others record courses per annum. It is therefore not possible in this instance to determine the exact number of either.

The majority of radiotherapy courses/patients treated in Scotland 2003 were with radical intent (51.5%) representing 82% (72% – 83%) of the total treatment fractions delivered (Table 2). The average number of fractions per course of radical radiotherapy for Scotland was 22, for palliative 7, and for metastatic treatment 4. The average number of fractions per course (by treatment intent) varied between the cancer centres (Table 3). In total, the average number of fractions per treatment course/patient treated was 14 (12 fractions -17 fractions).

The fractionation schedules appeared to vary considerably for similar cancers. For example, the average number of fractions per treatment course for primary radical prostate ranged from 21 fractions to 36 fractions (Table 4). Not all fields were completed in the data returns and in some cases the averages represent only a minimum of 2 centres.

December 2004

Table 2: Radiotherapy courses/patients & fractions delivered by Scottish Cancer Centre 2003

Treatment Intention	SCOTTISH CANCER CENTRE											
	Aberdeen		Dundee		Edinburgh		Glasgow		Inverness		All SCOTLAND	
	N	%	N	%	N	%	N	%	N	%	N	%
Total Radical Patients	716	46	587	47	1478	49.5	2995	53.33	356	66	6132	51.5
Total Palliative Patients	424	27	262	21	551	18.5	1085	19.33	85	16	2407	20
Total Metastatic Patients	401	26	390	31	911	30.5	1534	27.33	94	17.5	3330	28
Total Benign Patients	8	1	11	1	42	1.5	0	0	2	0.5	63	0.5
TOTAL PATIENTS	1549	100	1250	100	2982	100	5614	100	537	100	11,932	100
Total Radical fractions	13,082	72	11,294	77	30572	81	71,204	85	7681	82.8	133,833	82
Total Palliative fractions	2733	15	1618	11	3506	9	6977	8	834	9	15,668	9.5
Total Metastatic fractions	2281	12.6	1550	11	2973	8	5465	7	742	8	13,011	8
Total Benign fractions	80	0.4	150	1	681	2	0	0	19	0.2	930	0.5
TOTAL FRACTIONS	18,176	100	14,612	100	37,732	100	83,646	100	9276	100	163,442	100

Table 3: Average fractions per radiotherapy course by treatment intention and Scottish Cancer Centre 2003

Treatment Intention	SCOTTISH CANCER CENTRE					ALL SCOTLAND
	Aberdeen	Dundee	Edinburgh	Glasgow	Inverness	
Av # Radical	18	19	21	24	22	22
Av # Palliative	6.5	6	6	6.5	10	6.5
Av # Metastatic	6	4	3	3.5	8	4
Av # Benign	10	14	16	0	9.5	15
Av # per treatment course	12	12	13	15	17	14

Table 4: Average fractions per treatment course by cancer type and treatment site (including range of averages for the 5 cancer centres)

BREAST		Average # per course	GYNAECOLOGICAL (CERVIX/UTERUS/VULVA/VAGINA)	Average # per course
	Conservation	24 (21-27)	Primary Radical	21 (19-25)
	Chest Wall	19 (10-25)		21 (19-25)
	Loco-regional palliative	12 (3-25)	Post-operative Loco-regional palliative	14 (7-25)
PROSTATE			OESOPHAGUS	
	Primary Radical	31 (21-36)	Primary Radical	24 (20-30)
	Post-operative	18 (3-32)		20 (10-30)
	Loco-regional palliative	16 (5-32)	Post-operative Loco-regional palliative	7 (6-8)
LUNG			LYMPHOMA (NHL/HD)	
	NSCLC Primary Radical	24 (19-30)	Primary Radical	18 (14-20)
	NSCLC Post-op	14 (6-21)	Consolidation Curative	15 (11-19)
	SCLC curative	14 (8-19)	Palliative to nodes	8 (5-15)
	SCLC PCI	15 (7-30)		
	Loco-regional palliative	7 (5-10)	BLADDER	
HEAD & NECK			Primary Radical	22 (19-30)
			Loco-regional palliative	9 (5-15)
			ANUS	
	Primary Radical	26 (23-33)	Primary Radical	27 (25-29)
	Post-operative	25 (20-30)		
	Loco-regional palliative	12 (8-19)	Loco-regional palliative	9 (7-12)
RECTAL/COLON			TESTES	
	Pre-operative	8 (5-13)		14 (11-20)
	Post-operative	23 (17-28)	Adjuvant	
	Loco-regional palliative	12 (6-25)		

CNS		Average # per course
	Primary Radical	29 (26-30)
	Primary Palliative	6 (5-8)
SARCOMA		
	Primary Radical	23 (22-25)
	Loco-regional palliative	5 (1-11)
NON MELANOMA SKIN CANCER		
	Primary Radical	9 (5-13)
	Loco-regional Palliative	13 (4-11)
MELANOMA		
	Loco-regional adjuvant	20
	Loco-regional palliative	7 (3-10)
PAEDIATRIC (age < 18)		
	Primary Radical	27 (26-27)
	Palliative Local	5 (4-5)
BENIGN		
	Primary Curative	11 (8-14)
	Adjuvant Curative	
	Palliative	

PALLIATIVE RADIOTHERAPY TREATMENTS to sites other than primary

DIAGNOSIS		Average # per course
	Brain Metastases	7 (5-10)
	Bone Metastases	5 (3-10)
	Palliative Thoracic (not lung)	10 (6-15)

Clinical Strategies: Cancer
Scottish Executive Health Department
December 2004

CLINICAL ONCOLOGY SURVEYS (examples)

LYMPHOMA

Initial presentation	Number per 100 NHL cases	Fractionation		Proportion would currently recommend complex technique e.g. IMRT
		Current	Ideal	
Low grade NHL localized suitable for radical RT				
Low grade NHL treated chemotherapy alone				
Low grade NHL treated chemotherapy and radiotherapy				
Low grade NHL palliative RT only				
Low grade NHL no treatment				
High grade NHL treated with chemotherapy alone				
High grade NHL treated with chemotherapy and radiotherapy				
High grade NHL palliative RT only				
High grade NHL no treatment				
TOTAL NHL				
Initial presentation	Number per 100 Hodgkin's cases	Fractionation		Proportion would currently recommend complex technique e.g. IMRT
		Current	Ideal	
HD Stage I suitable for radical RT				
HD Chemotherapy only				
HD Chemotherapy and radiotherapy				
HD Palliative RT only				
HD No treatment				
Total HD				

OESOPHAGUS

Initial presentation	Number per 100 oesophageal cancer cases	Fractionation		Proportion would currently recommend complex technique e.g. IMRT
		Current	Ideal	
Early stage operated +/- chemo but no RT				
T1/2 N0/1 Operated +/- chemo post -op RT				
Pre-operative chemo RT				
Radical RT alone				
Radical chemo-RT				
Locally advanced or metastatic palliative local RT +/- chemo				
Metastatic bone mets palliative RT +/- chemo				
Metastatic chemo only no RT				
Any stage no treatment				
Total				

Future Predictions for Lymphoma

Using your specialist knowledge for each of the cancer sites could you complete the following questions – with reference to external beam radiotherapy

1. In 2010, for what groups of patients will radiotherapy likely to be no longer indicated?

Group	Current treatment (including fractionation)	Treatment 2010

2. In 2010, what groups of patients, not currently receiving radiotherapy will be treated with radiotherapy?

Group	Current treatment	Treatment 2010 (including fractionation)

3. In 2010 in what groups of patients would you think the fractionation will change and how?

Group	Current (actual not ideal)	2010

4. In 2010, in what groups of patients will more sophisticated techniques be used?

Group	Current treatment technique	Treatment technique in 2010

Future Predictions for oesophageal cancer

Using your specialist knowledge for each of the cancer sites could you complete the following questions – with reference to external beam radiotherapy

- 1) In 2010, for what groups of patients will radiotherapy likely to be no longer indicated?

Group	Current treatment (including fractionation)	Treatment 2010

- 2) In 2010, what groups of patients, not currently receiving radiotherapy will be treated with radiotherapy?

Group	Current treatment	Treatment 2010 (including fractionation)

- 3) In 2010 in what groups of patients would you think the fractionation will change and how?

Group	Current (actual not ideal)	2010

- 4) In 2010, in what groups of patients will more sophisticated techniques be used?

Group	Current treatment technique	Treatment technique in 2010

RADIOTHERAPY ACTIVITY PLANNING

HORIZON SCANNING REPORT – TECHNOLOGIES AND TECHNIQUES

The remit of this group was to look at the impact of future technology on workload and practice. Assumptions about the overall impact on the radiotherapy service resulting from evolving technologies and potential effects on treatment duration is considered in the final report.

Consideration was not been given to the following issues, although some, such as fractionation schedules, are considered in the final report:

- likely shifts away from or towards linear accelerators for treatments which are currently being given by a different modality,
- fractionation schedules
- concomitant treatments,
- radiolabelling / molecular targeting,
- biologically-optimized radiotherapy

In addition, the following technologies and practices were omitted from the deliberations as it was felt that these were unlikely to have a significant role in radiotherapy treatment in Scotland within the timescale of this project - either because of the vast financial implications or due to the complete lack of supportive evidence. However, it is suggested that these technologies are reserved for consideration in any future review:

- Hyperthermia therapy
- Photodynamic therapy
- Proton / neutron / carbon ion facilities
- Intravascular brachytherapy

Non-Technology Issues

One point which was raised by several professionals relates to patient changing facilities. It is widely acknowledged that the length of time which each patient takes in the treatment room could be reduced if appropriate changing facilities were available. Such changing facilities should, if planned and managed effectively not compromise the patients care or dignity. Although not a technical issue, given the impact on linac throughput and hence productivity, it was felt to be of significant value to be included within this report.

1) Superficial & Orthovoltage Treatments

A quick survey of superficial and orthovoltage facilities in Scotland revealed the following:

- Inverness currently has a 16 year old Stabilipan unit. Indications are that this machine will not be replaced when it fails, and the patients will be transferred to the linear accelerator for electron treatment.
- Dundee has a new orthovoltage unit, but this is only being used by one consultant.
- Edinburgh has a superficial machine which is due to be replaced.

- Glasgow has a kV unit which treats up to a maximum of 5 patients per day.
- Aberdeen no longer has a kV unit.

It therefore seems possible that patients who are being treated with superficial & orthovoltage machines at present will be treated by electrons in the future. This will have an impact on linear accelerator usage, although the number of patients may be relatively small. Further work is needed to consider the best way to manage the use of Scottish superficial and orthovoltage resources.

2) Simulation

CT simulators were originally thought to be capable of replacing conventional simulation. The experience in Scotland varies between the two departments that currently have CT simulators. In one case the about 15 patients per day are scanned, with about half of them having field placement done at that stage. Radical and palliative patients are being CT simulated, but there will continue to be a need for a conventional simulator for some sites. Slice sizes are between 3 and 5mm and are not causing any problems. In the other centre the slices are taken between 1mm and 3mm to ensure that the digitally reconstructed radiographs (DRRs) are good enough to compare with portal images. This causes overheating of the X-ray tube and requires a Server for storage of the large volume of data. In radical sites, e.g. prostate, if the small slice widths are used then the conventional simulation stage can be omitted. The first centre is not yet at the stage of comparing online images and therefore is unable to comment of the comparability of images, but the initial impression is that the images are of good quality. It is concluded that a mixture of CT simulators and conventional simulators will be required in the future. The current assumption of one simulator serving up to three linacs will probably continue to be required supported by access to a CT scanner, either a diagnostic model with wide bore or a therapy CT simulator.

3) Brachytherapy

Brachytherapy for gynaecological cancers is likely to move from delivery by low dose rate afterloading devices to medium and high dose rate delivery. The service delivery is likely to move from an inpatient based service to an outpatient service for uterine insertions. Insertions for Ca cervix continue to be delivered on an inpatient basis in most centres. There is no projected alteration to the linac workload as a result of changes to the brachytherapy service for gynaecological malignancies.

There are a few UK centres using brachytherapy to treat palliative oesophagus, lung and head and neck cancers. Although the staff say “some patients do very well” there is no supporting evidence to suggest that this will become the treatment of choice for a significant number of patients and therefore the impact on linac workload cannot be predicted.

A review of literature on the use of interstitial radioactive implants in early prostate cancer indicates that this technique is being widely developed in the USA and the UK. NICE Interventional Procedures Advisory Committee is currently in the process of preparing a consultation document on this procedure and in time will issue a recommendation document for the use of the procedure in the NHS.

An article by Dan Theodorescue of the university of Virginia gives a clear overview of the current American practice. He reports that the American Brachytherapy Society formed a committee of experts to develop consensus guidelines through critical analysis of published data supplemented by their clinical experience. Their recommendation is that 'patients with a high probability of organ confined disease are appropriately treated with brachytherapy alone. Most practitioners include patients with T1-T2a, PSA level of 10ng/ml or less and Gleason score six or lower. Brachytherapy candidates with a significant risk of extraprostatic extension should be treated with supplemental EBRT'.

Theodorescue goes on to report that when compared to historical series using classic external beam radiotherapy to treat prostate cancer, brachytherapy series appear to offer better disease free specific survival as measured by biochemical failure rates. However the debate continues regarding the effectiveness of prostate brachytherapy in comparison to radical prostatectomy in the treatment of localised prostate cancer.

In Scotland, the prostate brachytherapy service in Edinburgh and Glasgow has taken off, with the belief being that there is a need for more capacity. However, no downturn in the number of requests for prostate patients to be treated with external beam has been noticed. This could reflect that those patients being treated with brachytherapy are not those who would have had external beam treatment, or simply that the overall numbers are increasing for all treatment modalities. There is also a report that the fractionation is increasing and therefore any saving in linac time due to brachytherapy will be more than lost by using increased fractionation. The patients treated in Edinburgh are those with stage I and stage IIA disease. The patients are given the choice of brachytherapy, external beam or prostatectomy and therefore there is no way of knowing if what the future impact will be on linac requirements..

4 Autosequencing

Local results at Aberdeen Royal Infirmary confirm those found in other centres (Routsis D et al, 2002). There is a 5-10% time saving for some techniques. It is used on around 40% of the patients on treatment at any one time. Whilst the use of auto sequencing has benefits on set-up accuracy and radiographer perceived output, in reality it is not enough to contribute to an increased throughput of patients. Its contribution forms part of the larger picture when you start to evaluate the use of even more complicated set-ups such as IMRT & IGRT. Portal Imaging can be used easily on autosequenced techniques with no additional set-up time required over a 'standard technique'.

5 Portal Imaging

The time-requirements associated with portal imaging can vary considerably, depending on the protocols employed. The protocols will typically be based around one of three techniques:

Off-line: Off-line correction uses a series of portal images obtained during the first few fractions to determine the systematic setup error. This is then corrected on subsequent fractions, with check images collected weekly.

On-line : On-line correction requires imaging to be performed before each fraction, and adjustments to be made to the patient setup before treatment delivery. Experience

with on-line correction from the Netherlands and the USA indicate that on-line correction can take anywhere between 2 and 5 minutes of additional time per fraction.

¹Routsis D, Burnet N, Thomas S, et al. 'Measuring the impact of new radiotherapy technologies on treatment times' Clinical Oncology 2002, 14 (4): 533-535

Adaptive Radiotherapy : Adaptive radiotherapy uses repeat CT scans during the first week of treatment to assess the movement of the target within the patient. This data is then used to generate a patient specific PTV. The extra workload involves organ contouring on multiple CT scans, and repeat planning with the new PTV. Depending on the disease, it is possible that a treatment may use several plans. If the scanning is performed using a cone beam attachment on the linac, this will take approximately one and a half minutes to deploy the detector and rotate to collect the scan. The time involved for contouring may be minimal, as the algorithms to achieve this will probably be well advanced. However, the time involvement for planning will depend heavily on the complexity of the plan being produced.

Imaging treatments fields alone requires only the additional time for deploying the detector, and setting up the acquisition. Double exposures take approximately two minutes longer. However, this assumes that the fields are being imaged at the treatment gantry angles. If this is not the case, extra time will be required to set the gantry and acquire images at orthogonal, non-treatment angles. Time requirements are also likely to be influenced by the type of equipment being used.

As a first-line approximation, it is probably reasonable to assume that for the days that imaging is to be included within a treatment protocol, 1 minute should be added for the collection of simple treatment images, 2 minutes for double exposure images, and 5 minutes for on-line correction and adaptive radiotherapy. If imaging is required at non-treatment angles, it is probably more realistic to assume 5 minutes for treatment images or double exposures as well.

At present, all portal imaging in Scotland uses some form of off-line method. However, the percentage of patients who are imaged varies from centre to centre. The two centres who are probably currently undertaking the highest number of exposures per linac are the centres imaging least. With the current moves towards more complex treatments, and tighter margins, it is strongly recommended that extra capacity be included to allow patients to have the necessary images taken.

6 Image-Guided Radiotherapy (IGRT)

Image-guided radiotherapy uses additional imaging equipment mounted on the linac's gantry to acquire a cone-beam CT scan prior to every treatment. This CT scan is then registered with the original planning dataset to calculate the setup error. The couch is then shifted to correct for the setup error, and treatment commences. The Netherlands Cancer Institute have been performing clinical trials of IGRT, and it has added around an extra 5 minutes per patient. However, as the system develops, it is likely that the algorithms will get faster, reducing the time requirements.

7 Intensity Modulated Radiotherapy (IMRT)

IMRT can be used to treat tumours that are in close proximity to dose limiting structures, and for dose escalation, e.g. head and neck, prostate, cervix, and CNS. It can also be used to compensate dose heterogeneity e.g. breast.

The impact of IMRT on radiotherapy treatment times is likely to be driven by the technology available by 2014. Manufacturers are already aware that as treatment becomes more complicated time issues are more relevant. The technological issues currently experienced are likely to be improved upon by 2014 in terms of both speed and functionality. This is likely to bring actual IMRT treatment times on the Linear accelerators to near 'standard treatment' times.

All the planning and pre-patient quality assurance that must be done in advance of an IMRT treatment is a separate issue. Whilst not directly impacting on the allocated treatment time, there are other influences on resources. Physics and Medical staff workloads increase in comparison to the work that would be required for a 'standard treatment'. The reasons are mainly, increased target definition workload, additional plan production complexity, and quality assurance (QA) prior to the first treatment of the patient. QA also requires actual non-clinical time on the treatment machine of about one-hour per IMRT patient. These time burdens are also likely to have seen significant improvement by 2014 as computer programmes and the tools for quality assurance are refined and improved.

This use of IMRT is obviously only a significant problem if this was the recommended treatment of choice for a large volume of patients. IMRT can be broken down into different levels of complexity. The production of a breast plan using IMRT to compensate for missing tissue is already a fairly routine procedure; it doesn't require the steep dose gradients (Potters L et al, 2003). Certainly this less complicated application of IMRT means treatment times are currently as normal (Medical Physics Ipswich Radiotherapy department 2004). Other sites such as CNS may only ever be seen as a specialist use of IMRT, rather than for the majority of CNS patients. Prostate would be the one site where large volumes of patients may benefit from the application of IMRT.

Medical Physics Ipswich Radiotherapy department began IMRT treatments in 2001, well ahead of most other centres in the U.K. To date they have treated over 30 cases of complex IMRT, in addition, to using IMRT to compensate for dose heterogeneity in the standard treatment of breasts. Information provided by R. Perry (superintendent radiographer), and S. Smith (senior physicist).

Potters L, Steinberg M, & Wallner et al. 'How one defines intensity modulated radiotherapy', Int J Radn Oncol Biol Phys 2003, 56 (3): 609-610

8 Intra-Operative Radiotherapy (IORT)

This technique is at a very early stage of development in Scotland. One centre has started a research programme. The majority of the research is on the use of this technique in early breast cancers, but other potential indications include following resection of brain metastases and intra-abdominal tumours. If IORT replaces external beam radiotherapy for early breast cancer this would have a profound affect on the requirement for machine capacity.

9 Gating Techniques

Respiratory gating generally allows the treatment of tumours at certain defined points within the respiratory cycle. Planned target volumes can be defined with improved certainty that the tumour will remain within the defined treatment volume during treatment.

In comparison to a 'standard technique' a respiratory gated technique protracts the length of time taken to deliver a treatment. The machine can only be on when the patient is in the right phase of their breathing cycle. Difficulties with this technique arise, even in patients with 'coached breathing', in being certain that the tumour continues to fall within the treatment margin (Kini V et al, 2002).

Respiratory gating is unlikely to be a technology employed in its own right for treatment but rather used in combination with other technologies such as IMRT. Improvements in the speed of technologies will only have limited influence on patient throughput rate due to the physical limitations of a patient's own respiratory cycle. It is likely that a treatment slot involving gated therapy will continue to need up to a 100% more time allocated to it than a 'standard treatment' (Medical Physics, Royal Marsden Hospital London).

An alternative to respiratory gating is 4D radiotherapy. This uses a spiral CT scanner to acquire the planning images whilst the patient's respiratory motion is recorded. The images are then sorted into groups according to the phase of the respiratory cycle. A 4D plan, which includes a weighting for time, is then calculated. This technique is very complex and labour intensive to plan but delivery should not be protracted.

Kini V, Vedam S, Keall P, et al. 'Patient training in respiratory-gated radiotherapy', Medical Dosimetry 2003, 28 (1): 7-11

10 Ultrasound

This is used to locate mobile structures such as the prostate gland however, an alternative is placement into the structure of small gold marker seeds, which are visible on X-ray imaging. It is likely that most centres will opt for the seeds, but if this is not possible ultrasound would be a viable option. Unlike seeds this would take more Linac time as the localisation would have to be done everyday on the treatment couch for 'on-line' correction. Chandra et al (2003) suggest a 19 min appointment time. Ultrasound in combination with on-line correction would seem to double the time an appointment takes. Given the number of prostate patients in a normal workload this would reduce throughput capacity.

11 Tomotherapy

Information on Tomotherapy has been provided by Jake Van Dyke of London Regional Cancer Centre, Ontario. TomoTherapy Inc. had firm sales of 30 tomotherapy units as of May 2004. Currently, only 6 to 8 of these units are treating patients. Obviously it is early days for this equipment, so current practice is likely to change relatively quickly.

One of the tomotherapy users performed a survey in February of this year. There were 6 responders of which 5 were clinical. Sites currently being treated are prostate, head and neck, including retreatment, brain, spinal column, rectum, anus, pancreas, and abdomen. No data was available on fractionation, although it was thought that centres were starting with conventional fractionation before aiming for hypofractionation protocols.

The 5 clinics that are clinical are treating between 5 and 20 patients per day, although the limit is because of patient selection for the new technology, rather than treatment hours. As familiarity with the technology grows, more patients will be treated..

Chandra A, Dong L, Huang et al. 'Experience of ultrasound-based daily prostate localization' Int J Radn Oncol Biol Phys 2003 56 (2): 436-447

12 Quality Control & Maintenance Requirements

A survey of the Scottish centres has indicated that the routine physics work for a multimode linear accelerator with MLC and portal imaging amounts to around 434 hours per year. This figure is averaged across the five sites, and not weighted according to the number of linacs at each site. It is based on working 5 days per week, and includes the time taken for daily run-up of the machines, quality control, calibration and routine planned maintenance. Weekend working and / or significant out-of-hours treatment will increase the requirements. It does not take account of breakdown, repair and any necessary checks thereafter. It is important to note that this figure should only be used as a guide, as it depends heavily on local practice, equipment, techniques etc. Single energy equipment appears to require approximately 70% of the time required for a multimode machine. Simulators and CT simulators require around 30% of the time required for a multimode linac.

The split of the work carried out between the "normal working day" and "out of hours" varies from department to department. However, if Agenda for Change is accepted, there will be an knock-on effect in terms of cost for out of hours working. An element of spare linac capacity would allow improved contingency arrangements, as well as allowing some maintenance, quality control and development activity during normal working hours.

The introduction of additional facilities necessitates additional quality control checking. Best estimates are as follows:

- Stereotactic Facilities : an additional 15 minutes is required per day for preparation and an additional hour is required weekly for quality control. In addition, pre-treatment checks are required.

- IGRT with in-room kV imaging : it is estimated that preparation will take approximately 30 minutes each day and weekly quality control will require an additional hour. In addition, 2 days per year is estimated for planned maintenance.
- Respiratory Gating : it is estimated that this will require an additional 10 minutes per day for preparation, and an additional 40 minutes per week for quality control.
- IMRT : an additional 10 minutes per day will be required for preparation, in addition to pre-treatment checks. In the initial phase of using IMRT, two and half hours maybe required for dosimetric checks, though these are generally away from the machine.
- IORT : currently in Dundee quality control and calibration is undertaken using a set of test equipment supplied by the manufacturer. The unit is not user-serviceable, so if any of the tests fail, the unit (or part of it) must be sent back to the manufacturer for repair. Currently, quality control has taken approximately 1 hour before each patient.
- Tomotherapy : Because the technology is so new, it is difficult to estimate how long quality control and maintenance will take. However, over the next decade the technology will improve it is therefore probably reasonable to assume that overall quality control and maintenance requirements will be similar to those of a multimode linear accelerator.

**Horizon Scanning Group of the Radiotherapy Activity Planning Group
November 2004**

RADIOTHERAPY ACTIVITY PLANNING

HORIZON SCANNING REPORT – STREAMLINING TECHNOLOGIES

The remit of this group was to look at how ‘streamlining new technologies and improving communications’ between radiotherapy centres in Scotland could be used to provide better access to these technologies, with a resulting improvement in the availability of state of the art treatment for patients.

1) General communication/collaboration

Before even looking at the use of information technology to communicate between centres, it is necessary to look at better collaboration between centres. Taking as an example the introduction of IMRT. If each Scottish department continues to work independently developing and implementing what is essentially the same process, each will have considerable resource requirements in terms of time, workforce and financial cost. In addition, limited resources of some departments may restrict timely development resulting in inequitable access to modern treatment deliveries across Scotland. There needs to be national sharing of experience and even the workload to ensure faster progress. In addition such partnership development would allow on-going audit between centres thereby assisting in the development of quality control procedures.

How would we achieve this? We could have, for example, a Scottish IMRT Development Group with frequent meetings held during the implementation period, open to all centres to attend and therefore including those that may not be currently going through the process. Examples where this approach could have been useful in the past (and possibly still useful) are prostate brachytherapy and stereotactic radiotherapy. In the future the development of both image guided and image gated radiotherapy could benefit.

An alternative approach would be to identify one centre to develop a specific technique and then use their expertise to install it in another centre, including teaching and training of staff. It recognised that now all centres would be in a position to consider this option and therefore further consideration might be given to the provision of supernumerary staff to assist with new developments and implementing them nationally.

The diversity of equipment may be a problem but given the recent move to buy Varian this should be less of an issue. Freedom of choice for all departments, about the manufacturer they select, must be preserved but debate between centres on the rationale might prove beneficial. In the future, if it is seen that the overheads involved with the development of new technology can be substantially reduced by purchasing from a particular manufacturer, then that could play a significant factor in decision making.

We suggest looking at developing better collaboration now, if we can accept the cultural change. A first move could be to set up a Scottish Development Group with representatives from all centres to explore the possibility and with the remit to cover all new techniques, not just IMRT. The group should draw from all professions working in radiotherapy, but would be mainly composed of physicists because of their role in the development and introduction of new technology. Part of the remit of any such group should be to monitor the development of IT to provide data communication between centres.

2) Data transmission between centres

The next level up would be to set up data communication links between the radiotherapy centres. Two components would be necessary:

a) The transfer of images, contours etc. to the remote site and completed plans returned.

Most data communication between different scot.nhs.uk locations takes place on 'Health Net Community' a virtual private network (VPN) run for the NHS by BT. This is either an upgrade to or another name for NHSNet. HealthNet Community Gateway connects NHS Scotland to the wider NHSNet. At least half of Trusts in Scotland have migrated to HealthNet Community Scotland. It appears that communication does not go out over the wider Internet and therefore there should be no problem with data security. However, this is not entirely consistent with other advice that only data going to a local scot.nhs.uk address is secure.

There would not be a great deal of difficulty in setting up a connection between specific locations within radiotherapy departments as this would be done by configuring their various firewalls. At present, the bandwidth of some of the networks is quite low so large data sets would probably require minutes or tens of minutes to send.

b) A video conferencing arrangement to allow interactive discussions based around planning system displays.

The present situation is that there is a slow migration from the use of ISDN lines to using the data network. Because of the low bandwidth of the network, video conferencing signals can often be of poor quality and could easily have a serious effect, even on static images. Discussions are taking place about upgrades to the networks involved, but no plans are in place yet and that could be one of the most serious difficulties that would need to be overcome. All videoconferencing technology is currently limited to XGA resolution (1024 x 768). It is only in the past year that XGA has become widely available, and higher resolution requires higher bandwidth, so the limitation may exist for some time.

Videoconferencing security is provided by either the use of NHS data networks, or encryption between the teleconferencing hardware. The encryption requires the hardware at either end to be compatible; otherwise the conference will still be possible but will not be encrypted. Most manufacturers' equipment is converging towards universal standards, and it is only older installations where there is still a problem. ISDN communication is not generally encrypted. However, it would not be straightforward to intercept patient information as the data is compressed into packets before it is transmitted.

Current video conferencing installations have dual large display screens, programmed touch-panel control, and high-quality audio pick-up. It is possible to broadcast two streams simultaneously from each site in the conference, for example the view of an audience plus either diagnostic images or a data screen. The requirements for radiotherapy planning would presumably be modest. Small-scale solutions include dual large screen monitors mounted on a mobile unit with cameras. Customised solutions involving a planning workstation would also be possible.

In conclusion, it must be realistic to say that there will be no problems in 10 years time.

3) Use of the data network

Assuming that the above is in place, what use could be made of it? On more than one occasion in the past, the suggestion has been made for 'a planning centre for Scotland' where all other centres send their patient data. This has never taken off because technology was not capable of supporting it. Today, the linac complement in Scotland is sufficiently well matched to be able to use common beam data sets and that is a plus. However, the complexity of planning has increased considerably and in the most complex cases requires continuous interaction with medical staff during the process making the practicalities of scheduling such interaction around busy Consultant diaries difficult.

Taking IMRT as an example. All Scottish departments have the technology to treat IMRT since it is standard on all new linacs. If the total number of patients requiring IMRT in Scotland is small, would it be feasible to plan these patients through a centralised and expert resource, but continue to treat at the referring centre? In theory yes, but how would individual centres feel about losing at least some control of the planning process? IMRT planning is an interactive process and not simply 'pushing a button', so video conferencing to observe the planning process at the other end is necessary. Dicom-RT should make the transmission of images/structures/DMLC files straightforward if the same kit is used. We are probably not far away from being able to do this now, but would we want to? The general feeling is that overall there is not much to be gained, as staff from the referring centre would still need to be involved in the planning process and would still need to set up and perform their own QA.

Other main developments for which we will need to gain expertise in the near future are image guided and image gated radiotherapy, but these are not suitable for this approach as they are used dynamically at the time of treatment. Planning of HDR brachytherapy is another possibility for centralised planning but there are similar problems to IMRT, although the planning is not so complex, even if CT is used.

In conclusion, since planning, and in particular complex treatment planning, is an interactive process there does not appear to be much that can be gained from adopting a centralised planning resource. Further consideration of this will be warranted if a devolved configuration of cancer centres is indicated for Scotland in the future.

5) General conclusions

There is undoubtedly potential in using IT to improve and streamline communication although this is difficult to appreciate given the current difficulties in setting up and maintaining a network between radiotherapy centres in Scotland.

Through better collaboration significant gains are to be made by:

- sharing expertise through organised development programmes and frequent meetings
- sharing out major development projects between centres and rolling out to others using the staff from the development site.
- looking at the possibility of funding supernumerary staff to assist in-house staff with development and provide the roll out to other centres.

These points should be addressed immediately. In addition, the potential and possible future uses of IT technology to improving the treatment and management of patients should be continually assessed.

**Horizon Scanning Group of the Radiotherapy Activity Planning Group
November 2004**

THE RADIO THERAPY WORKFORCE – DESCRIPTION OF KEY PROFESSIONAL GROUPS

As identified in the report, the key professional groups essential to the planning and delivery of radiotherapy treatment include Clinical Oncologists, Radiotherapy Physicists (including dosimetrists and engineers) and Therapeutic Radiographers. The complete multi-disciplinary team is very diverse and a wide range of clinical and non-clinical staff groups are crucial to the delivery of a quality and patient centred radiotherapy service. These staff group should not be overlooked and as recommended in the main report, the impact resulting from any core service change must be considered further in relation to the complete multi-professional team.

The following descriptions provide a brief overview of the professional role of Clinical Oncologists, Radiotherapy Physicists and Therapeutic Radiographers to aid understanding of their contribution to the radiotherapy service in Scotland.

Clinical Oncologists

Clinical oncologists have a medical degree and have undergone a formal programme of specialist postgraduate medical education. In the United Kingdom, a clinical oncologist is trained in the use of both radiotherapy and chemotherapy to treat patients with cancer.

In relation to radiotherapy:

Clinical oncologists prescribe radiotherapy, generally following a multi-disciplinary meeting to discuss the treatment and management of a patient. The clinical oncologist takes overall responsibility for defining the gross tumour volume, clinical target volume, planning target volume and organs at risk. Before the first fraction of a radical treatment is administered to a patient, the clinical oncologist must authorise the treatment plan.

Clinical oncologists carry considerable patient lists and continue to review patients for some years following cancer treatment/diagnosis. Current recommendations state that a consultant should receive no more than 315 new referrals per annum - this is under review and is likely to be reduced to 250 new referrals per annum. In addition, to the clinical work carried out at the base hospital, consultant oncologists undertake a number of oncology clinics at locations remote to the base hospital.

Radiotherapy Physicists

Radiotherapy Physicists are state registered clinical scientists possessing a degree in a physical science or equivalent, 2 year postgraduate training in medical physics and a further 2 years postgraduate training in radiotherapy physics.

The key roles of a radiotherapy physicists are summarised below:

- Management, development and scientific direction of the radiotherapy physics service
- Ensuring the accuracy of radiotherapy treatment through scientific supervision of dose calculation procedures and ongoing quality control of both equipment and treatment
- Design and implementation of new and innovative treatments

- Leadership of research and development , especially in the technological basis of radiotherapy
- Providing advice on appropriate treatment techniques
- Ensuring radiation safety
- Management of computer systems and software design and development
- Equipment management and procurement of radiotherapy equipment
- Teaching and training of staff (including junior clinical scientists, clinical technologists, doctors, radiographers and nurses).

Dosimetrists

The dosimetrist is a new and evolving role in radiotherapy. The term is being used to describe staff undertaking all aspects of treatment planning, including patient immobilisation and the preparation of patient related accessories. Dosimetrists may also undertake radiotherapy equipment dosimetry and quality control, and patient *in vivo* dosimetry. This role may be undertaken by staff trained as clinical technologists, clinical scientists or radiographers but the dosimetrist must be professionally accountable to a medical physicist for the dosimetric aspects of work.

Engineers (sometimes referred to as technologists)

Qualified engineers usually hold an appropriate degree, HND, HNC or equivalent. Four years of further post certification training are required to be eligible for assessment for Incorporated Membership of IPeM and where appropriate Incorporated Engineer status. These professionals normally come from a number of backgrounds, the main ones being electronic engineering, mechanical engineering and clinical physics. Much of the post certification training is undertaken through a designated programme of in-service training. The main roles of engineers in radiotherapy include:

- Management and service development
- Equipment procurement
- Training of staff (including junior engineers, clinical scientists, doctors, radiographers and nurses)
- Preventative and corrective maintenance of radiotherapy equipment
- Manufacture of treatment aids
- Mould room work
- Research and development
- Quality control and assurance
- Safety testing
- Management of computer systems and software development
- External beam treatment planning including treatment verification
- Brachytherapy treatment planning

Therapeutic Radiographers

Therapeutic radiographers are state-registered practitioners possessing a vocational BSc Hons degree in radiation oncology or equivalent. Therapeutic radiographers possess detailed knowledge of cancers and their associated disease processes. They have an understanding of the variety of modalities employed in the treatment of cancer including surgery, chemotherapy and hormone and gene therapy. During radiotherapy treatment a patient will have daily contact with a therapeutic radiographer since they carry main responsibility for treatment delivery. The main responsibilities of therapeutic radiographers include:

- Mould room work, including manufacture of treatment aids

- Simulation and verification
- Ct planning/MRI Planning
- Dosimetry planning
- Treatment delivery
- Radiation protection
- Clinical governance and risk management
- Patient care, information and support
- Research and development
- Information management and technology
- Audit and quality management

The role of all staff groups is changing continually to meet the needs of services as they develop. Therefore, the responsibilities listed above may vary between radiotherapy departments and is dependant on the available skill base, local service requirements and opportunity for cross professional development and skill mix within each aspect of the service.

March 2005

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Astron B44673 1/06

ISBN 0-7559-4929-3

