Multinational assessment of some operational costs of teletherapy

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Received 4 September 2003; received in revised form 6 January 2004; accepted 25 February 2004

Abstract

Background and purpose: Decisions in planning radiotherapy facilities in countries with limited financial resources require information on economic factors to make provision for sustainability. This study aims at acquiring data on some of these factors involved in delivery of teletherapy in 11 countries of different economic status.

Patients and methods: Representatives of three European, one African, three Latin American and four Asian countries, were identified from radiation oncology institutions that operated both cobalt and linac teletherapy machines. Productivity data were prospectively collected for the year 2002. A detailed log was recorded for each machine over an arbitrary two-week period. Data on quality assurance (QA), maintenance, the capital costs of each machine, and the source replacement costs for the cobalt units were also recorded.

Results: Both linear accelerators and cobalt machines treat more than 10,000 fractions per year per machine with 2.5 and 2.3 fields per fraction, respectively. The capital costs of the machines vary considerably, with a factor of more than 10 for linear accelerators. Cobalt sources show a huge variation in price. The median costs of QA and maintenance of a linac was US$ 41,000 compared to US$ 6000 for cobalt machines. This results for the economic factors considered in median costs per fraction of US$ 11.02 for linear accelerators and US$ 4.87 for cobalt machines. These figures do not include the costs for physicians.

Conclusions: The variation of the costs per fraction is more due to the result of differences in machine usage and costs of equipment than of national economic status. A treatment fraction on a linac with functionality comparable to cobalt, costs 50% more than cobalt therapy. This project shows that it is possible to collect data on economic factors prospectively as well as retrospectively.

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Keywords: Multinational cost assessment; Costs of radiotherapy; Economic factors

1. Introduction

Radiotherapy is a multifaceted process of which one of the most evident components is the actual delivery of the radiation dose. Data available regarding costs predominantly refer to industrialized countries and/or single institutions [1–8,11]. Because of different methodologies used, these are difficult to compare and the conclusions may not be applicable to less developed countries. In order to obtain data that were broadly applicable, the IAEA supported a study aiming to evaluate several cost components of teletherapy and to identify the magnitude of the
effect of each of these components in institutions from different regions with differing economic, health systems, and resources. Since the most evident component of radiotherapy is the delivery of the radiation dose by teletherapy, this study was confined to the investigation of teletherapy delivery costs. Instead of trying to collect complete data on all cost components covering radiotherapy from beginning to end, it was preferred to subdivide the study into smaller facets, and to start with the actual delivery of one fraction of a teletherapy series. Even when doing so, the problem of drawing the boundaries between different aspects of the radiotherapy process exists. For instance, which components can really be defined as contributing to the direct costs and which belong to the overhead? Should the direct costs include the treatment room building costs, depreciated over 30 years? Should these include dressing rooms, waiting areas, sanitary areas? What about the costs of cleaning, maintenance of the treatment room, medical checks during treatment, clinical quality control and others? Should interest paid on capital costs be included?

The participants of the study concluded that it would be impossible to define all cost components and further that the study would have to be restricted to data that could be collected prospectively or could be determined retrospectively in an accurate way, e.g. the number of fractions per year and the historical price of the machine, respectively.

It was also decided that principally building costs should be seen as direct costs and to include these, if possible, also in the study.

2. Materials and methods

The IAEA advertised a study aiming to evaluate cost components of teletherapy in the field in disparate countries. Eleven institutions responded timely. The eleven participants represented radiation oncology institutions that operated both cobalt and linac teletherapy machines in three European (Croatia, Greece and The Netherlands), one African (South Africa), three Latin American (Brazil, Cuba, Peru) and four Asian (China, India, Indonesia, Pakistan) countries. The institutions were representative for the status of radiotherapy in their countries. Agreement on data to be compiled and analyzed was obtained at an introductory meeting held in Vienna in December 2001.

The participants recorded over an extended period the productivity of these machines and their associated costs. Productivity data were prospectively collected as the total number of fractions was treated monthly per machine for one calendar year, the year 2002. A detailed log was recorded for each machine over an arbitrary two-week period during the same calendar year. Participants were asked to choose a period, which they considered representative for normal operation. The details recorded during those 2 weeks were:

(i) the time the unit was switched on and off daily,
(ii) the number of patients treated,
(iii) the number of fields per patient,
(iv) the number of radiographers on duty at any time during patient treatment, and
(v) the time and nature of any scheduled and unscheduled machine down-time.

A monthly summary of all scheduled and unscheduled maintenance costs as well as hours spent by different professionals for maintenance and quality control was collated. Costs considered were salaries, service and spare part costs, and service contract costs. Other associated costs were electrical and water supply costs. The original capital cost of each machine and of quality assurance (QA) equipment and the source replacement costs for the cobalt units were recorded.

All costs were specified in US dollars, calculated for other currencies by using the historical currency exchange rates. For the cost components associated with the data collected in 2002, the currency exchange rate per 1 July 2002 was used.

A supplementary group of machines previously utilized by the participating institutions were identified and their commissioning and de-commissioning dates were documented to determine the life expectancy.

A simple mathematical model, based on the data collected, was used to calculate the costs of a radiotherapy fraction, insofar these costs are attributable to the components defined. These components were:

- the yearly depreciation of the machine
- the salaries of the radiographers or nurses involved
- the QA and maintenance costs
- the power consumption
- the yearly depreciation of the building costs.
- in case of cobalt machines the costs of regular source replacement have been included.

By dividing the total yearly costs by the yearly number of fractions the cost per fraction was determined. This calculation was carried out for the reference year 2002 and for all machines in the study. A more generally applicable model has also been developed to investigate the relative importance of the different cost components in low-, medium-, and high-salary countries. This model uses the same mathematics as described before but is based on the actual median values for some components and estimates for others.

3. Results

3.1. Treatment machines and personnel

A total of 50 machines in 16 institutions from 11
countries, all of which had both cobalt machines and linear accelerators (linac), were surveyed over the 12-month period (1/1/2002–31/12/2002) selected for analysis. In one country six radiotherapy departments with one or two machines participated; together they were able to provide sufficient data to adequately represent the situation in that country. No private facilities were surveyed. The total number of cobalt machines studied was 20 and the total number of linacs was 30. Among the cobalt machines were locally produced static units with 50 cm source–skin-distance (SSD) as well as recently installed computerized isocentric units with 100 cm source–axis-distance (SAD) and asymmetrical collimators. The linear accelerators ranged from single photon machines without electrons to dual photon machines with electrons, multi-leaf-collimators (MLC), and portal imagers.

One linac that broke down in December 2001 and was decommissioned in 2002 and one linac that was commissioned eventually in December 2002 were excluded from the statistics of functioning machines. Four linacs were commissioned in 2002 and one cobalt machine was decommissioned. Since these operated for more than 6 months in this period, they were included. The usage data of these machines were extrapolated to a full year.

For the 600 machine-months recorded, one linac was able to operate only in electron mode for the full 12 months. This was due to technical problems with the X-ray target, which could not be repaired because of lack of financial resources. For the 50 machines, there were 29 months when breakdowns significantly limited patient treatment; 2 months for the 20 cobalt machines and 27 on the 30 linacs, including the 12 months of the electron-mode only machine. There was no relation between the age of the machines and the downtime.

The life expectancy of the machines was determined from an additional group of 24 machines decommissioned before this study. This group comprised of 18 cobalt therapy machines decommissioned at a median age of 17.3 years and six linear accelerators at 17.7 years. The data suggest that there is a shift towards shorter life expectancies for more recently installed machines so the term for depreciation was accordingly set at 15 years for both cobalt and linacs. The median ages of the 50 functioning machines in our study were 15.5 years for cobalt and 5.8 years for linacs on 1 July 2002.

The number of radiographers carrying out the treatments varies considerably, from 1 to 5 per machine.

Note that the number of cobalts and linacs in some of the calculations differs from the total number of machines in the study. The reason is that some institutions in the country that participated with six departments were not able to provide the two-weekly data that formed the basis for many of the calculations. However, some of those institutions were still able to produce the total number of patients treated, and/or the capital costs of the machines and these data were used.

### 3.2. Productivity, complexity, and quality assurance

The total number of fractions given over this period was 535,553; of which 223,915 were on cobalt machines and 311,638 on the linear accelerators. The number of fractions per unit per year ranged from 1214 to 37,336, median 10,555, for cobalt machines and 2247 to 21,404, median 10,847, for linear accelerators. Note that 37,336 fractions per year were achieved by extending the working day to more than 20 h on one of the units.

To check the representativity of the two-week period used for the detailed registration the productivity in this period multiplied by 26 was compared with the yearly data. For most machines, the difference was much less than 10%, and for no machines larger than 20%. The agreement was considered to be adequate.

To correct for large differences in working day lengths the statistics quoted in this study are reduced to fractions per operating hour. Fractions per hour were a median of 4.4 (2.3–8.0) on cobalt units and 5.1 (3.3–7.7) on the linacs.

The complexity of the treatment technique is reflected among others in the number of beams (fields) per fraction used to deliver the dose to the target volume. The number of fields per fraction was a median 2.42 (1.05–3.49) over all machines. For cobalt machines the median was 2.27 (1.50–2.76) and for linear accelerators 2.54 (1.05–3.53).

Hospital personnel were found to perform most of the routine QA on machines. Whilst the time spent on linac QA and maintenance was typically 1.5 times that of cobalt (median 310 h compared to 190 h) the inter-country variability was most pronounced, ranging from 48 h minimum on both cobalt and linac to a maximum of 790 h on a cobalt unit versus 1020 for a linac. There is also a considerable variation in the personnel performing the QA. In some countries radiographers performed simple daily checks and the physicists more extensive QA. In other countries, only physicists are involved. Engineers were sometimes also involved in QA but evidently have their main tasks in maintenance where sometimes physicists are also involved. The median number of hours spent by the radiographers, physicists, and engineers for cobalt machines 70, 65, and 55, and for linacs 70, 130, and 110, respectively.

### 3.3. Cost elements

#### 3.3.1. Capital costs

The nominal groups of cobalt and linac machines used in this study were highly heterogeneous in terms of their age and features, the cobalts with ages ranging from 1 to 26 years, and with different technical features like SSDs ranging from 50 to 100 cm, with hand-driven or motorized collimators, with simple read-outs or fully computerized. Likewise the linacs ranged in age from 0.5 to 16 years, with SADs from 80 to 100 cm, from single photon energy to dual
photon energies in combination with electrons, and with additional features like portal imaging and MLC.

The price of the linear accelerators varied accordingly from US$ 129,532 (purchased December 1986) to US$ 1,800,000 (purchased January 2001).

Seven of the 20 cobalt teletherapy machines were from one manufacturer and the same model. These were found to have risen in price from under US$ 70,000 (mid 1980s) to about US$ 480,000, including the source.

3.3.2. Costs of cobalt sources

The current cost per TBq of cobalt sources varies widely between countries. Sources may be obtained from the original equipment supplier, or a reprocessor. The price range from the participants was from US$ 100 to 900 per TBq and is shown in Fig. 1. India utilizes local reprocessing of sources while Chinese sources are locally produced and reprocessed. These are shown to be cheaper than sources derived from outside the user country. The median replacement period was 7.4 years over 21 sources identified from all cobalt units. The cost of a cobalt source replacement, based on 2002 local pricing, was distributed over 7 years and was added to the maintenance cost of each unit.

3.3.3. Quality assurance and maintenance

The total annual cost of all servicing and QA procedures was calculated in US$. These were comprised of four components: the costs, if any, of contracts, other third party costs, the depreciation of QA equipment, and costs of hospital personnel involved in maintenance and/or QA. Personnel costs were calculated from the gross salary. For cobalt machine the range of the total annual costs of QA and maintenance was US$ 1270 to 35,680 with a median of 5970, for linacs it was US$ 3000 to 91,740 with a median of 41,390.

3.3.4. Power costs

Power consumption of the various linac models was obtained from Varian, Siemens, Elekta, GE and Mitsubishi. Utilizing local rates for electricity in kW h and individual machine usage, a median cost per year of US$ 2800 (731 to 8078) was obtained for linacs while cobalt machine costs for power were only US$ 250 per year. Water costs were also identified for participating countries, but, as all linacs used recirculating systems, this factor was irrelevant in cost assessment.

3.3.5. Personnel

The hourly wages were calculated from the annual salaries, taking into account public holidays, vacations and the length of the working day, usually, but not always, 8 h. Since we were interested in the gross salaries this figure was increased with the employers contribution to social security schemes, ranging from 0 to 33%. The gross hourly wages for radiographers ranged from US$ 0.78 to 29.87 with a median of 3.20, for engineers from US$ 0.87 to 33.56 with a median of 2.51, and for physicists from US$ 1.00 to 75.26 with a median of 4.73. Physician salaries were not relevant since the calculation related to the delivery of a standard fraction, where a doctor usually is not involved.

3.3.6. Building costs

Only four countries were able to provide an indication of the building costs for a radiotherapy treatment room. The range was very large, from US$ 40,000 in India to US$ 1,000,000 in The Netherlands. The costs of the land were not included. Because the data were scarce and comparison complicated by determining the associated control area and waiting room costs, it was decided to leave this component out of the cost calculation.

3.4. Costs per fraction

An analysis of the combined cost components per fraction delivered showed a range from US$ 1.29 to 34.23 for cobalt machines with a median of 4.87 and from 3.27 to 39.59 for linacs with a median of 11.02. Fig. 2 shows the costs per fraction per participating country, averaged over the machines in that country. The costs per fraction are predominantly determined by three components: the number of fractions per year, the capital costs of the machine, and the costs of QA and maintenance. This is shown in Fig. 3 for the linacs. This figure shows the different trends despite of the large variation. For cobalt machines the same dependence is found to be less striking.

Table 1 shows the median values of the different components and the calculated costs per fraction for cobalt machines and linacs. For the calculation, a life expectancy of 15 years is used for the machines and 7 years for the cobalt source. Table 2 shows the costs per fraction based on the same data as in Table 1 but now for the different machines when purchased in 2002. Prices are based on information from the manufacturers and actual quotations but will vary according to the factors mentioned before.

![Figure 1: Variation of price of cobalt sources in US$ per TBq.](image-url)
4. Discussion and conclusions

4.1. Treatment machines and capital costs

Age and technical specifications, i.e. functionality, are primary factors influencing the initial capital cost of the linac teletherapy machines. There is also an inter-country variability which depends on secondary factors such as insurance and import duties, agents fees, the total equipment package purchased, e.g. whether this includes record and verification systems, planning systems, simulators, CT-scanners and/or other diagnostic equipment. Sometimes other factors also play a role, like extended warranty (up to 5 years), whether a maintenance contract including some or all spare parts is included and whether training is offered to personnel.

Factors impacting specifically to costs of cobalt machines, additional to those of relevance to linacs are the national regulations regarding handling and disposal of the radioactive source.

For the investigated machines the breakdown time of the linacs was considerably higher than the cobalt machines, i.e. 8% versus less than 1%. The main cause was that repairs were often delayed because of lack of financial resources.

It is striking that the costs of cobalt sources vary by a factor of more than 10. Low costs are found in countries that supply locally produced source or reprocessed ones, but high costs are difficult to explain. An international supplier of cobalt sources was asked for their list prices and these varied from US$ 255 to 310 per TBq depending on source activity and source diameter. There is no clear explanation why some countries had to pay up to three times that amount, other than extra costs due to local regulations, insurance rates and costs of transportation.

4.2. Productivity, complexity, and quality assurance

Although the productivity in terms of fractions per hour in general did not show large differences, except for as few special cases, the number of fractions per year varied considerably because of the variation in working day length. This explains how more than 37,000 fractions can be carried...
out on a cobalt machine in a country where the working day length was more than 20 h.

The median values of the number of fractions per year for cobalt machines and linacs are almost equal, 10,500 and 10,900, respectively. However, the number of fractions per hour is slightly less for cobalt machines than for linacs (4.4 versus 5.1), most likely due to the doserate at isocentre which during the useful lifetime of a cobalt source can be on average half, or even lower, that of a linac. While setting up the patient will take roughly the same time, the beam-on time on a cobalt will on average be twice or more than that of a linac.

On 12 machines 6–8 patients were treated per hour but not at the cost of technique complexity, since in all cases except one, the number of fields per fraction was more than 2.10. One of the measures taken was to group patients with similar treatment techniques in order to prevent unnecessary mounting and dismounting of auxiliary equipment. The machine used to treat more than 37,000 fractions annually, did so by treating 8 patients per hour, with 2.23 fields per fraction.

The difference between the number of fields per fraction of cobalt machines and linacs indicates that simpler techniques are carried out on cobalt machines. In institutes with cobalt units and linacs the latter unusually have more sophisticated functionality and are therefore preferably used for more complex techniques, while cobalt machines are used more often for palliative and consequently somewhat simpler techniques.

Two machines had low fields per fraction values, 1.05 and 1.26. The first was found on the machine that was used in electron mode only and electron treatments are usually single-field techniques. The other value was found in an Institute that used non-standard protocols with successive fields of a multi-field technique treated on successive days. Some high values, between 3 and 4, were found on linacs used for more complex conformal techniques.

The variation in the costs of QA and maintenance is caused by many factors. First, for those machines for which maintenance is covered by a contract there is a large variation in the cost of those contracts depending on their conditions. All-in contracts are obviously more expensive than contracts only covering preventive maintenance. The cheapest contract recorded for cobalt machines was US$ 1400 per annum, the most expensive US$ 32,000. For linacs they were US$ 3500 and US$ 80,000, respectively.

Other factors influencing these costs are whether or not major parts like magnetrons or klystrons had to be replaced, and the number of hours spent by own personnel; this also shows a large variation.

The high end of the costs found for linacs and cobalts are similar to published values for modern dual energy linacs and cobalt machines [9,10].

Other costs which were discussed, were those of acceptance testing and commissioning. However, a rough calculation shows that these costs are almost negligible.
The difference between low salary countries and the median results in a change of more than 5% in the costs per fraction. Raising the cost by 10% of one of these items, the number of radiographers per machine, and the number of cases the calculation is most sensitive for changes in salary, is in the median salary country in high salary country.

Table 2
Costs per fraction for different treatment machines when purchased in 2002

<table>
<thead>
<tr>
<th>Treatment machine</th>
<th>Capital costs</th>
<th>Costs per fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>in median salary country</td>
<td>in high salary country</td>
</tr>
<tr>
<td>Dual energy linac with extra features like MLC, portal imaging, etc.</td>
<td>1,500,000</td>
<td>14.80</td>
</tr>
<tr>
<td>6 MV single energy linac without extra features</td>
<td>650,000</td>
<td>8.90</td>
</tr>
<tr>
<td>Cobalt machine</td>
<td>450,000</td>
<td>5.80</td>
</tr>
</tbody>
</table>

NB. Costs in US$. The median salary for radiographers in this study is US$ 3.20 per hour, the high salary US$ 25.

Assuming that two physicist commissioning a linac are involved for 3 months and including the depreciation costs of the equipment (water phantom, dosimetry equipment, beam scanner, film) this amounts even in the highest salary country to about US$ 50,000. Over the useful lifetime of the linac of 15 years during which 160,000 fractions are delivered, this is US$ 0.31 per fraction. This is a small amount compared with the total costs per fraction, which for a high-salary country is of the order of US$ 35 to 45. This cost component was therefore not included in the cost calculation.

4.3. Costs per fraction

In general, the costs per fraction on a linac are higher than those of cobalt, up to 530%, the highest in countries that supply their own cobalt sources. On average linac costs were 85% higher than cobalt. In two countries where they were lower, the cobalt machines were not used to their full capacity, namely for 3500 and 3900 fractions in 2002. In one country, the costs were equal. This country had the cheapest linac (US$ 130,000) with the lowest QA and maintenance costs (US$ 3000). This was the machine that treated with electrons only.

The model based on our observed median data on equipment, maintenance, personnel and usage allows us to draw some conclusions about the sensitivity of the costs per fraction for the different components. By changing the values in Table 1 this sensitivity can be established. Table 3 shows what happens in the median value model when the value of the different items is raised by 10%. The median value model is most sensitive for the yearly number of fractions and the capital costs of the machine and less so for the costs of QA and maintenance. Raising the yearly number of fractions by 10% decreases the costs per fraction by 7.8%. This is less than 10% because the number of working hours increases and so do the salary costs. When the price of the linac is raised by 10% the costs per fraction increase by 5%. A similar table, not shown here, can be calculated for high salary countries, i.e. with a salary of US$ 25 per hour. In that case the calculation is most sensitive for changes in salary, the number of radiographers per machine, and the number of fractions per hour. A change of 10% in one of these items results in a change of more than 5% in the costs per fraction. The difference between low salary countries and the median value model is less striking because the median salary is close to the lowest salaries.

Because of the lower capital costs and costs of QA and maintenance for cobalt machines the dependence on the different items is different from linacs. The costs per fraction for cobalt machines are almost equally sensitive to changes in the capital cost of the item, the number of fractions and personnel cost.

Our model gives somewhat higher results for a low-cost linac than those published by Greene [4] for his hospital in the UK. Assuming that radiographers and physics staff divide their time equally between treatment preparation and actual treatment these costs per fraction in 1983 (the year of his study) were US$ 7.91 which would now amount to US$ 14.20 taking inflation into account. Using his data in our model, we calculate a cost per fraction of US$ 20.45 in high-salary countries with an hourly wage of US$ 25. On the other hand, our results are lower than that calculated by Dunscombe et al. [2] for Canada a cost per fraction of US$ 51. However, they use a life expectancy for a linac of 10 years, capital costs of US$ 1,500,000, and they only treat 3.7 fractions per hour and 7200 fractions per year. When we insert those figures in our calculation we get a cost per fraction in high-salary countries of US$ 39.85. Goddard et al. [3] published a range of US$ 14 to 56 for the costs per fraction for some high-salary countries. These include the building costs, the costs of the treatment preparation, simulation and planning as well as the actual treatment. According to Greene [4] and Lievens [5] the costs of the actual treatment is about half of the total and assuming that this is generally true the actual treatment according to Goddard costs US$ 7 to 28 per fraction. Under the same assumption Penn [7] gives a value of US$ 32.10 in a large hospital in the UK to US$ 52.50 in a small one, Atherton [1] US$ 10.46 for a simple linac, and Wodinsky [11] US$ 35.73 for a 25 MV linac. We realize that comparison between costs derived from different types of calculations, using different inputs and methodologies and performed in a different time frame and health security environment should be done with caution. However, the general conclusion that our data for developed countries are in accordance with other publications seems appropriate. For countries with limited financial resources we have not found relevant data in the literature.

From Table 1 it would appear that a fraction on a linac is
almost three times as expensive as cobalt. This conclusion is not justified since the group of linacs ranged from simple, single photon energy machines to sophisticated dual energy machines with electrons, MLCs and other features providing much more functionality than cobalt machines. However, among the linacs were five 6 MV single photon machines in three countries. The average cost per fraction for these machines was US$ 8.27. In the same institutes are six cobalt machines for which the average cost per fraction is US$ 8.69. In these institutes the costs of cobalt and 6 MV linac therapy are therefore almost equal but this is mainly caused by the much larger usage of the linacs, i.e. 17,200 versus 10,650 fractions per year. When corrected for this difference by using the median value for a linac of 10,900 fractions per year the average cost per fraction on the linacs in those institutes increases to US$ 13 and this is 50% higher than cobalt.

In conclusion, the costs per fraction insofar these can be attributed to the components investigated vary considerably between the participating institutes. This variation is more due to the result of differences in usage of the machines, the costs of equipment, and the costs of QA and maintenance than of economic status, as it reflects in the hourly wages of the personnel. Institutes in countries with limited financial resources and consequently limited treatment capacity tend to compensate by extending the usage of the machines through longer working days but not at the cost of treatment complexity. All countries put a fair amount of time into QA and maintenance of their machines and in this respect linacs are much more expensive than cobalt machines. As far as the investigated components are concerned, a treatment fraction on a linac with functionality comparable to cobalt costs 50% more than on a cobalt machine.

This project covered only part of the complete radiotherapeutical process and to determine the overall costs of radiotherapy the costs of intake, treatment preparation, clinical quality control and follow-up should also be included as well as overhead costs and probably interest rates. There are other models evolving [5] which intend to cover the complete process but the accuracy and applicability will largely depend on the accuracy of the input data. This project shows that it is possible to collect these data prospectively as well as retrospectively and we hope that it is a useful contribution to the economic modeling of radiotherapy.

The study has proved valuable to the IAEA in indicating the wide variability of costs for delivery of teletherapy in developing countries. It further reinforces the opinion that the cost determinations, performed in industrialized countries bear little relevance to poorer developing countries. A more sophisticated model utilizing real costs of items will need to be developed to predict the budgets required for initiation and sustainability of radiotherapy in these countries.

### Table 3: Sensitivity of cost calculation for an increase in the value of the different components with 10% change in %

<table>
<thead>
<tr>
<th>Component increased 10%</th>
<th>Cost of linac</th>
<th>Fraction per year</th>
<th>Fraction per hour</th>
<th>Radiographs per machine</th>
<th>Salary</th>
<th>Costs QA, maint.</th>
<th>Running costs</th>
<th>Costs per fraction</th>
<th>Change in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median value</td>
<td>950,000</td>
<td>10,900</td>
<td>5.10</td>
<td>2.80</td>
<td>3.20</td>
<td>41,390</td>
<td>2800</td>
<td>11.65</td>
<td>–</td>
</tr>
<tr>
<td>Price linac</td>
<td>1,045,000</td>
<td>11,990</td>
<td>5.61</td>
<td>3.08</td>
<td>3.52</td>
<td>45,529</td>
<td>3080</td>
<td>11.81</td>
<td>+1.6</td>
</tr>
<tr>
<td>Fraction per year</td>
<td>950,000</td>
<td>10,900</td>
<td>5.10</td>
<td>2.80</td>
<td>3.20</td>
<td>41,390</td>
<td>2800</td>
<td>10.72</td>
<td>–</td>
</tr>
<tr>
<td>Fraction per hour</td>
<td>950,000</td>
<td>10,900</td>
<td>5.10</td>
<td>2.80</td>
<td>3.20</td>
<td>41,390</td>
<td>2800</td>
<td>11.14</td>
<td>–</td>
</tr>
<tr>
<td>Radiographs per machine</td>
<td>950,000</td>
<td>10,900</td>
<td>5.10</td>
<td>2.80</td>
<td>3.20</td>
<td>41,390</td>
<td>2800</td>
<td>11.14</td>
<td>+1.6</td>
</tr>
<tr>
<td>Salary</td>
<td>950,000</td>
<td>10,900</td>
<td>5.10</td>
<td>2.80</td>
<td>3.20</td>
<td>41,390</td>
<td>2800</td>
<td>12.00</td>
<td>+1.6</td>
</tr>
<tr>
<td>Costs QA, maint.</td>
<td>950,000</td>
<td>10,900</td>
<td>5.10</td>
<td>2.80</td>
<td>3.20</td>
<td>41,390</td>
<td>2800</td>
<td>12.00</td>
<td>+1.6</td>
</tr>
<tr>
<td>Running costs</td>
<td>950,000</td>
<td>10,900</td>
<td>5.10</td>
<td>2.80</td>
<td>3.20</td>
<td>41,390</td>
<td>2800</td>
<td>12.00</td>
<td>+1.6</td>
</tr>
</tbody>
</table>

NB: The calculation is based on the median values given in the first line. In the next lines the value of one item is raised by 10% – the others are not changed. The changed item is presented in bold. Note that changing the salary also effects the costs of QA and maintenance.
Acknowledgements

This study was supported by IAEA funds through the Cooperative Research project E3.50.07. We are grateful to all personnel of our departments for keeping detailed records of the treatments.

References