UNIVERSITY
OF YORK

CENTRE FOR HEALTH ECONOMICS
HEALTH ECONOMICS CONSORTIUM

The Costs of Radiotherapy in Cancer Treatment

by
Maria Goddard and
John Hutton

DISCUSSION PAPER 48

UNIVERSITY OF YORK

CENTRE FOR HEALTH ECONOMICS

THE COSTS OF RADIOTHERAPY IN CANCER TREATMENT

by

Maria Goddard
and
John Hutton

 October 1988

The Authors

Maria Goddard is a Research Fellow and John Hutton a Senior Research Fellow in the Centre for Health Economics at the University of York.

Acknowledgements

We gratefully acknowledge the assistance of our colleagues at York and our research collaborators in the NHS, especially Professor P Horton and Dr W White of St Lukes Hospital, Guildford. We would also like to thank Vanessa Windass and Vanessa Waby for typing the paper in its present and previous forms. The authors accept full responsibility for any remaining errors.

Further Copies

Further copies of this document are available (at price £4.00 to cover the costs of publication, postage and packing) from:

The Secretary
Centre for Health Economics
University of York
Heslington
York YO1 5DD.

Please make cheques payable to the University of York. Details of other Discussion Papers can be obtained from the same address, or telephone York (0904) 430000, ext. 3647/6.

The Centre for Health Economics is a Designated Research Centre of the Economic and Social Research Council and the Department of Health and Social Security.

Abstract

Radiotherapy is used extensively in the treatment of many cancers. It is often used alone as the primary therapy, or in conjunction with other forms of treatment such as surgery and chemotherapy, on both a curative and palliative basis.

In many instances, there are choices to be made between competing therapies and with regard to the optimum duration and intensity of the chosen treatment. In order to make properly informed and efficient choices that maximise benefits to patients, decision makers need access to information regarding both the relative effectiveness of treatment in treating the cancer and the relative costs of providing the therapies.

This paper directly addresses the question of establishing the costs of radiotherapy, one of the main cancer treatments available today. In doing so it reviews existing studies and attempts to account for their apparent inconsistencies. Most are found to be limited in their treatment of costs and difficult to compare due to methodological variations in the calculation of costs. Two of the more comprehensive studies are re-analysed in order to provide a measure of relativity of costs in departments of varying sizes, and a preferred methodology for costing is outlined.

If choices are to be properly informed, more and better cost information for all types of cancer treatment is needed. Additionally, there is a need for knowledge of the benefits of therapies for the patients. Detailed effectiveness data, focusing on quality as well as quantity of survival would complete the basis for well-informed and efficient choices to be made.

THE COSTS OF RADIOTHERAPY IN CANCER TREATMENT

Introduction

In many types of cancer, a choice exists between the use of surgery, radiotherapy, chemotherapy, or combinations of these, as the primary form of treatment. Even when a form of treatment has been chosen, its optimum duration and intensity must be determined. On a broader level there is a choice to be made between allocating resources to cancer treatment or to the treatment of other conditions. Concern has been expressed over the apparent lack of knowledge of, and interest in, such resource issues within the medical profession (Timothy, 1988).

In order to make these choices in an informed and efficient way, two sorts of information are required. Data regarding the <u>effectiveness</u> of different techniques in the treatment of cancer is essential. Such data should include not only information on length of survival after various treatments as this is not always the outcome of relevance (for example in palliative therapy), but also measures of the quality of life during survival. Secondly, it is important to have knowledge of the <u>costs</u> of treatments for cancer. This should be as accurate and comprehensive as possible if the allocation of resources between and within cancer therapies is to produce maximum benefits for patients.

To answer these questions fully is beyond the scope of this paper, as detailed evidence is required on the costs and effectiveness of various treatments for the whole range of cancers. However, by concentrating on one specific aspect of the problem, it is hoped some progress can be made towards the final goal. An attempt is made here to draw together the evidence on the cost of radiotherapy for cancer treatment. By examining the context of the studies and the costing methodologies used by the authors, possible explanations for inconsistencies and anomalies in the results are discussed. The analysis excludes those studies where radiotherapy is costed as part of the overall treatment package but where costs for the radiotherapy are not given separately, as evaluation of the costs of only the radiotherapy input is impossible in such cases. The paper then goes on to examine the results of two of the studies in more detail and by making several revisions to the costing methodologies, a more direct comparison of the costs of radiotherapy treatments in departments of different sizes, is made possible. Finally, some observations regarding the costing of radiotherapy for cancer are made and a preferred methodology is outlined, noting that the approach adopted would vary according to the purpose of any costing study undertaken.

(I) The Use of Radiotherapy in Cancer Treatment

Radiotherapy is used extensively in the treatment of many cancers. In some cases, it is the primary curative treatment, for example, in some localised inoperable lung cancers and some early head and neck cancers. More often it is used in conjunction with another treatment such as surgery for conservative breast cancer treatment; or with chemotherapy for Hodgkins disease. In addition, radiotherapy is often used on a palliative basis for a wide range of cancers in order to relieve the symptoms of cancer.

Treatment involves the use of X Rays and Gamma Rays which cause damage to cancerous cells. Healthy cells are not as sensitive to radiation as the malignant cells and therefore are less likely to suffer damage during treatment. However, doses of radiation must be kept below the level at which normal cells are damaged too much to allow recovery. Many treatments require doses approaching this level in order to be effective and such high doses are associated with the unpleasant side effects of radiotherapy treatment, such as nausea, tiredness and hair loss.

Megavoltage beams can be delivered from various types of machines (Prosnitz et al 1983). Cobalt units provide the lowest energy and least precise beams whereas Betatron machines give higher energy beams but are large and expensive. Linear accelerators produce the highest output and have sharply defined beam edges allowing accurate delivery of treatment. Planning and delivering the course will also involve the use of other items of equipment such as simulators, planning computers and deep and superficial X ray machines.

A course of treatment comprises a set of fractions of radiotherapy with each fraction consisting of exposures to radiation. Different doses of radiation are given in different fractionation schedules for various cancer types. This is because cells are most sensitive to radiation before mitosis (i.e. before they begin duplicating themselves) and therefore, as cells are not all at the same stage of their cycle at the same time, repeated exposures will result in more cancerous cells being irradiated at the sensitive stage and thus in more cancerous cells being killed (Hancock and Bradshaw 1981).

(II) Existing Evidence on Radiotherapy Costs in Cancer Treatment

Despite the widespread use of radiotherapy treatment for cancer, there is little evidence on the costs of radiotherapy in the UK or indeed elsewhere. Evaluation of what little information exists is made difficult by two factors in particular. Firstly, the costings refer to different units of 'output' such as fractions, attendances at out-patient departments, courses of treatment or weeks of treatment which therefore makes the direct comparison of costs difficult. Secondly, the costing methodologies vary enormously between studies with some taking into account capital costs of machinery (an important cost element in radiotherapy), maintenance, space for machinery, and other overheads; whilst others simply divide annual departmental running costs by total number of patients or attendances. Evaluation is made even more difficult where authors do not specify precisely the elements they have chosen to include or exclude. This is particularly the case when charges for services are used as measures of costs as it is not usually clear if an element for overheads and capital has been included in such figures.

In the tables that follow, the studies have been divided into two categories. Table 1 shows the results from studies that cost individual units of radiotherapy such as a fraction (i.e. a set of exposures to radiation) or attendance at an out-patient department; whilst Table 2 includes those that estimate the cost of more general units such as weeks of treatment or courses of therapy for different cancer types. Some authors appear in both sections due to the fact that they base their estimates of the cost of the courses of radiotherapy on the average costs of individual attendances or fractions multiplied by the duration or frequency of the typical treatment given for various cancer types. Table 3 lists elements of the costs of radiotherapy treatments indicating how comprehensive the studies are in relation to these cost elements. The table allows us to begin to account for some of the variation in estimated costs illustrated in the previous tables.

Table 1: Estimated Costs of Radiotherapy Treatment (1988 £UK)

Author(s)	Date	Origin of study	Estimated cost per unit
J.S. SIMPSON	1982	NEW ZEALAND	£ 8.60 PER FRACTION
D. GREENE	1983	U.K.	£ 16 PER FRACTION
L. ATHERTON	1984	U.K.	£ 37 PER FRACTION
D.L. BALL	1982	AUSTRALIA	£ 58 PER ATTENDANCE
M. FRIEDLANDER AND M. TATTERSALL	1982	AUSTRALIA	£ 46 PER ATTENDANCE
D. HUGHES AND M. McEVEDY	1981	U.K.	£ 21 PER ATTENDANCE

(All costs converted to 1988 £UK using the OECD purchasing power parities and the U.K. retail price index)

Table 1 gives the results from three studies that costed fractions of radiotherapy and three that considered attendances at radiotherapy departments. The first set of estimates show a marked variation in the estimated cost of fractions of radiotherapy. Some of this variation is relatively easy to explain. Simpson's estimate of the cost of 25 fractions is based upon hospital charges for foreigners treated in New Zealand. It is not clear whether this includes an allowance for capital or overheads and thus actual resource costs may be underestimated.

Greene attempts to cost one radiotherapy treatment on a linear accelerator, considering both the capital and running costs of a radiotherapy department. Table 3 illustrates the coverage of the costing methodology used by Greene with the major exclusions (recognised by Greene) being medical and administrative staff costs and buildings to house the auxiliary equipment. These points are taken up by Atherton who extends Greene's costing methodology, adding in allowances for medical and support staff, overheads and building costs for other equipment. Atherton also points out that Greene's method of calculating the annual costs of capital based on simple interest rates, underestimates capital costs, and Atherton amortises costs correctly but at a higher interest rate than Greene. An additional difference between these two studies is the size of the department considered. Greene's study is set in the context of a large radiotherapy department with 4 linear accelerators whereas Atherton considers just a 2 machine department. Therefore, certain fixed cost elements such as building costs can be spread over a large number of machines in Greene's study which lowers the average cost per patient and per fraction. These results and the methodology used by these authors is discussed further in Section (III) where some revisions are made in order to make these studies more comparable and to draw some conclusions regarding the influence of size of department on average costs.

Table 1 also presents the cost estimates of studies that looked at attendances at radiotherapy departments and again there is substantial variation in results. Ball divides the annual running costs of a large radiotherapy department by total attendances in one year to arrive at the estimate given. A breakdown of departmental costs is given and Table 3 shows that Ball has included items such as maintenance, power and administrative overheads. However, the breakdown is not given in sufficient detail to ascertain whether an allowance has been made for the cost of the machinery. Ball notes that as salaries, heat and power constitute a large proportion of the total costs, a reduction in the number of attendances will not necessarily reduce costs by the full estimated average costs.

Friedlander and Tattersall estimate a slightly lower cost per attendance. They state that the estimate allows for initial capital costs and maintenance costs and point to the similarity of their estimate to

Ball's. Unfortunately, Friedlander and Tattersall do not give enough detailed information regarding the source of their estimate to take the comparison any further. Hughes and McEvedy calculate a lower estimate of £21 per attendance. The estimate is based on an analysis of financial figures for the radiotherapy department in a South East Thames hospital. Again, whilst the authors state that capital cost of the machine on an 'historical basis' has been taken into account, no further information is given.

Table 2 lists the results of studies that cost more general units such as weeks of therapy or "courses" of treatment for particular cancers. In order to make some comparisons, it is useful to examine the results where more than one author has costed the radiotherapy input for a particular cancer. This applies only to breast, lung and testicular cancer. Two studies specifically cost the radiotherapy input for breast cancer. Scitovsky presents estimates based upon the actual cost of treatment received by 5 women treated only by radiation therapy in 1981. The costs are based on charges for specific services used in the treatment such as physician visits and hospital costs. The estimate is therefore likely to include in-patient costs but probably not capital costs. Scitovsky also reports costs for other modes of treatment for breast cancer. The lower estimate reported by Mattsson et al is again based on actual treatment received by patients and is limited to postoperative radiotherapy. The authors do not elaborate on the basis of this cost estimate as the study's main aim is to examine the cost of chemotherapy for cancer treatment. Neither of the authors give the duration or frequency of treatment so it is possible that this may also account for some of the variation in cost per course of treatment.

Table 2: Estimated Costs of Course of Radiotherapy Treatment (1988 £UK)

Author(s)	Date	Origin of study	Estimated cost
G. REES	1985	U.K.	£ 465 - 2 WEEKS PALLIATIVE RT FOR LUNG.
			£1151 - 6 WEEKS CURATIVE RT FOR LARYNX.
			£3723 - 6 WEEKS CURATIVE RT FOR LARYNX. (WITH 2 WEEKS AS IN-PATIENT)
D. HUGHES AND M. McEVEDY	1981	U.K	£ 622 - 2 WEEKS RT FOR BLADDER
			£ 415 - 4 WEEKS RT FOR LUNG
			£ 415 - 4 WEEKS RT FOR LYMPHOSARCOMA
			£ 415 - 4 WEEKS RT FOR TESTES
B. MITTAL ET AL	1983	U.S.	£1828 - 6/6.5 WEEKS RT FOR GLOTTIC CARCINOMA
M. FRIEDLANDER AND M. TATTERSALL	1982	AUSTRALIA	*£1163 - TESTES
			£ 830 - SMALL CELL LUNG
H. KAY ET AL	1980	U.K.	£ 350 - 5 WEEKS RT FOR BONE MARROW TRANSPLANT
A. SCITOVSKY	1982	U.S.	*£3909 - BREAST
W. MATTSSON ET AL	1979	SWEDEN	*£2571 - BREAST
			£3956 - LUNG
G. HANKS AND K. DUNLAP	1986	U.S.	*£3626 - EARLY PROSTATE

* Duration of treatment not specified.

Costs for treatment of testicular cancer are presented by two authors and again there is some variation in magnitude. Both authors base total treatment costs upon their estimates of cost per out-patient attendance given in Table 1. It would appear therefore that both studies cost a similar duration and number of attendances, but use very different average costs per attendance in their calculations. For lung cancer, again the variation in cost estimates is wide. The differences between Hughes and McEvedy and Friedlander and Tattersall are again linked to their original average cost estimates, and again, although the authors are using quite different costs per attendance, the total estimated costs of the course of treatment suggests that both use similar numbers of attendances in their calculations for lung cancer. Rees uses an average cost of one treatment calculated by another author[1] and multiplies this by the number of treatments needed for lung cancer and also cancer of the larynx. Whereas Hughes and McEvedy use 4 weeks of out-patient radiotherapy for their calculation, Rees uses 2 weeks but specifically states that this is palliative radiotherapy. This therefore may be the source of the variation. The estimate presented by Mattsson et al is based on actual treatment received by patients with lung cancer but is certainly far higher than any of the other estimates. As previously mentioned, the authors give no detail of the method used to estimate radiotherapy costs and therefore it is not possible to account for the wide difference in order of magnitude. It is, however a hospital based cost and it is possible that in-patient costs are included in the total cost figures presented.

The other cancers considered are cancer of the larynx, glottis and bladder, lymphosarcoma and leukaemia. The method used by Hughes and McEvedy and Rees has already been discussed.

---

1 The paper does not clearly state the precise source of the estimate but it seems likely to come from Atherton's paper.

Kay's figure of £350 for 5 weeks radiotherapy for Bone Marrow Transplant patients is based on an estimated daily cost of £14 and refers to 'whole body' radiation. The costing is on an in-patient basis only and is based on the running costs of the hospital department. Kay points out that only one quarter of all BMT patients receive radiotherapy and thus the mean cost spread over <u>all</u> patients would be much lower. Further details regarding allowances for capital costs, overheads etc. are not given.

The study by Mittal et al considers the costs incurred for radiotherapy treatment for eighteen patients with glottic carcinoma. The authors include one patient who was treated as an in-patient as the travelling distance to the out-patient clinic was prohibitive. The cost figure presented in Table 2 excludes the much higher costs incurred by this patient and relates only to out-patient radiotherapy treatment. The estimate is based on bills for radiotherapy (for insurance purposes) and includes treatment and physician charges but probably excludes capital costs, although no details of this are given.

The average cost estimate of Hanks and Dunlop for cancer of the prostate is again based upon the radiotherapy bills for one hundred and twenty eight actual patients treated in two centres in the U.S.A.

It is clear from Table 3 and the above discussion, that at least part of the variation in estimated costs is due to the comprehensiveness of the methodology used to cost the radiotherapy input. Many of the studies do not give sufficient detail to allow conclusions to be made concerning the elements they have chosen to include as part of the costing exercise. For example, it is not possible to ascertain whether capital cost of the machinery has been included in some studies. Even where authors state that an allowance has been made, they often do not give details of <u>how</u> the allowance has been incorporated. Also, where staff salaries have been included, most of the studies do not specify whether or not they have included employers costs of national insurance and superannuation in the salary figures. Where such on-costs are not mentioned, it is likely that they have indeed been excluded.

In addition to the comprehensiveness of the methodology used for costing, there are several other possible reasons for some of the cost variations.

Firstly, the size of the department is likely to influence average cost per fraction or attendance. Certain elements are not likely to vary proportionately with, for example, the number of machines in the department. This point is taken up again later in the paper in Section (III), where the studies by Greene and Atherton are examined in more detail.

Secondly, throughput or workload will influence average costs. Many costs do not vary with workload per machine - for example, the building costs, machine costs, administrative costs, and to some extent, other staff costs. Thus if throughput is very high, average cost per patient will be low. The study by Greene used 800 new patients per year per machine as the measure of average throughput. This is based on DHSS guidelines which stated that this was an appropriate planning base. However, the recent Coopers and Lybrand report on Cancer Services in North East Thames, shows a wide variation in actual throughput with numbers of new patients as low as 250 per annum in some centres (Coopers and Lybrand Associates 1986). Furthermore, Greene uses an average of 12 fractions per course which is based upon experience at his own institute where patients having curative

TABLE 3: COMPREHENSIVENESS OF COSTING METHODOLOGIES EMPLOYED BY AUTHORS.

	SIMPSON	GREENE	ATHERTON	BALL	FRIEDLANDER TATTERSALL	HUGHES McEVEDY	KAY	SCITOVSKY	MATTSSON	HANKS DUNLAP	MITTAL
CAPITAL											
MAIN RADIOTHERAPY EQUIPMENT eg linear accelerators	?	✓	✓	?	✓	✓	?	?	?	?	?
AUXILIARY MACHINES eg simulator planning computer	?	✓	✓	X	?	?	?	?	?	?	?
ACCOMMODATION FOR EQUIPMENT											
- MAIN MACHINE	?	✓	✓	X	?	?	?	?	?	?	?
- AUXILIARY	?	X	✓	X	?	?	?	?	?	?	?
INSTALLATION COSTS	X	X	X	X	X	X	X	X	X	X	X
STAFF SALARIES											
MAIN STAFF											
- RADIOTHERAPISTS	PROBABLE	X	✓	PROBABLE	PROBABLE	PROBABLE	?	PROBABLE	PROBABLE	PROBABLE	PROBABLE
- RADIOGRAPHERS	PROBABLE	✓	✓	PROBABLE	PROBABLE	PROBABLE	?	?	?	?	?
- OTHER eg PHYSICISTS	?	✓	✓	✓	?	?	?	?	?	?	?
SUPPORT STAFF eg administration portering cleaning	?	X	PROBABLE	?	?	?	?	?	?	?	?
EMPLOYMENT COSTS - national insurance + s.a.	?	?	PROBABLE	?	?	?	?	?	?	?	?
OTHER											
MAINTENANCE ON EQUIPMENT	?	✓	✓	✓	✓	?	?	?	?	?	?
PARTS	?	✓	✓	?	PROBABLE	?	?	?	?	?	?
POWER	?	✓	✓	✓	?	?	?	?	?	?	?
OTHER OVERHEADS	?	?	✓	✓	?	?	?	?	?	?	?

treatment have an average of 15 fractions, whereas palliative treatment averages at 8 fractions. However, there appears to be a trend towards increasing numbers of fractions per course which may in turn reduce the number of courses that can be undertaken per annum (Southend Health Authority Report 1987). The sensitivity of cost per course, fraction or attendance to workload variations is again examined in more detail later in this paper. However, as many of the studies do not state the average throughput for the machine or department they are considering, it is likely that some of the variation in estimates of average costs may be caused by variations in workload.

A further influence on estimated costs is related to the location of the radiotherapy services. The pattern of departmental costs is likely to be quite different for a service organised as part of a general hospital when compared with services that form part of a specialised centre for cancer treatments.

The type of machine considered is also important as some of the studies are now dated and will therefore be based upon older techniques which may have been less efficient and more costly to operate. Whilst Greene, Atherton and Ball explicitly state that the costing refers to treatments using linear accelerators, other studies do not give such information and may relate to Cobalt or Betatron equipment.

(III) Some Revisions of Existing Studies

In order to tackle some of the points raised in the previous section regarding the influence of size of department and throughput on average costs, two of the studies have been examined in more detail.

Greene's study is based on a large department where at least 4 linear accelerators are operated. In contrast, Atherton responded to the study with his own estimates of costs for a smaller, 2-machine department. As they stand, the two studies cannot be directly compared due to several inconsistencies and the variations in comprehensiveness of the costing. Therefore what follows is an attempt to re-work the figures of both studies on a more comparable basis.

Capital Costs

Greene's study included an allowance for the linear accelerator, simulator and planning computer. These costs were spread over the expected lifetime of the equipment (15 years for the accelerator and simulator and 10 for the computer). However, Greene calculated simple interest at 10%, assuming that interest would be paid on the diminishing capital sum.

Additionally, Greene allowed for the building cost associated with accommodating the linear accelerator. This cost was assumed to be written off over 20 years.

Atherton correctly pointed out that the method of calculating interest adopted by Greene produced an underestimate of true cost and he therefore adjusted the method in order to amortise capital and to arrive at an annual equivalent cost. Atherton chose to use 15% as a discount rate rather than 10%. In addition, Atherton allowed for the building costs associated with the accommodation for simulator and planning equipment also.

In re-working both studies, the capital costs have been discounted at 5% which is the test discount rate for the public sector (HM Treasury, 1982). Also, the useful life of the planning computer has been adjusted to 10 years in accordance with Greene's observation. Greene's study aimed to calculate the cost of 1 treatment on 1 machine but the context of the costings was a large 4 machine department. Therefore the revised costings include all elements of the whole 4 machine department in order to compare this with Atherton's smaller 2 machine department. The capital costs of 4 treatment rooms and also rooms for the simulator and computer have been added to Greene's study. Diagnostic equipment such as CT scanners and nuclear magnetic imaging equipment has not been taken into account here. Total annual capital costs, discounted at 5%, with the above adjustments made, are as follows:

Annual Capital Costs (£1988)

GREENE	:	£265,854
ATHERTON	:	£147,377

Staff Costs

(i) Radiographers

Greene calculates that one linear accelerator requires 2 senior radiographers, 2 basic radiographers and 10% of superintendent. Additionally, he estimates that the operation of the simulator requires half this allowance (i.e. 6.15 in total).

Atherton is less specific and costs "8 x £9000" for the total number of radiographers required in the 2 machine department.

With no further information available, the re-working takes into account the recommended staffing requirements of the Royal College of

Radiologists and calculates that a 4 machine department with simulator and computer would need 19 Radiographers (which is consistent with Greene's estimate of 6.15 for 1 machine, simulator and computer) and 11 for the 2 machine department.

(ii) Medical technicians and physicists

Greene presents figures for the total salary bill of this group of staff for the whole region. He then calculates that one-tenth of their time can allocated to 1 linear accelerator (plus associated work on auxiliary equipment). In the absence of any other information, the revised estimates for the 4 machine department allocates four-tenths of the total salary bill to the department.

Atherton uses 1.25 WTE for physicists and 1.25 for technicians. This remains the same in the revised estimate.

(iii) Radiotherapists

Greene does not make any allowance for radiotherapists in his original estimates and this is therefore one possible cause for the lower average cost estimate.

Atherton allows for "3 x £20,000" for radiotherapists. Again, using the Royal College staffing norms, the figure for larger departments appears to be about 5 radiotherapists and this is used in the relevant calculations.

(iv) Support staff

Again, these costs are omitted altogether by Greene. Atherton costs 1 administrator, 2 secretaries, 2 receptionists, 4 porters and 2 cleaners in his study.

The same costs for the support staff are added to Greene's estimates as they are unlikely to be higher, even for the larger department.

(v) Employment costs

Atherton adds 20% overheads onto staff costs. This is approximately the correct amount for national insurance and superannuation costs. Therefore the same percentage has been calculated for Greene.

The total amount of staff costs calculated as above are:

Annual Staff Cost (£1988)

GREENE	:	£490,583
ATHERTON	:	£362,930

Maintenance and Power

Both authors calculate the cost of spare parts, maintenance and power for the machines. Both arrive at different estimates of each element, but the reworking leaves them unadjusted apart from the allowance made for the extra machines in the large department.

The total annual costs for the above elements are:

Annual Maintenance Costs (£1988)

GREENE	:	£49,404
ATHERTON	:	£31,739

General Overheads

Atherton includes a 15% allowance on departmental costs for general lighting, heating etc. This has been calculated for Greene also who omits this in his original study.

Total Costs

Adding all the revised elements together, gives the estimated annual total costs for the departments of different sizes as shown in Table 4. Whilst recognising that many assumptions have been made in this reanalysis, in order to reduce inconsistencies between authors, it at least provides some measure of relativity of costs in departments of varying sizes.

Table 4: Estimated Annual Total Costs - Summary

	Greene (4 machine dept.)	Atherton (2 machine dept.)
Capital	265,854	147,377
Staff	490,583	362,930
Maintenance and Power	49,404	31,739
General Overheads	47,288	26,869
TOTAL	£853,129	£568,915

Calculating cost per course and per fraction

If Greene's figures of 800 new patients per machine and 12 fractions per patient are used as the workload measure, as they are in Table 1, the comparative costs of a fraction are £22.21 in a large department and £29.63 in a smaller department.

By adjusting some of the cost elements in order to make the methodology consistent, the difference in costs is obviously much reduced. Originally, table 1 shows that Atherton's estimate was more than twice as much as Greene's, whereas the difference is now less than 40%.

By using some alternative estimates of numbers of patients treated per machine and numbers of fractions per course, the effects of varying throughput can be examined.

Table 5 illustrates the cost per fraction under different assumptions on patient throughput and average numbers of fractions per course.

Table 5: Cost per Fraction Using Various Throughput Assumptions

	Cost per Fraction (£1988)	
Assumed throughput	Small dept.	Large dept.
800 PATIENTS - 12 FRACTIONS	£29.63	£22.21
600 PATIENTS - 12 FRACTIONS	£39.50	£29.62
1000 PATIENTS - 12 FRACTIONS	£23.70	£17.77
600 PATIENTS - 15 FRACTIONS	£31.60	£23.70

(IV) Preferred Methodology

The approach taken to the costing of radiotherapy for the treatment of cancer will depend on the aim of the study. For example, the aim may be to compare the cost of different treatments for the same cancer as in the case of surgery versus radiotherapy. Alternatively, the purpose may be to compare the cost of delivering the same treatment at different departments or locations. These factors will influence the type of approach taken. However, before considering how the purpose of the study affects the unit of measurement, it is possible to set out some general guidelines for the costing of radiotherapy services. In the following discussion, each element of cost is considered in turn.

(i) Costs to National Health Service

This category includes all costs borne by the hospital and community health service sector in delivering radiotherapy services. The following cost elements are relevant:

Capital

Capital is obviously an important cost element in radiotherapy due to the large amount of equipment required. The discussion of previous studies noted two main capital elements:

(i) machinery for radiotherapy - linear accelerators, cobalt units and auxiliary equipment such as simulators and planning equipment.

(ii) buildings to accommodate such machinery.

Whichever element is being considered, it is important to begin with the replacement value of the item and not historical costs. Several of the studies mentioned in the discussion do not make clear whether the costs they have used are replacement or historical costs.

The calculation of equivalent annual cost (EAC) as in the revision of the studies by Greene and Atherton (see Section (III)) makes allowance for depreciation of the machinery or building over time and also for the opportunity cost of the capital involved.

The earlier discussion noted that both Greene and Atherton used market interest rates in discounting the capital outlays. However, the preferred approach to costing projects in the NHS would be to begin with the test discount rate of 5% and perhaps to examine later the sensitivity of the results to varying discount rates.

Another issue is the choice of time period over which to discount the capital costs. Both Greene and Atherton choose 15 years for the linear accelerators, but Greene notes that the useful life of the planning computer is less than this. When choosing a time period it is the useful clinical life of medical equipment that is relevant.

For buildings, the convention is 60 years (Drummond et al 1987) but both Greene and Atherton use 20 years. Greene's justification is that the treatment room is likely to last for approximately the life of two machines with relatively minor modifications. This may well be the case for specialised buildings such as treatment rooms with little chance of alternative use, but otherwise it is probably as well to follow convention and use 60 years, assuming that the building will be used for other purposes later.

If the purpose of the study is to cost fractions or courses of radiotherapy, rather than total departmental costs, it will be necessary to apportion the cost of capital over the total number of fractions or courses completed during the time period of interest.

When considering the auxiliary equipment such as simulators and computers, it is important to note that they can manage the workload of more than one radiotherapy machine. In small departments there will therefore often be spare capacity associated with auxiliary equipment which implies that the marginal cost of an extra treatment plan for example, may be very low; whereas average costs may be high relative to average costs in a larger department where auxiliary machinery may be used to full capacity due to the availability of larger numbers of radiotherapy machines.

Staff

As noted earlier in the paper, many studies do not appear to allow for the full range of staff costs associated with the provision of radiotherapy services in cancer treatment. Staff directly associated with provision include radiotherapists, radiographers, medical physicists and technicians. Additionally, the costs of administrative and support staff need to be included. In all instances, it is necessary to add on the employers costs of national insurance and superannuation payments.

The difficulty in costing staff for radiotherapy services lies in assessing how much of their time (and therefore their cost) is to be allocated to particular tasks or machines within the department. In some instances, as recorded by Greene, a group of staff may undertake all the workload for a region and therefore the cost of employing them must be shared between hospitals and departments in the region.

Other

There will be considerable costs associated with the running of the equipment involved in radiotherapy and these should be included. As table 3 illustrates, the costs of maintenance, parts and power must be accounted for. Additionally, there may be other overheads such as general heating and lighting which should be allocated according to some reasonable method such as proportional square feet of space occupied.

In-Patient Costs

Much radiotherapy treatment is organised on an out-patient basis. However, in some instances, in-patient treatment is given. Many large centres therefore have in-patient beds designated for radiotherapy patients and most radiotherapy departments have access to beds in other specialities. Where in-patient stays form part of the course of radiotherapy then the cost of this must be included. This involves similar procedures to those outlined above, ie allocating overheads, staff time etc, according to number of in-patient days needed. Alternatively, there is a possibility that the cost per in-patient day may be available for some of the specialities and providing it is not thought that the patients use significantly more or less resources than the average patient in the hospital, then this could be used in the calculations.

Transport Costs

Only two of the studies listed, consider transport costs for radiotherapy treatment (Hughes & McEvedy 1979 and Mittal et al 1983). These costs are not included in the cost estimates of Table 1 as this would cloud the comparisons being made. Patients attending out-patient facilities might require up to six weeks therapy and in some circumstances the transportation might be the responsibility of the health service ie ambulance or hospital cars.

(ii) Costs Outside National Health Service

Patient and Family

Transport costs may fall on the patient and family rather than the health service, if patients make their own transport arrangements. The magnitude of these costs will obviously depend on both the frequency (usually daily from Monday to Friday) and duration of treatment as well as the distance to the clinic or centre. The question of travelling distance becomes important, if patients travel to specialist centres located far from their home areas. In many cases a trade-off may exist between requiring the patient to travel in order to be treated at an out-patient centre or hospitalising the patient in order to save transport costs and also to reduce the inconvenience of having to travel daily. Mittal et al point out that this was indeed the case for one of the patients in their study who was admitted to hospital as an in-patient because of excessive travelling distance to the clinic. For all other patients in this study travelling costs comprised approximately 7% of total treatment costs.

In addition, if the patient is brought for daily treatment by someone in their family, or a friend, costs may also arise due to missed employment or leisure time. The identification and valuation of such time costs are a problematic area and are discussed more fully elsewhere (eg Drummond 1980). However, they are likely to be much more significant in some cases than in others, for example, extended radiotherapy treatment for children might impose significant costs on parents who may need to take time off work and stay in accommodation near the place of treatment. Several studies have addressed the question of the non-medical costs of cancer, some estimating that substantial proportions of such costs in cancer treatment are due to lost wages (Hants et al 1984, Lansky et al 1979).

Social services and voluntary organisations.

Several other sectors may incur some of the costs of radiotherapy treatment. For example, counselling or home nursing costs may fall on the social services or voluntary organisations. However, many of these services could be common to all types of cancer treatment (and in fact may be more likely for certain surgical techniques such as laryngectomy or mastectomy) and not specific to radiotherapy treatment. Such costs would be important where cancer treatment is being compared with treatment for other conditions which may not require such inputs.

Purpose of the Costings

The methodological points made above in the context of radiotherapy are of importance in any costing study and are elaborated in other texts (Drummond 1980, Drummond et al 1987). However, there are additional factors to take into account depending upon the main purpose of undertaking the study. The main interest might be to establish the cost of treating specific cancers with different treatments such as radiotherapy, surgery, chemotherapy or combinations of these treatments. In such a case, the relevant unit of analysis would be average costs of providing a course of each treatment. Thus the calculation of radiotherapy costs would take into account all inpatient and outpatient treatment and also costs to the patient where appropriate. Alternatively, the aim might be to compare the costs of using radiotherapy for different cancers and again the relevant focus is average cost per course of treatment for the different cancer sites. It is possible that the aim is to determine departmental costs in order perhaps to explore the effect of scale on costs. In such a case, total costs standardised for departmental size would be the appropriate unit. Similarly, in looking at costs in various departments, it might be of interest to calculate estimates of marginal costs of treatments at different centres in order to make some conclusions about optimal provision. The principle of marginal costing of units of radiotherapy (fractions) would be relevant where issues of the length of the course of radiotherapy become important. For example, shorter intensive courses versus longer, lower dose courses in palliative treatment. When relatively small changes in workload are considered, average costs are unlikely to be affected in the first instance and marginal costs would be the appropriate unit of analysis.

(V) Conclusion

This review has shown that existing evidence on the costing of radiotherapy is limited and not strictly comparable because of the different approaches adopted in the various studies.

However, in reconciling some of these differences it can be seen that the substantial discrepancies which remain might be attributable to different medical approaches to the delivery of radiotherapy treatment to cancer patients. If substantial cost differences do indeed exist between the different approaches it is doubly important that the relative effectiveness of different methods of treatment should be established. Only if this is known can judgements be made on the appropriate distribution of resources in this sensitive area.

The immediate research needs suggested in the radiotherapy area are for empirical studies to confirm the estimated costs of treatment, and comparative studies of the effectiveness of different approaches to the use of the technique. These should involve assessment of the impact on length of survival and quality of life during the survival period. Ongoing research will therefore focus on further work with existing literature and participation in prospective trials in order to make progress in these areas.

Once the position with regard to the use of radiotherapy has been clarified, the comparison between different forms of cancer treatment may become easier, as equivalent information on other forms of treatment emerges from other studies. Choices regarding competing therapies for cancer are being made every day. Any information shedding further light on the relative costs and effectiveness of different treatments could lead to better decision-making and increased benefits to patients.

References

Atherton L (1984), The cost of radiotherapy treatments on a linear accelerator. The British Journal of Radiology, 57, 106 - 107.

Ball D L (1982), Cost implications of different fractionation schedules in palliative radiotherapy. Australian Health Review, 5(2), 24 - 25.

Coopers and Lybrand Associates (1984), Review of Cancer Treatment Services. North East Thames Regional Health Authority

Drummond M F (1980), Principles of Economic Appraisals in Health Care. Oxford University Press, U.S.A.

Drummond M F, Stoddart G L and Torrance G W (1987), Methods for the Economic Evaluation of Health Care Programmes. Oxford University Press, U.S.A.

Friedlander M L and Tattersall M H N (1982), Counting the costs of cancer therapy. European Journal of Cancer and Clinical Oncology, 18(12), 1237-41

Greene D (1983), The cost of radiotherapy treatment on a linear accelerator. The British Journal of Radiology, 56, 189 - 91

Hancock B W and Bradshaw J D (1981), Lecture Notes on Clinical Oncology Blackwell Scientific Publications. Oxford.

Hanks G E and Dunlap K (1986), A comparison of the cost of various treatment methods for early cancer of the prostate. International Journal of Radiation : Oncology, Biology, Physics, 12 (10), 1879-81.

Hants P S, Lipton A, Harvey H, Martin B, Simmonds M, Dixon R, Longo S, Andrews T, Gordon T, Meloy J and Hoffman S (1984), Non-medical costs to patients and their families associated with out-patient chemotherapy. Cancer, 53, 2388-92.

Hughes D J and McEvedy M B (1981), The effective cost of medical treatment. Management Accounting, February, 38-39.

HM Treasury (1982), Investment Appraisal in the Public Sector, London, HMSO.

Kay H E M, Powles R L, Lawler S D and Clink H M (1980), Cost of bone-marrow transplants in acute myeloid leukaemia. Lancet (i) 1067-9.

Lansky S B Cairns N U, Clark G M, Lauman J, Miller L and Trueworthy R (1979), Childhood Cancer: non-medical costs of the illness. Cancer, 43, 403-08.

Management Advisory Service to the NHS (1987), Southend Health Authority: the appraisal of options for the provision of cancer services to the population of S.E. Essex with particular reference to the Radiotherapy and Oncology Service provided by Southend Health Authority.

Mattsson W, Gynning I, Carlsson B and Mauritzon S E (1979), Cancer chemotherapy in advanced malignant disease: A cost benefit analysis. Acta Radiological Oncology, (18), 509-520.

Mittal B, Rao D V, Marks J E and Ogura J H (1983), Comparative cost analysis of hemilaryngectomy and irradiation for early glottic carcinoma. International Journal of Radiation : Oncology, Biology, Physics, 9(3), 409-16.

Prosnitz L R, Daniel M D, Kapp S, and Weissberg J B (1983), Radiotherapy. New England Journal of Medicine, 309, (13) 771-777.

Rees G J G (1985), Cost effectiveness in Oncology. Lancet, (ii), 1405-28.

Scitovsky A A (1982), Changes in the costs of treatment of selected illnesses, 1971-81. Medical Care, 23, (12) 1345-57.

Simpson J S (1982), The cost effectiveness of conservative surgery for breast cancer. Australian Health Review, 5(2), 18-19.

Timothy A R, (1988), Report of conference : cost versus benefit in non-surgical management of patients with cancer. British Medical Journal, 297, 471-2.