Equipment, Workload and Staffing for Radiotherapy in Scotland 1997–2003

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Foreword

After surgery, radiotherapy is the next most effective modality for cancer treatment, and is given to 40% of all patients who are cured. These advances in treatment together with the rising incidence of cancer and new indications for treatment have led to increasing demand for radiotherapy. It is a demand that can only be met if manpower and equipment are sufficient to deliver it. Without sufficient resource, efforts to reduce deaths from cancer will have less chance of succeeding. Recent years have witnessed major advances in radiotherapy technology and change is continuing faster than ever before. Technological trends in radiotherapy have enhanced the therapy's precision, safety and effectiveness, with much improved tumour targeting and sparing of normal tissue, which helps to achieve higher cure rates with less risk of debilitating side-effects. As new technologies emerge, it is possible to improve the level of care and the range of treatment options that can be provided to patients.

The current survey complements previous surveys conducted by the Royal College of Radiologists (RCR) in 1992 and 1997,[1,2] and the UK-wide survey of 2003. During the period 1997 – 2003, oncology services in Scotland received increased investment from the Scottish Executive. This welcome investment is reflected in the survey that follows. Unfortunately, as can be seen, this investment has not been sufficient to meet demand. Waiting lists are lengthy and are likely to continue to grow. Modern treatment is inhibited by lack of up-to-date equipment and inadequate staffing. The position of Scotland in relation to other comparable European countries is therefore a weak one in terms of radiotherapy capacity. If patients are to be offered the best chance of cure or timely effective palliation, then significant further investment in staff and machines for radiotherapy planning and delivery is essential.

This survey examines the provision of oncology services, specifically radiotherapy services, from 1997 to 2003 in Scotland and reflects accurately the current situation. For discussion purposes, and in an effort to simplify key findings, comparisons and references are made to Department of Health policies and targets.

It is hoped that this document will be of assistance to clinical oncology departments and, in particular, to the bodies responsible for resource provision and allocation, to reflect on ways in which radiotherapy services for all cancer patients can be placed on a secure and sound footing.

The College recognises and is enormously encouraged by the significant effort and resources being expended by the Scottish Executive to address the issues raised in the earlier RCR report. The Scottish Executive, via its Scottish Cancer Group which includes the 5 Cancer Centre Directors in Scotland, have worked in close collaboration with the Cancer Service to develop a coherent programme of linac refurbishment and replacement. Funding for 2 new and 6 replacement linacs has been awarded (2004) and authorised and is greatly welcomed.

Taking into account this additional funding, this survey appears to indicate, at the minimum, an immediate need for a further 8 new linacs and for a rolling programme of equipment replacement. We hope the report will provide a baseline against which future progress can be measured and will assist members and Fellows in Scotland to work together with professional colleagues, the Scottish Cancer Group and the Scottish Executive to make further advances for the benefit of people with cancer.

The College would like to thank members and Fellows in Scotland for their input to this document and, most especially, Dr AG Robertson (Glasgow) for drawing the information together and presenting it so concisely and clearly. In particular, we would wish to thank Dr Carrie Featherstone (Glasgow), Mr Fraser Brunton (Glasgow), The Scottish Radiotherapy Physics Group, Ms Diane Braun (Inverness) Professor Alan Rodger (Glasgow), Dr J Dewar (Tayside), Dr Graham Howard (Edinburgh), Dr D Bisset (Aberdeen), Ms F Milne (Glasgow), Ms Christine Blyth (Queen Margaret University College), and Ms Cathy Meredith (Caledonian University).

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Dean and Vice President, Faculty of Clinical Oncology

1 Summary

1.1 Radiotherapy is currently a mainstay of curative cancer treatment and is also central to maintaining / improving patients' quality of life by palliating many symptoms. Its key role in cancer treatment will continue for the next 10 – 20 years, at least.

1.2 Cancer incidence in Scotland is 5,240 per 1 million head of population. The incidence rate varies from 4,900 per 1 million in both Edinburgh and Glasgow to 6,000 and 6,500 per 1 million in Inverness and Tayside, respectively. Aberdeen is closest to the national average at 5,300. [See Table 1] The proportion of patients in Scotland diagnosed with cancer who receive radiotherapy is on average 50%. The suggested optimal proportion who should be treated with radiotherapy for most cancers is between 60 and 76%.

Table 1 (Cancer registrations per annum 2003)

Cancer Centre	Population	Cancer registrations per annum	Cancer incidence rate / 10^3 population per annum
Aberdeen	564,440	3,000	**5.3**
Edinburgh	1,384,430	6,800	**4.9**
Glasgow	2,484,430	12,500	**4.9**
Inverness	234,340	1,400	**6.0**
Tayside	396,000	2,500	**6.5**
Total	5,054,800	26,200	**5.2**

URL for full data set: www.canceruk.net.

1.3 In the 1992 – 1997 survey of equipment, workload and staffing in radiotherapy provision in Scotland, the situation was characterised as inadequate to meet the growing needs of the population, distributed inequitably and delivered with an inadequate number of machines.[2] To meet the target of 4 linacs per million population, it was necessary to purchase 12 new machines, over and above those that had to be purchased to replace old machines, and install them at the various Scottish centres. Since 1997, there has been considerable investment by the Scottish Executive in both equipment and in the number of medical and radiographer trainees.

1.4 It is the case, however, that the oncology scene is not static. As was predicted in Cancer Scenarios (2001), during the last 5 years there has been an increasing demand for radiotherapy.[3] The number of exposures delivered per year increased in all 5 Scottish centres over the period 1997-2003. The mean percentage increase was 9.8%.

1.5 Between 1997 and 2003 the number of megavoltage machines for radiotherapy in clinical use in Scotland increased from 15 in 1997 to 20 in 2003, an increase of 33%, i.e., 6.6% per year.

1.6 In 2003, 16% of linacs were aged 10 years or more, compared with 26% in 1997. In 2003, 21% of linacs were between 6 and 10 years old, and 63% were 1 to 5 years old. A linac is a very sophisticated piece of electronic equipment. Most manufacturers recommend an active life of 10 years for their machines and do not give a guarantee on spare parts after that time, particularly for the software controls. In Scotland in 1997, 4 of the 15 linacs were 10 or more years old; 5 were 6-9 years old and 6 were 1-5 years old. The 2003 replacement programme for linacs in Scotland did much to address the problem of out-of-date radiotherapy machines, but this is a matter that will likely emerge again in the coming years without adherence to a rolling programme of equipment replacement.

1.7 The number of linacs per million of population in June 2003 in Scotland stood at 3.96, a significant improvement over the 2.9 per million population in 1997.

1.8 In 2003, the range of linac provision per million population in Scotland is from 3.54 to 5.16. The target of 4 linacs per million population was achieved only by the 2 smallest radiotherapy centres in Inverness and Tayside. Only 0.6 million (12%) of the population in Scotland is presently served by 4 linacs or more per million.

1.9 Although overall, Scotland-wide provision stood at 3.96 linacs per million population, a significant improvement over the 2.9 per million in 1997, the second and third largest population centres (i.e., Edinburgh and Aberdeen) are still under-equipped.

1.10 Comparable European countries have either exceeded the 5 per million population target for linac provision proposed by the World Health Organisation in 1999 (e.g., France with 6.1 linacs per million population) or are planning to achieve it soon (e.g., the Netherlands and Spain).

1.11 In 1998, 28% of patients had to wait longer than 4 weeks to start potentially curative radiotherapy. In 2002, 81% of patients surveyed waited longer than 4 weeks.

1.12 Access to radiotherapy in Scotland continues to be limited by lack of linacs and staffing, and there remains marked inequality of access in different parts of the country.

1.13 In spite of a 4.6% increase in workload on linacs over the period 1992-1997, the treatment machine capacity did not increase. In fact, if the number of treatments carried out on kilovoltage machines is included, then the number of therapy machines actually decreased, as a lot of the palliative work was carried out on kilovoltage machines.

1.14 Waiting time for radiotherapy treatment in Glasgow is longer than the accepted maximum recommended by the Joint Collegiate Council for Oncology (JCCO).[4] The waiting time for Edinburgh is 29 days, which is just above the maximum recommendation of the RCR. It has been difficult to give an exact waiting time for patients attending for therapy in Glasgow as there are a number of categories and the definition of 'date of referral for treatment' has been variable. It is hoped that with the introduction of "ready to start radiotherapy date" on the booking forms, more precise information will be available in the future. Those for the other 3 centres are within the guideline recommendations.

1.15 The consequences of under-provision are:

- long waiting lists for radiotherapy;
- an inability to deliver best effective treatment;
- an inability to compensate for potentially fatal delays in treatment;
- an inability to compensate for potentially fatal unscheduled gaps in therapy resulting in prolongation of overall treatment time.

1.16 Extra linacs and supporting staff and infrastructure are needed urgently to bring provision up to an optimum level of linacs per million head of population. This will mean the acquisition of 13 new linacs: 5 extra machines and 8 replacements. Two are scheduled to be installed in Glasgow during the next 3 years (2005-2007). Authorisation has now been given for the replacement of 6 linacs over the next 18 months, 2005-2006. To achieve the level of 5.5 linacs per million head of population by 2011 at least a further 3 machines are required, bringing the minimum extra machine requirement to 8. These figures do not allow for any change in the Scottish population.

1.17 Besides investing in equipment, the Scottish Executive has recognised that there will be an ongoing need for state of the art radiotherapy facilities to ensure that the Scottish people have access to optimal cancer therapy for the next 10 to 20 years. A national programme for the purchase of radiotherapy equipment and training of adequate numbers of staff has been set up under the guidance of The Radiotherapy Activity Planning Steering Group to endeavour to supply adequate facilities for cancer therapy until 2015.

1.18 Changes in skill mix and patterns of working cannot solve the problem of under-provision. There is a real need for increasing numbers of staff, including clinical oncologists, therapy radiographers and medical physicists. The availability of adequate numbers of trained staff especially Medical Physicists and Radiographers is now as important as the availability of adequate numbers of linacs.

1.19 There needs to be forward planning in recruiting adequate numbers of staff to be trained.

1.20 Because of the increasing incidence of cancer and the increasing number of exposures needed for each patient, a minimum annual 5% increase in workload should be built into future planning assumptions.

2 Introduction

2.1 40-50% of all cancers are curable, and 15% of these by radiotherapy alone.[5] Approximately 30% of all cancers are cured by local therapy: surgery, radiotherapy or a combination.[6] The addition of chemotherapy to radiotherapy has also improved results.[7] Besides its central role in curing patients, radiotherapy is also crucial in the management of patients' symptoms especially pain associated with bone metastases. It has been suggested that 60-76% of those with cancer, depending on the type of cancer, should receive radiotherapy. The number of patients in Scotland with cancer who receive radiotherapy is lower than it should be due to lack of staff and equipment. However, over the past decade the numbers referred for radiotherapy have increased. This has been due to a range of factors including: increase in the average age of the population; increasing incidence of cancer (i.e., 450 cancers per 100,000 population currently); and changes in the indications for therapy.

2.2 Appendix I presents detailed data on the time trends in incidence in 4 major cancers, changes in radiotherapy utilisation and the resource implications for the 5 radiotherapy centres in Scotland.

2.3 Treatment delivery has, however, become more complex and sophisticated in an attempt to reduce life-threatening toxicity and late associated long-term morbidity. The increased complexity has lengthened treatment time and reduced patient throughput. The overall effect has been to increase demand on linacs and on the staff required to deliver the service.

2.4 Although sophisticated modern equipment has reduced radiotherapy side effects, the side effects associated with combined therapy (i.e., combined radiotherapy, surgery and chemotherapy) can be intense and last a number of months. This greatly reduces the patient's quality of life. Patients require more support from a variety of paramedical staff. It is, therefore, important that there are adequate levels of medical and paramedical staff in the oncology centres to deliver appropriate care, oncological and supportive, to the expected high standards that the patients deserve.

2.5 There have been a number of publications over the past 5 to 10 years reporting national radiotherapy resource requirements.[8,9,10,11,12] Algorithms aimed at calculating the number of linacs required to deliver an effective and efficient radiotherapy service to the local population have been developed. The numbers estimated vary from 4 to 6 linacs per million population. The numbers reported by different countries vary from 8.2 treatment units per million in New Zealand to 0.1 per million in Poland.[13] In the initial publications from the Royal College of Radiologists (RCR) for the UK[1] and Scotland,[2] the fact was highlighted that there were inadequate numbers of machines and staff in Scotland and the UK generally to provide a responsive service. It was recommended that the number of linacs available should be increased to give a level of 4 per million population. This meant that 12 new machines needed to be purchased and installed at the different Scottish centres over and above those that had to be purchased to replace old machines.

2.6 After the publication of the two reports,[1,2] substantial investment in radiotherapy services occurred. There was also an increase in the number of medical and radiographer trainees.

2.7 Unfortunately, demand for radiotherapy has continued to rise steadily and will continue to do so in the coming years.[3]

2.8 Recent European recommendations state that the number of linacs required to deliver an efficient radiotherapy service should be between 4.88 and 5.66 per million population.[14] If these recommendations are followed, Scotland now requires between 25 and 29 machines. In 2003, there were 20.

2.9 This survey was carried out to determine what improvements there had been in the availability of oncology services, specifically radiotherapy services, over the 5 years from 1997, and what might be required in the near future.

3 Methods

3.1 Data for the survey were collected with the assistance of the audit section of the Royal College of Radiologists, and medical physicists and radiographers at the 5 Scottish centres. Data collection was carried out between June and November 2003. All centres were asked to use 1st of June 2003 as the census date. Data were received from all 5 Scottish centres.

4 Results

4.1 Linacs available and required

The number of linacs required for a population depends upon the following factors:

- Required treatment capacity, which depends upon the number of patients likely to need radiotherapy and the various fractionation schedules adopted by the clinicians in the centre concerned
- Workload or throughput of each accelerator
- Length of the working week.

4.2 The number of linacs in Scotland has increased between 1998 and 2003. There were 15 in 1997 and there were 19 at the census date of 1st June 2003. Since then an additional machine has been added, bringing the total to 20, 10 of which were in Glasgow. The 10th (existing) machine in Glasgow was in place in June 2003 but could not be used as there were insufficient staff to operate it. The number of linacs per million of population has increased from 2.9 to 3.75, and at date of publication stands at 3.96, a significant improvement. 3 centres achieve the National Cancer Plan target of 4 linacs per million. 1 achieves the RCR recommended level of 5 per million, a target which all centres are expected to achieve by 2006.[14,15] The recommended level for 2011 is 5.5 linacs / million of population.

Table 2 (Linacs in clinical use in 2003 and in 1997)

	6/2003			1997		
Centre	**Population**	**Linacs in clinical use**	**Linacs / million population**	**Population**	**Linacs in clinical use**	**Linacs / million population**
Aberdeen	564,440	2	3.54	517,000	2	3.64
Edinburgh	1,384,430	5	3.61	1,222,000	4	3.08
Glasgow	2,484,430	9	3.62	2,632,000	6	2.14
Inverness	234,340	1	4.27	235,000	1	4.00
Tayside	387,420	2	5.16	423,000	2	4.44
			3.75			
	8/2003					
Total	5,055,060	19	3.96	5,123,000	15	2.9

Glasgow had 10 Linacs at time of 2003 survey. Only 9 were being used clinically.
The actual number / million population was 4.02

4.3 Unfortunately, the introduction of new technology does not always result in quicker throughput. Therapy is becoming more complex, quality assurance is more demanding and the number of fractions per course of treatment is increasing. The number of patients treated on each machine each working day is therefore decreasing. Recent reports have claimed that delays in starting treatment affect outcome. [16,17,18,19,20] To control the waiting time to start treatment and keep it within the recommended limits, it is important that efforts are made to raise the ratio of linacs per million population to the recommended RCR and European levels.

4.4 The survey reveals that in 2003 a number of machines in commission were elderly. 3 (16%) were over 10 years old and 4 (21%) were between 5 and 10 years old. A fourth machine over 10 years old was kept as a back-up machine in Inverness where there was only 1 clinical machine. The majority, however, were less than 5 years old due to the recent expansion and replacement programme adopted by the Scottish Executive. [Table 3]

Table 3 (Age of linacs in clinical use 2003)

Linacs	Age		
	<5 yrs	5-10 yrs	>10yrs
Aberdeen	2	0	0
Edinburgh	4	1	0
Glasgow	4	3	2
Inverness	1	0	1 (BU)
Tayside	1	0	1 (Com)
Total	**12**	**4**	**4**

Note: BU=back up machine; Com=commissioned.

4.5 With the purchase of new equipment each cancer centre now has the capability to treat patients with electron therapy. Aberdeen is the only centre that does not appear to have the potential to offer patients Intensity Modulated Radiotherapy Treatment (IMRT) [Table 4]. IMRT involves treating patients with 5 or more therapy fields and automated shielding blocks. This results in improved sparing of normal tissues and the potential to escalate the dose to the tumour mass.

Table 4 (Available equipment in Scottish Centres 2003)

Centre	Aberdeen	Edinburgh	Glasgow	Inverness	Tayside	Total
Population	564,440	1,384,430	2,484,430	234,340	387,420	5,054,800
Brachy	1	1	2	0	2	6
Ortho	0	1	1	1	1	4
Elect	2 (4-16)	2 (6-20)	3 (4-20)	(4-18)	(6-20)	9
Linac ICU	2	5	9	1	2	19
Linac soon to be ICU	2 (6,15)	3(6), 2(8 & 15)	10 (5,6,10)	1 (4-15)	1 (6,10) 1 (6)	20
PV	2	5	6	1	0	14
MLC	2	5	7	1	2	17
IMRT		Pot	Pot	Pot	Pot	4 Pot
Simulators	1	2	3	1	1	8
Networked	Y	Y	Y	Y	Y	
Stereo	N	Y	N	N	N	

Notes:
Elect and Linac values in parentheses are the energy of electrons/ photons available.
Pot = centre has ability to provide the treatment.
PV = portal vision
MLC = multileaf collimator
ICU = in clinical use

4.6 Linac workload

Workload can be measured by the number of courses of treatment or exposures. The number of courses of treatment can involve a variable number of attendances, fractions and exposures. Each fraction within a course of treatment can involve between 1 and 6 exposures. The most sensitive indicator of workload is, therefore, the number of exposures. [Table 5] Table 6 shows the data submitted by the 5 Scottish centres to the RCR for the census to 1st April 2002. There was a wide variation in the number of exposures per machine in the UK: 11,088 to 30,632 (average 20,412).[14] The variation in Scotland, however, was not as great: 17,159 to 24,481 (average 20,211).

Table 5 (Linac workload measures 2003)

Centre	Linacs	Courses	Courses/ Machine	Exposures	Exposures/ Machine	Fractions	Fractions/ Machine	E/C
Aberdeen	2	1.36	679	40.9	20439	N/A	8519	30.1
Edinburgh	4	3.098	775	87.4	21861	40,727	10,182	28.2
Glasgow	8	5.71	713	195.8	24481	75,218	9402	32.1
Inverness	1	0.55	545	20.2	20240	N/A	8366	36.7
Tayside	2	1.22	610	34.3	17159	N/A	6632	28.1

Notes:
E/C =exposures/course
N/A Not available

4.7 The data in Table 6 show a significant increase in the total number of exposures between 1997 and 2002 in 2 centres in Aberdeen and Edinburgh, a moderate increase of 9% in Glasgow, a small increase in 1 centre in Inverness, and a negligible increase in Tayside. The exposure per machine was reduced in Glasgow over the survey period to 2002. This was due to the fact that the facilities in Glasgow were undergoing upgrading in the period under review. The number of machines there increased from 6 to 8.

Table 6 (Exposures per linac 1992, 1997, and 2002)

	1992			1997			2002			
Centre	**Linacs**	**Exp/ Linac**	**Total Exp**	**Linacs**	**Exp/ Linac**	**Total Exp**	**Linacs**	**Exp/ Linac**	**Total Exp**	**% change from 1997 – 2002**
Aberdeen	2	15,600	31,200	2	16,700	34,000	2	20,439	40,878	+22
Edinburgh	4	19,000	76,000	4	19,200	76,800	4	21,861	87,444	+14
Glasgow	6	29,100	174,000	6	29,900	179,400	8	24,481	195,846	+9
Inverness	1	15,400	15,400	1	19,500	19,500	1	20,240	20,240	+4
Tayside	2	15,000	30,000	2	17,100	34,200	2	17,159	34,318	+0.3

4.8 The average number of hours worked per linac is 7.27 hours. The range reported is 2 to 9.75 hours. The average number of radiographers running each machine is 4. The range is 2 to 5. It must be appreciated that the total output from a machine is not only related to the number of hours it is operating. Rather, it depends on the number of staff available to operate it, working practices, and the complexity of the treatments being given. The fact that a linac was only worked for 2 hours per day was due to staff shortages. A Dutch review predicts that 5-6% of the workload will involve very complex therapies, which will reduce the patient throughput.[21] The use of machines outwith normal working hours depends upon funding, availability of staff, and patients being prepared to come for treatment during "unsocial" hours. This culture change may not be easy to achieve. It should also be appreciated that extended working hours may not be cost effective. One report argues that operating extended working hours is more expensive than purchasing an extra linac to work during normal working hours.[22,23]

4.9 The number of treatment courses per million population is said to reflect a combination of geographic access and adequacy of provision of facilities. The range reported for the UK was 1.5 to 4.7.[14] The Scottish range was much tighter: 2.1 to 3.1, with the average being 2.3. [Table 7] The number of courses per 1000 new cancers varies from 0.39 to 0.46, average 0.44.

Table 7 (Population and treatment courses 2003)

Centre	Population	Courses 1000s p.a.	Courses /M Population p.a.
Aberdeen	564,440	1.36	2.409
Edinburgh	1,384,430	3.10	2.239
Glasgow	2,484,430	5.33	2.145
Inverness	234,340	0.55	2.347
Tayside	387,420	1.22	3.149
Total	**5,055,060**	**8.46**	**2.305**

Table 8 (New cancers per annum and treatment courses 2003)

Centre	New cancers p.a.	Courses 1000s p.a.	Courses / 1000s new cancers
Aberdeen	3,000	1.36	0.45
Edinburgh	6,800	3.10	0.46
Glasgow	12,500	5.33	0.43
Inverness	1,400	0.55	0.39
Tayside	2,500	1.22	0.49
Total	**26,200**	**8.46**	**0.44**

4.10 Planning equipment available and required

Radiotherapy requires radiological imaging support, in addition to computer-controlled multi-leaf collimators and planning computers to deliver conformal radiation or intensity modulated radiation therapy. There are currently 8 simulators in clinical use in Scotland. 1 of these is more than 5 years old. 2 of the 5 centres are in the process of installing new planning systems, because of the advanced age of their present equipment. [Tables 9-12] All Centres have access to computed tomography (CT) scanners for diagnosis and planning, but only Glasgow & Edinburgh have dedicated CT simulators. Increasing demand for radiotherapy will also increase the burden on planning equipment and imaging facilities.

Table 9 (Equipment in clinical use 2003)

Centre	Population	Linacs in clinical use	Linacs / Million pop.	Ortho Mac	Simulator + / – CT
Aberdeen	564,440	2	3.54	0	1
Edinburgh	1,384,430	5	3.61	1	2
Glasgow	2,484,430	10	4.03	1	3
Inverness	234,340	1	4.27	1	1
Tayside	387,420	2	5.16	1	1
Total	5,055,060	20	3.96	4	8

Table 10 (Age of simulators 2003)

Centre	< 5 years	5- 10 years
Aberdeen	1	0
Edinburgh	2	0
Glasgow	2	1
Inverness	1	0
Tayside	1	0
Total	7	1

Table 11 (Planning systems and year commissioned 2003)

Centre	Systems	Year commissioned	New systems
Aberdeen	1	1992	2003 / 04
Edinburgh	2	1994 / 1999	2003
Glasgow	2	1991 / 1995	2003
Inverness	1	2000	
Tayside	1	1996	
Total	7		

Table 12 (Age and number of Brachytherapy machines 2003)

Centre	< 5 years	5-10 years	10< -15 years	> 15 years
Aberdeen	0	0	1	0
Edinburgh	0	0	0	1
Glasgow	0	0	0	2
Inverness	0	0	0	0
Tayside	0	0	0	2
Total	0	0	1	5

The age of the Brachytherapy machines is not as important as that of the linacs. A number of these machines, however, are due to be replaced in the next three years.

4.11 Staff resource

4.12 Clinical oncologists

There is debate over how many new patients a clinical oncologist should see in a year. A Spanish report calculates that the number should be in the region of 132-148.[8] On the basis that ½ hour is spent in consultation with each new patient, the RCR estimates that a clinical oncologist should see approximately 315 new patients in a year.[24] Certainly, as the complexity of treatments and their planning increases the number of patients who can be seen by a consultant will decrease. There is at present a total of 50 consultant clinical oncologist posts, including professors and senior lecturers, in Scotland. However, due to difficulties in recruitment, both nationally and internationally, there were only 42 consultants in post at June 2003. The largest cancer centre in Glasgow was the centre with the largest number of consultant vacancies. [Tables 13 & 14]

Table 13 (Clinical oncology establishment 2003)

	Aberdeen	Edinburgh	Glasgow	Inverness	Tayside	Total
Population	564,000	1,384,000	2,484,000	234,000	387,000	5,055,000
Consultant	5	11.8	22	3	5	46.8
Staff Grade	0	4	5.5	0	1.7	11.2
SpR	2	9	17	0	3	31
SHO	2	0	13	0	7	22
Professor	0	0.5 (1post)	1.2 (2posts)	0	0.5 (1post)	2.2 (4 posts)
Senior Lecturer	0	1	0	0	0	1
Con/Million pop – Ideal	8.9	8.5 / (9.0)	8.9 / (9.3)	12.8	12.9 /(14.2)	8.5
Con/Million pop – Actual	7.1	8.5 / (8.9)	6.7 / (6.9)	8.5	12.9 /(14.2)	

Note: Staff numbers are whole time equivalents. Numbers in brackets are the total NHS and academic staff.

Table 14 (Clinical oncology vacancies 2003)

	Aberdeen	Edinburgh	Glasgow	Inverness	Tayside	Total
Population	564,000	1,384,000	2,484,000	234,000	387,000	5,055,000
Consultant	1	0	5.4	1	0	7.4
Staff Grade	0	2	0.1	0	0	2.1
SpR	0	0	1	0	0	1
SHO	0	0	0	0	0	0
Professor	0	0	0.6 (1 post)	0	0	0.6 (1 post)
Senior Lecturer	0	0	0	0	0	0

4.13 Clinical oncology trainees

There are 31 clinical oncology trainees in Scotland, and it is to be hoped that over the next few years they will finish their training and eventually accept consultant posts in 1 of the 5 Scottish centres to help bring the staffing levels up to what is required to give an efficient and effective service throughout Scotland.

4.14 Retirements

Table 15 shows that there will be a minimum of 15 consultant clinical oncologists retiring in the next 10 years. This represents 30% of available consultant posts and nearly 36% of such posts currently filled. If all current trainees take up posts in Scottish centres, their number will only just compensate for the expected retirements of consultants and will not contribute extra resource to meet the increasing demand for cancer treatment expected to occur in the next decade.

Table 15 (Consultant retirements: clinical and medical oncology, and palliative care 2003)

		5 years	10 years
Clinical oncology	**Aberdeen**	1	2
	Edinburgh	0	4
	Glasgow	2	2 / (0.6)
	Inverness	0	1
	Tayside	1	2
Total		**4**	**11 / (0.6)**
Medical Oncology	**Aberdeen**	1	1
	Edinburgh	0	1
	Glasgow	1	0
	Inverness	0	0
	Tayside	0	0 /(0.5)
Total		**2**	**2 / (0.5)**
Palliative care	**Aberdeen**	0	0
	Edinburgh	0	0
	Glasgow	0	0 / (0.5)
	Inverness	0	0
	Tayside	0	2
Total		**0**	**2 / (0.5)**

Figures in brackets are retirements of academic staff.

4.15 Medical oncologists

There is a total of 16.4 consultant medical oncologist posts, including professors and senior lecturers, in Scotland. At the census date there were 3.8 consultant vacancies in medical oncology. [Tables 16 and 17]

4.16 Medical oncology trainees

There are 24 medical oncology trainees in Scotland, 18 with NTNs. There should therefore be no difficulty in maintaining the number of consultant posts in medical oncology, and even expanding the service.

Table 16 (Medical oncology establishment 2003)

	Aberdeen	Edinburgh	Glasgow	Inverness	Tayside	Total
Population	564,000	1,384,000	2,484,000	234,000	387,000	5,055,000
Consultant	2	6	4	0	0	12
Staff Grade	0	0	0	0	0	0
SpR	2	9	8	0	3	22
SHO	2	0	0	0	0	2
Professor	0.5 (1 post)	0.5 (1 post)	0.6 (1 post)	0	0.5 (1 post)	2.1 (4 posts)
Senior Lecturer	0	0	1.8 (3 posts)	0	0.5 (1 post)	2.3 (4 posts)
Proposed Consulants/M population	3.54 (4.43)	4.33 (4.70)	1.61 (2.58)	0	2.58	2.37 (3.24)
Actual Consulants/M population	3.54	4.33 (4.70)	1.13 (1.85)	0	0 (2.58)	2.14 (2.79)

Figures in brackets are NHS plus Academic Staff.

Table 17 (Medical oncology vacancies 2003)

	Aberdeen	Edinburgh	Glasgow	Inverness	Tayside	Total
Population	564,000	1,384,000	2,484,000	234,000	387,000	5,055,000
Consultant	0	0	1.2	0	0	1.2
Staff Grade	0	0	0	0	0	0
SpR	0	0	1	0	0	1
SHO	0	0	0	0	0	0
Professor	1	1	0	0	0	2
Senior Lecturer	0	0	0.6	0	0	0.6

4.17 Palliative Care

The palliative care service is an important supportive service for oncologists. The numbers in Table 18 are the palliative care specialists attached to the 5 cancer centres in Scotland. The figures do not include those who may be working in the local hospices. The figures, however, represent a ratio of 1 palliative care physician for a population of approximately 500,000. This area of service is in serious need of increased staff resource. The Royal College of Physicians recommends 1 wte consultant per 160,000 population.

Table 18 (Palliative care establishment 2003)

	Aberdeen	Edinburgh	Glasgow	Inverness	Tayside	Total
Population	564,000	1,384,000	2,484,000	234,000	387,000	5,055,000
Consultant	2	2	2	2	2	10
Staff Grade	0	0	0	0	0	0
SpR	1	1	0	0	1	3
SHO	2	0	0	0	0	2
Professor	0	0.5 (1post)	1.2 (2posts)	0	0.5 (1post)	2.2 (4 posts)
Senior Lecturer	0	1	0	0	0	1

4.18 Radiographers

It is difficult to predict the number of radiographer staff required at each centre and in Scotland generally.[25] Guidelines allow for wide variation in numbers which will arise due to different working practices and use of technology. The employment of radiotherapy helpers for non clinical tasks will assist in making the best use of the skills of the clinically and professionally qualified staff in centres. If it is assumed that each machine (linac, orthovoltage, or simulator) requires 4 radiographers per 9am-5pm working day then, theoretically, to bring staffing in the four other centres onto a level with Glasgow, at least 33 more radiographer posts are required: 2 in Aberdeen, 17 in Edinburgh, 8 in Inverness and 6 in Tayside. These calculations are flawed as the level of staffing required by the five centres is not necessarily comparable due to the variations in complexity of the work and work patterns. Furthermore, staffing in Glasgow may not be optimal.

4.19 Table 19 shows that there are 32.25 wte vacancies for therapy radiographers in Scotland. These vacancies make it difficult for all linacs to be used throughout the full working day. Lack of trained staff to operate the linacs reduces the overall capacity of the service.

Table 19 (Radiographer establishment 2003)

	Aberdeen	Edinburgh	Glasgow	Inverness	Tayside	Total
Radiographer Establishment	17	33.25	88.4	11	19	162.64
Actual No. Radiographers	17	27.25	70	9.5	12.6	130.35
Vacancies	0	6	18.4	1.5	6.4	32.35
Radiographers in department / Linac	8.5	5.45	7	9.5	6.3	–
Radiographers in department / machine	5.67	3.4	5	3.17	3.15	–
Total Linac time / day	13h 40m	31h	71h 30m	7h	15h	–
Linac time / day/ million pop.	24.22	22.39	28.78	29.87	38.72	–

4.20 Efforts are being made to address the problem of shortage of therapy radiographers. The Glasgow School of Radiography has recently increased the number of students on its therapy degree programme. However, as the shortage of therapy radiographers is an international problem it will take some time before there are adequate numbers available. [Table 20] It is anticipated that the numbers graduating with BSc Hons in Therapeutic Radiography in Edinburgh will increase from 2008.

4.21 The RCR and the Society and College of Radiographers continue to explore ways of adjusting skill mix which could allow radiographers to work in ways that will facilitate modern treatment pathways and make best use of specialist skills. The shortage of therapy radiographers impedes the progress of these efforts.

Table 20 (Graduates from radiographer schools)

School	2003	2004	2005	2006	2007	2008
Edinburgh	5	5	22	24	8	14
Glasgow	9	11	9	14	13	15
Total	**14**	**16**	**31**	**38**	**21**	**29**

The numbers for 2005 and 2006 are high as they include a cohort of those graduating with Pre-registration Postgraduate Diploma in Radiotherapy and Oncology.

4.22 Medical physicists

Medical physicists play an important role in the running of a radiotherapy centre. Serious risk is incurred by failure to maintain an adequate establishment of medical physicists. Trained technicians are also needed to service equipment to high standards and commission new machines. The Institute of Physics and Engineering have made recommendations regarding the numbers of medical physicists that a radiation oncology unit should have.[26,27] There are 30.4 wte promoted posts and 15.3 wte trainee posts in medical physics in Scotland. There are 4 vacant promoted posts and 3.5 unfilled trainee posts. It takes 8 years to become a fully qualified medical physicist. [Tables 21 and 22]. More recently (2004) the Scottish Radiotherapy Physicists Group using IPEM recommendations have calculated that there should be 135.6 wte physicist posts in the five Scottish Cancer Centres (Appendix 2). At present, there are 107.7 with 7.7 vacancies. To assist in reducing the shortfall in staff, adequate training posts need to be established. At present, only 4 Grade A medical physic trainees per year are taken on for a four year training post. Eight might be a more realistic number as only a fraction of these will end up working in radiotherapy physics. Those that do not work in radiotherapy support the other medical physics specialties.

Table 21 (Medical physicist establishment 2003)

	Aberdeen	Edinburgh	Glasgow	Inverness	Tayside	Total
Population	564,000	1,384,000	2,484,000	234,000	387,000	5,055,000
Consultant	1	3.5	2	1	1	8.5
Principal	2.9	2	14	1	1	20.9
Trainee Sr	2	2.8	4	2	2	12.8
Trainee Basic	0	0	2	0.5	0	2.5
Grade A	*	*	*	*	*	4

*The 4 Grade A trainees rotate through the five centres

Table 22 (Medical physicist vacancies at census date)

	Aberdeen	Edinburgh	Glasgow	Inverness	Tayside	Total
Population	564,000	1,384,000	2,484,000	234,000	387,000	5,055,000
Consultant	0	0	0	1	0	1
Principal	1	0	1	1	0	3
Trainee Sr	1	0	0	2	0	3
Trainee Basic	0	0	0	0.5	0	0.5
Grade A	0	0	0	0	0	0

5 Facilities required to deliver modern radiotherapy

5.1 For a modern radiotherapy department to deliver an optimum service it should have the following characteristics:

- There should be linacs sufficient to achieve a provision equivalent to 5.5 – 6.0 per million population. At present, there are 20 machines available for a population of approximately 5 million (4 linacs / million). From the data available, the minimum extra requirement for Scotland, assuming the number of courses /machines /year is 25,000, is 3 linacs. If it is assumed that treatment schedules for those with lung and prostate cancers requiring radical radiotherapy will increase to 36 and 37 fractions respectively and that the percentage of patients with these tumours receiving radical radiotherapy increases to the levels reported in other European countries and the USA, then the minimum extra requirement will become 5 linacs (5 per million population). By 2011, when the ratio of linacs to size of population should be 5.5 / million, the number of linacs in Scotland should have increased to 29. This assumes that the population registered in 2003 has not increased by then. 29 allows for the geographical spread of the population; the number per Scottish population is 28. It is anticipated, however, that the population will decrease somewhat over the next decade so this may be a slight overestimate. [Table 23]

Table 23 (Linac requirements to 2011)

Centre	Population	Linac Cl	No. linacs req'd by 2011 (5.5 linacs / M pop.
Aberdeen	564,440	2	3
Edinburgh	1,384,430	5	8
Glasgow	2,484,430	10	14
Inverness	234,340	1	2
Tayside	387,420	2	2
Total	5,054,800	20	29

- There should be available in each centre a 3-dimensional planning computer and multileaf collimator to deliver 3-dimensional conformal radiation and / or IMRT. The review would suggest that 4 of the 5 centres already have modern treatment planning systems. Tayside still needs to update its system.
- Each centre should have a dedicated CT simulator. Only Glasgow and Edinburgh have access to a CT simulator at present.
- Each centre should have a full complement of therapy radiographers, medical physicists, technicians, supportive staff and clinical oncologists to allow waiting time targets to be met. As the number of linacs in commission increases the numbers of each category of staff required to deliver radiotherapy treatments will increase accordingly. Efforts must be made to ensure that there are adequate numbers of trainees in the various specialties to meet the demand. As treatment becomes more complex and treatment planning and quality assurance becomes more demanding, the number of therapy radiographers and medical physicists required per centre will directly increase. Equally, as clinical oncologists become more specialised, the number of new patients that each clinician can look after will decrease from the recommended 315 to the low 200's and hence the number of clinical oncologists required to staff each centre will increase.

- Each centre should have good IT facilities. As centres become more dependent on IT systems, each oncology centre will require dedicated in-house IT staff.
- Each centre should have the facility to track demand for its services and audit its performance.

6 Conclusion

In the past the resourcing of cancer care in Scotland suffered from lack of priority and strategy and difficulties with funding provision which led to major shortfalls in treatment capacity and treatment outcomes compared with other parts of the UK and Europe. The Scottish Executive's cancer strategy was clearly identified in 2001 in *Cancer in Scotland: Action for Change*. It is certain from that document that cancer is and will remain a high priority for the Scottish Executive and NHS Scotland. It is a commitment that recognises that cancer services require careful planning and substantial and sustained resourcing.

At the present time, there remains a need to continue to monitor and address waiting times for treatment and treatment capacity in each of the Scottish cancer centres. Waiting times must not be allowed to become unacceptably long. With rising incidence in cancer, unacceptable waiting times will return if care is not taken to address issues relating to staffing levels and equipment provision.

Past surveys of linac provision have indicated the need for 4 linacs per million population, rising to 5 per million. Increasing workload indicates a need for more machines in the future (5.5 – 6 per million).

It is regrettable that, unlike the installation of new CT scanners, new linacs do not allow much faster throughput of patients and may initially reduce it as new treatment techniques are introduced. They, on their own, will not contribute much to increasing capacity.

Examination of time trends in the incidence of cancer has positive predictive value in determining increasing linac workload. More rigorous data collection, however, is needed to precisely identify actual radiotherapy utilisation for cancer in Scotland. Information on the differences between optimal and actual radiotherapy utilisation, and utilisation between different health authorities and countries also requires better data collection and further research. Currently, radiotherapy utilisation in Scotland is recorded only for patients treated within 6 months of diagnosis. Figures available, therefore, currently underestimate its actual use, and direct comparison with data from other countries is somewhat misleading. The Scottish data also do not distinguish patients who require more than 1 course of treatment. Likewise, the increasing complexity of radiotherapy treatment planning and delivery cannot be fully accounted for. From the data presently available, however, it can be confidently concluded that the minimum number of linacs required in Scotland is 28, and this assumes the number of courses /machine /year is 25,000. If radiotherapy treatment schedules for patients with lung and prostate cancers increase to 36 and 37 fractions, respectively, and the percentage of patients with these tumours increases to the levels reported in other European countries and the USA, then the minimum number is 30 linacs.

Expansion in machine capacity must be linked with a commensurate increase in training capacity to ensure that there are enough staff to deliver the service. This will require joint planning across the 5 centres, and with universities, and with the associated professional bodies. Overseas recruitment is unlikely to supply sufficient staff. Staffing levels can only be increased following sustained significant increases in training places for clinical oncologists, radiographers and medical physicists.

Planning by local health care commissioners needs to ensure that local provision matches national standards to ensure equity of access to high quality care. A robust mechanism for funding, planning and approval of radiotherapy services needs to be instituted.

It is vital that medical students, medical physics students and radiographer students be exposed to oncology services during their training to attract them to work in the area.

Oncology modules should become compulsory parts of their curricula. The number of training posts and career structure for medical physicists should be improved through Government sponsorship.

In the final analysis, as this document has tried to make clear, the most important factor to consider is the patient with cancer who needs either cure or palliation. Currently, significant numbers of patients who could benefit from radiotherapy treatment are either not being referred for radiotherapy because of lack of resources or are having to wait so long for it that cure may be compromised. There is no doubt that patients are dying unnecessarily and many are not able to have timely palliation of the symptoms of advanced cancer due to the lack of radiotherapy capacity in Scotland.

It is worth remembering that no more than 2 weeks' wait is considered to be the standard of practice to aim for, with 4 weeks as the maximum acceptable wait. (JCCO)[4]

Improvements in radiotherapy technology have presented great opportunities for achieving higher cancer cure rates while at the same time reducing side effects. Initiatives on screening and improved diagnostics may well lead to increased detection of localised disease which is amenable to curative treatment. Radiotherapy has a major role to play in reducing deaths from cancer, but it has no chance of doing so if the population is denied access to high quality, timely treatment because of lack of equipment and staff.

Approved by the Board of the Faculty of Clinical Oncology:

Approved by Council:

Ref:
Date for review:

Table 24 Number of exposures under conventional (Conv) fractionation and CHART (CH) fractionation)

Tumour type	Conv / CH	Lung	Breast	Prostate	Colorectal
No. patients Diagnosed / Year 2000 – 2004		4,911	3,497	1,948	3,383
Expected increase in patients 2005 – 2009		0	379	413	264
Proportion in Scotland treated w/ RT in 6 months of diagnosis 1997 – 2000		34.2%	35.8%	9.1%	9.9%
Proportion in Scotland who should be treated w/ RT		47.3% (19.2% radical)	50%	36%	15%
No. of Fractions	**Conv**	20	25	37	25
	CH	36		37	
No. of fields	**Conv**	3	2	4	4
	CH	3		4	
Total No. of exposures	**Conv**	35,760	9,475	17,168	4,000
	CH	64,368		22,074	
Proportion in other countries treated w/ RT		40-51%	36 – 54%	21 – 36%	25%
Evidence base proportion who should be treated w/ RT[44,45,46,47,48]		61 – 76%	66 – 83%	60 – 61%	24%

Appendix I

Estimating the need for linacs from increased radiotherapy utilisation

A. Lung Cancer

Anticipated time trends in incidence of lung cancer
There are over 4,500 new cases of lung cancer diagnosed in Scotland each year. Future trends have been estimated reflecting the increase in incidence in females with a corresponding decrease in males.[28]

Current radiotherapy utilisation in Scotland
In 1995, the Scottish Cancer Therapy Network's Lung Cancer Audit reported that 30.8% of patients were being treated with chest radiotherapy. A further 5% required radiotherapy to sites other than the chest.[27] Scottish data during 1997 to 2000 confirm that about 34% of patients diagnosed with lung cancer are treated with radiotherapy.[29]

Other countries
Radiotherapy utilisation rates from France[30], UK[31], America[32,33] and Australia[,34] report actual radiotherapy utilisation rates for lung cancer of 40-51%.

Changes in radiotherapy utilisation
With the development of managed clinical networks and more respiratory oncologists, the proportion of patients with lung cancer receiving treatment will increase along with the complexity of treatment. Patients with localised disease should be treated by surgery or radiotherapy with radical intent unless excluded by age, performance status or co-morbidity. In these cases, palliative radiotherapy for symptom control may be indicated. 32% of patients were diagnosed with localised disease, in the Scottish Cancer Therapy Network's Lung Cancer Audit. Treatment with radical intent, with surgery or radiotherapy, was only recommended for 10.7% and 2.7% of patients respectively.[28]

A further 25% of patients were diagnosed with loco regional disease and a proportion of these should also be considered for treatment with radical intent.

An estimate made for resource implications assumed that 60% of patients with localised disease should be offered resection or high dose radiotherapy. This would increase the proportion treated with radiotherapy from 2.7% to 19.2%. This accounts for a further 596 patients requiring extra radiotherapy fractions. Current radical radiotherapy doses for lung cancer within Scotland are commonly delivered using a hypofractionated regimen of only 20 fractions. Alternative fractionation regimens that could be used are the CHART regimen (36 fractions), or standard fractionation using at least 30 fractions.

Extra resources required
A further 596 patients requiring treatment, with an average of 20 fractions, would account for a further 11,920 fractions or 35,760 fields for 3-field conformal radiotherapy. With 30 fractions this increases to 53,640 fields. If patients receive CHART, as recommended by NICE, then the number of exposures rises to 64,368

B. Breast Cancer

Anticipated time trends in incidence of breast cancer
Over the past 10 years there has been a 9% (326 patients) increase in the number of patients diagnosed with breast cancer. It has been suggested that if this present trend continues, then in the period 2005-2009 there will be at least 4,232 new cases of breast cancer diagnosed per annum. This accounts for an actual increase in patients requiring treatment of 379 (233-524) new cases per year.[35]

Current radiotherapy utilisation
Dewar, et al, have reported on changes in treatment and workload in the years 1987 and 1993. The use of postoperative radiotherapy increased by 72% (from 34% to 49%).[36] Data from Scotland suggest that only

35% of patients with breast cancer being treated with radiotherapy within 6 months of diagnosis[37]. Often radiotherapy is not administered until later than 6 months after diagnosis, due to the use of adjuvant chemotherapy.

Other countries
Internationally, there is a trend towards increasing utilisation of radiotherapy. Actual radiotherapy utilisation rates reported from UK[31], America[33] and Australia[38]are 36-54%.

Extra resources required
Radiotherapy will continue to be recommended to about 50% of patients diagnosed with breast cancer. Using the estimated projection of 379 extra new cases per year, receiving up to 25 fractions, would account for a further 4,737 fractions or 9,475 fields.

C. Prostate Cancer

Anticipated time trends in incidence of prostate cancer
There has been a 29% increase in the number of patients diagnosed with prostate cancer in Scotland over the past 10 years.[39] The anticipated increase in incidence for prostate cancer is based on increased use of Protein Specific Antigen (PSA) tests and the likelihood of the introduction of a PSA screening programme. Based on this model, it is estimated that there would be an extra 413 men diagnosed with prostate cancer per annum.[39]

Current radiotherapy utilisation
As the incidence of prostate cancer increases, the use of radiotherapy will also increase. This increasing incidence is not reflected in the percentage of patients currently receiving radiotherapy in Scotland (9%). This 9% is only the proportion of patients treated within 6 months of diagnosis and, therefore, underestimates the total number treated. The low percentage results from the increased use of neoadjuvant hormones, rather than late referral. Published UK data on the actual radiotherapy utilisation rate for patients with prostate cancer cannot at present be identified. Indeed, more work is required to determine how Scottish radiotherapy utilisation compares with other countries.

Other countries
The American patterns of care study identified that 28.6% of men were treated with radiotherapy and 28.3% with radical prostatectomy.[40] Data from Holland, where the incidence of prostate cancer is also rising, identified an increase in the use of radiotherapy from 11% to 36%.[41] In an Australian study the proportion of patients irradiated was 21%.[42]

Changes in radiotherapy utilisation
The change that affects the overall treatment for all patients that require radiotherapy is the increase from 32 fractions to 37 fractions (2,893 x 0.28 x 5 = 4,050 fractions or 162,000 fields).

The increasing availability and use of prostate brachytherapy and the increased number of fields and treatment time required for prostate IMRT have not been incorporated into this model.

Extra resources required
In anticipation that at least 28% of the 413 extra new cases per year will receive radiotherapy, a further 116 courses of treatment will be required. Current practice uses 37 fractions (4,292 fractions) and a 4-field conformal beam arrangement (17,168 fields). If the percentage receiving radical radiotherapy rises to the level treated in Holland then the increase in exposures will be 22,074 fields.

D. Colorectal Cancer

Anticipated time trends in incidence of colorectal cancer
A 12% increase in incidence of colorectal cancer was observed during the 10-year period from 1991 to 2000 . Extrapolating current time trends in incidence, Scotland can expect an increase of 264 new cases per annum.[43]

Current radiotherapy utilisation
In Scotland only 10% of patients diagnosed with colorectal cancer were treated with radiotherapy within 6 months of diagnosis.[38] The proportion treated with radiotherapy within this time frame each year has been stable.

Other countries
UK data from the Northern and Yorkshire Cancer Registry report an actual radiotherapy utilisation rate of 25% for colorectal cancer,[31] with 13% treated with radiotherapy alone and a further 12% in conjunction with surgery.

Changes in radiotherapy utilisation
The main factors influencing radiotherapy utilisation for colorectal cancer are whether a patient is treated with short-course preoperative radiotherapy, long-course postoperative radiotherapy or primary chemoradiation. Currently, most patients are treated with long-course postoperative radiotherapy of up to 25 fractions.

Extra resources required
An increase of 264 new cases per annum, where a minimum of 15% of patients require radiotherapy, would account for an extra 1,000 fractions or 4,000 fields.

Appendix II Scientific and Technical Support for Radiotherapy

	Physicists	Dosimetrists*	Engineers	Total
RECOMMENDED MINIMUM ESTABLISHMENT 2004				
Aberdeen	7.7	5.4	5.3	18.4
Dundee	6.8	3.9	4.1	14.8
Edinburgh	13.2	10.1	7.9	31.2
Glasgow	25.7	18.9	15.2	59.8
Inverness	5.2	3.2	3	11.4
TOTAL	**58.6**	**41.5**	**35.5**	**135.6**
ACTUAL ESTABLISHMENT 2004				
Aberdeen	6	2	2	10
Dundee	4	2.5	3	9.5
Edinburgh	7.3	8.7	7	23
Glasgow	22	15.5	22.5	60
Inverness	3	1	1.2	5.2
TOTAL	**42.3**	**29.7**	**35.7**	**107.7**
OVERALL SHORTFALL 2004				
Aberdeen	1.7	3.4	3.3	8.4
Dundee	2.8	1.4	1.1	5.3
Edinburgh	5.9	1.4	0.9	8.2
Glasgow	3.7	3.4	-7.3	-0.2
Inverness	2.2	2.2	1.8	6.2
TOTAL	**16.3**	**11.8**	**-0.2**	**27.9**
CURRENT VACANCIES 2004				
Aberdeen	0	0	0	0
Dundee	0	0	0	0
Edinburgh	1	0.7	0	1.7
Glasgow	6	0	0	6
Inverness	1	0	0	1
TOTAL	**8**	**0.7**	**0**	**8.7**

REQUIRED ESTABLISHMENT 2007				
Aberdeen	6	3	2	11
Dundee	6	3	4	13
Edinburgh	12	11	8	31
Glasgow	29	19.5	17	65.5
Inverness	4	2	2.2	8.2
TOTAL	**57**	**38.5**	**33.2**	**128.7**
INCREASE REQUIRED WRT 2004				
Aberdeen	0	1	0	1
Dundee	2	0.5	1	3.5
Edinburgh	4.7	2.3	1	8
Glasgow	7	4	– 5.5	5.5
Inverness	1	1	1	3
TOTAL	**14.7**	**8.8**	**– 2.5**	**21**

*Includes mould room staff and radiographers working in treatment planning.

The Appendix II spreadsheet shows the radiotherapy physics staffing figures for the five centres in Scotland, with both the current (2004) and the Institute of Physics and Engineering in Medicine (IPEM) recommended figures shown. The data is analysed separately for clinical scientists (physicists), physics technologists (dosimetrists) and mechanical/electronic technologists (engineers). The latter two are commonly grouped under the Medical Technical Officer title.

The IPEM figures are the minimum required for the provision of a routine physics service to radiotherapy and do not, for example, include a commitment to teaching & training or research and development. Neither do they include the computing/IT support that all radiotherapy physics departments are now asked to provide.

The conclusion is that all departments are well below their minimum recommended level for physicists and dosimetrists, averaging just over 70% of that required. The exception is the engineers staff group which, for valid reasons, is above that recommended in Glasgow and therefore pulls up the national average to that recommended. Glasgow has problems with recruiting physicists, as shown by their high number of vacancies.

References

1 The Royal College of Radiologists (1999) Equipment, Workload and Staffing for radiotherapy in the UK 1992-1997 BFCO(98)2. London: Royal College of Radiologists.

2 The Royal College of Radiologists (2000) Equipment, Workload and Staffing for radiotherapy in the Scotland 1992-1997 BFCO(00)1. London: Royal College of Radiologists.

3 The Scottish Executive / NHS Scotland (2001) Cancer Scenarios: An aid to planning cancer services in Scotland in the next decade: www.show.scot.nhs.uk/publications/csatp.

4 Joint Collegiate Council for Oncology (1993) *Reducing delays in cancer treatment – some targets produced by the Joint Collegiate Council for Oncology*. London: Royal College of Physicians.

5 Steele G (1993) *Basic clinical radiobiology*. London: E Arnold.

6 Souhami R, Tobias J (1986) *Cancer and its management.* Oxford: Blackwells.

7 Pignon JP, Bourhis J, Domenge C, Designe L (2000) Chemotherapy added to locoregional treatment for head and neck squamous-cell carcinoma: three meta-analyses of updated individual data. MACH-NC Collaborative Group. Lancet 2000; 355(9231): 767-8.

8 Esco R, Palacios A, Pardo J, et al (2003) Infrastructure of radiotherapy in Spain: a minimal standard of radiotherapy resources. Int J Radiat Oncol Biol Phys 2003; 56: 319-327.

9 Slotman B, Leer JWH (2003) Infrastructure of Radiotherapy in the Netherlands: evaluation of prognoses and introduction of a new model for determining the needs. Radioth Oncol 2003; 66: 345-349.

10 Bernier J, Horiot JC, Bartelink J, et al (1996) Profile of radiotherapy departments contributing to the Cooperative Group of Radiotherapy of European Organisation for Research and Treatment of Cancer Int J Radiat Oncol Biol Phys 1996; 34: 953-960.

11 Porter A, Aref A, Chodounsky Z, Elzaway A, Manatrakul N, Ngoma T, Orton C, Van't Hooft E, Sikora K (1999) A Global Strategy for Radiotherapy: A WHO Consultation. Clin Oncol 11:368-370

12 Delaney GP, Jacob S, Featherstone C, Barton MB (2003) Radiotherapy in cancer care: estimating optimal utilisation from a review of evidence-based clinical guidelines. Collaboration for Cancer Outcomes Research and Evaluation (CCORE), Liverpool Hospital, Sydney, Australia. 2003

13 OECD (1998) OECD Health Data 98 Paris OECD

14 Equipment Workload and Staffing for Radiotherapy in the UK 1997-2002. London The Royal College of Radiologists (2003) BFCO (03)3

15 The Royal College of Radiologists (2000) *The Provision and replacement of radiotherapy equipment.* London: The Royal College of Radiologists.

16 O'Sullivan B, Mackillop W, Grice B (1998) the influence of delay in the initiation of definitve radiotherapy in carcinoma of the tonsillar region. Int J Radiat Oncol Biol Phys 42 (Suppl): 323.

17 O'Rourke N, Edwards R.(2000) Lung cancer treatment waiting times and tumour growth. Clin Oncol ; 12:141-144.

18 Fortin A, Bairati I, Albert M, Moore L, Allaid J, Couture L (2002) Effect of treatment delay on outcome of patients with early stage head and neck carcinoma receiving radical radiotherapy. Int J Radiat Oncol Biol Phys 52: 929-936.

19 Coles CE, Burgess L, Tan LT (2003) An audit of delays before and during radical radiotherapy for cervical cancer – effect on tumour cure probability. Clin Oncol; 15: 47-54.

20 Waaijer A, Terhaard CHJ, Dehnad H, Hordijk GJ, van Leeuwen MS, Raaymakers CPJ, Lagendijk JJW (2003) Waiting times for radiotherapy: consequences of volume increase for the TCP in oropharyngeal carcinoma. Radioth Oncol : 66: 271-276

21 Slotman B J& Leer JWH (2003) Infrastructure of radiotherapy in the Netherlands: evaluation of prognoses and introduction to a new model for determining the needs. Radioth Oncology 66:345-349.

22 Extending the working Day for the delivery of Radiotherapy. London: The Royal College of Radiologists.(1997) BFCO (97)3

23 Salter Baker & Associates Ltd. (1996) *Review of Linear Accelerator Capacity*-Cancer Care. Southampton: Salter & Baker Associates.

24 Good Practice Guide for Clinical Oncologists (2nd Edition) . London: The Royal College of Radiologists.(2003) BFCO (03)3

25 *Radiographic Staffing Standards in the Clinical Oncology Department*. London: The Society of Radiographers(1999).

26 *Recommended minimum Staffing Levels for the Medical Physics support of Radiotherapy, Nuclear Medicine, Diagnostic Radiology and Associated Radiation Protection*. The Board of Directors of the Institute of Physical Sciences in Medicine (now known as the IPEM) (1993) York: IPEM.

27 *Manual of Cancer Services Assessment Standards-Consultation Document*. NHSE (2000) London: Department of Health.

28 Gregor A, Milroy R. Lung Cancer. Cancer Scenarios: An aid to planning cancer services in Scotland in the next decade. Scottish Executive Health Department (2001) Edinburgh www.show.scot.nhs.uk/sehd/publications/csatp

29 Gregor A, Thomson CS, Brewster DH, Stroner PL, et al. (2001) Management and survival of patients with lung cancer in Scotland diagnosed in 1995: results of a national population based study. Thorax 56:212-217

30 Grosclaude P, Galat JP, Mace-Lesech J, et al (1995) Differences in treatment and survival rates of non-small-cell lung cancer in three regions of France. BJ Cancer 72:1278-82

31 Northern and Yorkshire Cancer Registry Information. www.nycris.org.uk

32 Fry WA, Menck HR, Winchester DP.(1996) The national cancer database report on lung cancer. Cancer 77:1946-55.

33 National Cancer Institute. SEER cancer incidence public-use database, 1973-1999. Bethseda: Department of Health and Human Services, 2002

34 Richardson GE, Thursfield VJ, Giles GG.(2000) Reported management of lung cancer in Victoria in 1993: comparison with best practice. Med J Australia 172:321-

35 Twelves C (2001) Breast Cancer. Cancer Scenarios: An aid to planning cancer services in Scotland in the next decade. Scottish Executive Health Department (2001) Edinburgh www.show.scot.nhs.uk/sehd/publications/csatp

36 Dewar JA, Twelves CJ, Thomson CS(1999). Breast Cancer in Scotland: changes in treatment and work-load. Scottish Breast Cancer Focus Group and Scottish Cancer Therapy Network. Clinical Oncology.11.1:52-54.

37 Scottish Cancer Intelligence Unit http://www.show.scot.nhs.uk/isd/cancer/cancer.htm

38 Hill D, Jamrozik K, White V, et al. (1995) Surgical management of breast cancer in Australia in 1995, Sydney. National Health and Medical Research Council, National Breast Cancer Centre.

39 Kirk D. (2001) Prostate Cancer. Cancer Scenarios: An aid to planning cancer services in Scotland in the next decade. Scottish Executive Health Department (2001) Edinburgh http://www.show.scot.nhs.uk/sehd/publications/csatp www.show.scot.nhs.uk/sehd/publications/csatp.

40 Mettlin CJ, Murphy GP, Rosenthal DS, Menck HR (1998) *The National Cancer Database Report on prostate cancer after the peak in incidence rates in the U.S*. The American College of Surgeons Commission on Cancer and the American Cancer Society. Cancer 83(8):1679-84.

41 Spapen SJ, Damhuis RA, Kirkels WJ (2000) Trends in the curative treatment of locwalized prostate cancer after the introduction of prostate-specific antigen: data from the Rotterdam Cancer registry. BJU International. 85(4):474-80.

42 McCredie M, Bell J, Lee A, Rogers J (1991) Differences in patterns of care of prostate cancer, New South Wales. Australian and New Zealand Journal of Surgery. 66(11):727-30

43 Dunlop M (2001) Colorectal Cancer. Cancer Scenarios: An aid to planning cancer services in Scotland in the next decade. Scottish Executive Health Department (2001) Edinburgh http://www.show.scot.nhs.uk/sehd/publications/csatp www.show.scot.nhs.uk/sehd/publications/csatp

44 Delaney G, Barton M, Jacob S, Jalaludin B(2003). A model for decision making for the use of radiotherapy in lung cancer. Lancet Oncology 4:120-28

45 Foroudi F, Tyldesley S, Walker H, Mackillop WJ (2002). An evidence-based estimate of appropriate radiotherapy utilization rate for breast cancer. Int. J Radiat Oncol Biol Phys. 53:1240-1253

46 Delaney G, Barton MB, Jacobs S (2003) Estimation of an optimal radiotherapy utilization rate for breast cancer. Cancer 98(9);1977-86.

47 Foroudi F, Tyldesley S, Barbera L, Huang J, Mackillop WJ (2003). Evidence-based estimate of appropriate radiotherapy utilisation rate for prostate cancer. Int J Radiat Oncol Biol Phys. 55.1:51-63

48 Foroudi F, Tyldesley S, Barbera L, Huang J, Mackillop WJ. (2003) Evidence-based estimate of the appropriate radiotherapy utilisation rate for colorectal cancer. Int J Radiat Oncol Biol Phys. 56.5:1295-1307