Original Article

Estimating the cost of radiotherapy for 5-year local control and overall survival benefit

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ABSTRACT

Background and purpose: Escalating health care costs have led to greater efforts directed at measuring the cost and benefits of medical treatments. The aim of this study was to estimate the costs of 5-year local control and overall survival benefits of radiotherapy for the cancer population in Australia.
Materials and Methods: The local control and overall survival benefits of radiotherapy at 5-years and optimal number of fractions per course have been estimated for 26 tumour sites for which radiotherapy is indicated. For this study, a hybrid approach that merges features from activity based costing (ABC) and relative value units costing (RVU) were used to provide cost estimates. ABC methodology was used to allocate costs to all radiotherapy activities associated with each patient's treatment course, while the RVUs represent the cost of each radiotherapy activity relative to the average cost of all activities and were used to achieve a weighted cost allocation. A patient's journey for the financial year was constructed by consolidating all the radiotherapy activities and their associated costs, and the average cost per activity (fraction) was determined. The cost of radiotherapy per 5-year overall survival and local control was then estimated.
Results: The estimated population 5-year local control and overall survival benefits of radiotherapy for all cancer were 23% and 6%, respectively. The optimal number of fractions per treatment course if guidelines were followed was 19.4 fractions. The average cost per fraction for all cancer was AU$276. The estimated cost of radiotherapy was AU$23,585 per 5-year local control and AU$86,480 per 5-year overall survival (equivalent to 5 life years) for all cancer.
Conclusion: The cost of AU$86,480 per 5-year overall survival would translate to AU$17,296 1-year overall survival. Therefore, the cost of radiotherapy is inexpensive if delivered optimally. Policy implications from this study include knowledge about cost to deliver radiotherapy to allow one to quantify the expected benefit at a population level.

Cancer is one of the leading causes of morbidity and mortality worldwide [1]. Radiotherapy is a major component of cancer management for up to 50% of patients [2]. The recent Lancet Oncology Commission Report [3] concluded that investment in radiotherapy enables the treatment of a large number of cancer cases to save lives and brings positive economic benefits. Since the Baume report in 2002 [4] there has been an increase by the Australian government in radiotherapy investment. Australian government funding for radiation oncology is provided through a range of funding measures including Medicare Benefits Schedule (MBS) funding for medical services, the Radiation Oncology Health Program Grants (ROHPG) scheme funding for high-cost equipment and one-off funding grants for the construction of new and improved radiotherapy facilities. In 2014–2015 the Australian government provided approximately $68 million in capital reimbursement funding under the ROHPG scheme and $342 million in funding through the MBS for around 1.9 million radiotherapy services [5].

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Identifying the optimal allocation of resources to improve health is a major challenge to policy makers and legislators. In view of resource scarcity, there is a perpetual urgency to evaluate the cost of medical interventions [6,7]. The rapid uptake of new treatment strategies over the last decade in an under-resourced global environment highlights the need to develop a better understanding of costs and benefits of radiotherapy. Healthcare worldwide faces the dual challenge of providing services that realise the outcomes that matter to patients that are also financially sustainable. The production of relevant healthcare service cost information will be a key factor in realising these goals.

The aim of this study was to estimate the costs of 5-year local control and overall survival benefits of radiotherapy for the cancer population in Australia. This study will provide cost estimates under a hybrid approach that merges features from activity based costing (ABC) and relative value units costing (RVU) [8].

Methodology

Estimating benefit

The local control and overall survival benefits of radiotherapy at 5-years have been estimated for 26 tumour sites for which radiotherapy is indicated; bladder, brain, breast, cervix, colon, gall bladder, head and neck, kidney, leukaemia, liver, lung, lymphoma, melanoma, myeloma, oesophagus, ovary, pancreas, prostate, rectum, stomach, testis, thyroid, uterus, vulva, unknown primary and other (anus, non-melanoma skin cancer, soft tissue sarcoma) cancers [9,10]. The methodology used to estimate whole cancer population benefits has been previously reported in detail by our group [9,10] and is briefly outlined. These benefits were quantified as the absolute local control or overall survival gain from radiotherapy compared with no receipt of radiotherapy for radical indications and compared to that of surgery for adjuvant/neoadjuvant indications. No 5-year local control or survival benefit gains were observed for palliative radiotherapy and hence the benefit for palliative radiotherapy indications was denoted as 'zero' for all cancer sites. Evidence of local control and overall survival gain for each indication was identified through a systematic literature review. Radiotherapy population benefit was determined by multiplying the absolute proportional benefit of each radiotherapy indication by the absolute proportion in the whole cancer population with the indication, and summing all such products. Following this, local control and overall survival benefits for radical indications considering only the patient population for whom radiotherapy was recommended was estimated by dividing this number by the proportion of patients with that particular cancer recommended to have radiotherapy. An example for breast and uterus is shown in Supplementary material 1.

Estimating optimal number of fractions

An evidence-based optimal radiotherapy fractionation model was constructed to estimate the optimal number of fractions per treatment course. The method used to estimate the optimal number of fractions has been reported previously [11]. The recommended dose-fractionation schedules were derived from evidence-based treatment guidelines. For each cancer site, the optimal number of fractions per patient was first estimated. By dividing this number by the proportion of patients with that particular cancer recommended to have radiotherapy, the optimal number of fractions per treatment course was calculated. An example for breast and uterus is shown in Supplementary 1.

Estimating cost

Fig. 1 shows the different cost allocation steps involved in this study.

Activity-based costing

An activity-based costing model [12] was used to estimate the cost of radiotherapy. ABC calculates the cost of a treatment course as the summated cost of all activities and related resources involved in generating each activity. For this study, a single radiotherapy centre operating six multi-energy linacs, one orthovoltage unit and one brachytherapy unit was used as the base case scenario. ABC methodology was used to allocate costs to all radiotherapy activities associated with each patient's treatment course (including external beam and brachytherapy). All radiotherapy activities with radical indications were extracted from the local radiotherapy information system (MOSAIQ; Elekta, Stockholm, Sweden) from July 2016 to June 2017. The activities were divided into eight major categories; entry to the service (i.e. radiotherapy bookings), consultations, care coordination, pre-simulation, simulation, planning, treatment and exit (i.e. discharge from follow-up). The simulation, planning and treatment activities were divided into different levels of complexity bands as listed in Table 1.

Relative value unit costing

Relative value unit costing approach [13] was used in the clinical costing process to determine the allocation costs across each patient activity and are made up of three components: (i) the staffing inputs which are based on the capture of staff time inputs for each activity, and on the indirect activities (e.g. indirect physicists quality assurance activity), (ii) the additional energy costs associated with radiotherapy equipment that was determined using the energy cost data from the institution, and (iii) the significant costs of depreciation and maintenance contracts for radiotherapy equipment. The depreciation and maintenance costs obtained from the financial data were converted into cost per activity. These costs were separated into the medical equipment greater than AU $500,000 (assumed to be the linacs) and other equipment. The use of RVUs ensures that the cost will be more reflective of resource consumption and work effort between various radiotherapy activities that require varied amounts of resources and staff time. The activities against which the RVUs have been calculated were extracted at the level of the individual patient related activity from MOSAIQ. The RVUs represent the cost of each radiotherapy activity relative to the average cost of all activities and were used to achieve a weighted allocation. Expenses, including all direct and indirect labour, goods and services, repairs and maintenance, and administration were extracted from the local financial system. The final set of RVUs was designed to be used in conjunction with an activity extract from MOSAIQ to allocate radiotherapy costs across activities.

Cost per fraction

All radiotherapy activities (pre-treatment, treatment and post-treatment) associated with each tumour site and the associated cost was consolidated together. The cost per activity was determined by dividing the average total cost per patient by the average number of activities, independent of the complexity as the cost represents an averaging of the complexity. This cost per activity was assumed to be the cost per fraction to account for cost of all activities involved in the treatment preparation. For breast cancer for example (Supplementary material 2), the cost per fraction was
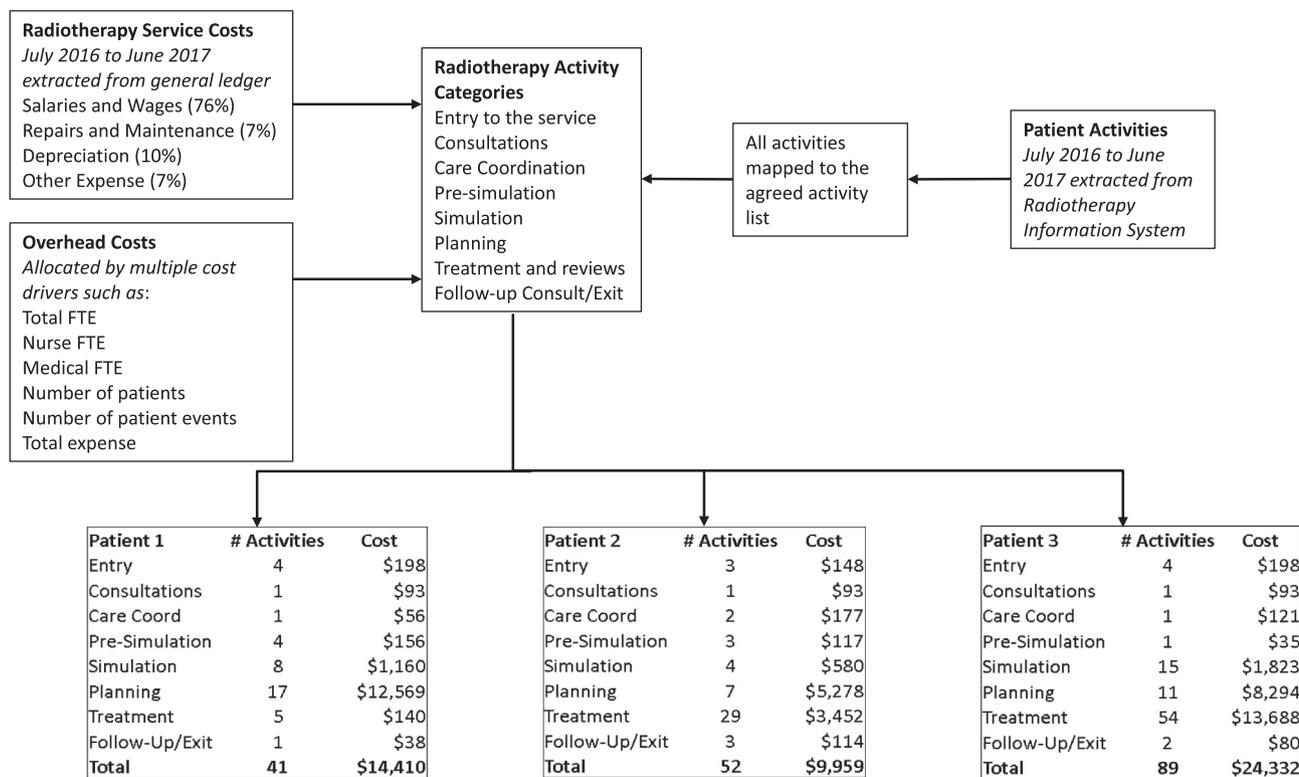
Fig. 1. Cost allocation steps.

calculated as: (average total cost for breast cancer) ÷ (average number of activities for breast cancer) = $13,450 ÷ 61 = $221.

Cost per benefit

The cost of radiotherapy per 5-year local control and overall survival was estimated for each tumour site (Eqs. (1) and (2)).

$$\text{Cost per local control} = (\text{No. of fraction} \div \text{local control})$$
$$\times \text{cost per fraction} \quad (1)$$

$$\text{Cost per overall survival} = (\text{No. of fraction} \div \text{overall survival})$$
$$\times \text{cost per fraction} \quad (2)$$

Results

The estimated population 5-year local control and overall survival benefits of radiotherapy for all cancer were 23% and 6%, respectively (Table 2). For several tumour sites (colon, gall bladder, kidney, liver, ovary, pancreas and unknown primary), there was no local control or overall survival benefits from radiotherapy. The optimal number of fractions per treatment course for all cancer was 19.4 (Table 2).

The list of activities included in the RVU costing model and its associated weighted cost is listed in Table 3. The RVU specific cost per activity ranged from AU$42 (EUR$26) to AU$1,051 (EUR$658). The cost per radiotherapy activity following the allocation of the total radiotherapy expense adjusted by RVU is listed in Table 3. The final cost per activity for the casemix studied ranged from AU$28 (EUR17) to AU$754 (EUR$472) with the average cost per simulation, planning and treatment estimated to be AU$117 (EUR $73), AU$445 (EUR$279) and $231 (EUR$145), respectively. The

proportion of all radical casemix by tumour site reflects the throughput of the base case department (July 2016 to June 2017) as listed in Supplementary Material 5.

The average cost per fraction for all cancer was AU$276 (EUR $173) and average cost per treatment course if radiotherapy was delivered with the optimal number of fractions was AU$5,360 (EUR$3,350) for all cancer (Table 4). Cost per treatment course for liver was $0 as the estimated optimal number of fractions for liver was zero according to evidence based guidelines. The estimated cost of radiotherapy was AU$23,585 (EUR$14,738) per 5-yeal local control and AU$86,480 (EUR$54,037) per 5-year overall survival (equivalent to 5 life years) for all cancer (Table 4).

Discussion

This study estimated the costs of 5-year local control and overall survival benefits of radiotherapy for the cancer population in Australia. To our knowledge, this is the first study to estimate the cost outcome of radiotherapy for 5-year local control and overall survival.

The estimated cost per fraction of AU$276 (US$196, EU$173) from this study is comparable to the operating cost per fraction (US$235) estimated by Atun et al [3] for high-income countries. The cost per treatment course of AU$5,360 (US$3,798, EU$3,350) estimated in this study is approximately 30% less than cost per course (US$5,368) estimated by Van Dyk et al [14] in high-income countries. When compared with a Belgium study, the cost per treatment course of AU$5,360 (EU$3,350) in this study is approximately 35% less than the cost (EU$4,209) estimated by Hulstaert et al. [15]. The costs in this study may be lower due to lower personnel costs compared to costs reported by Van Dyk et al [14] and Hulstaert et al [15]. In addition, the cost estimation by Atun et al [3] and Van Dyk et al [14] scaled the equipment and personnel costs to the needs of the region, while in this study, the available

Table 1
Simulation, planning and treatment activities divided into different levels of complexity bands.

Category	Band	Description
Simulation	Simulation-B1 Simple	Simple clinical mark-up procedures where imaging is not required
	Simulation-B2 Standard	Simulation using a CT Scanner without contrast using immobilisation devices
	Simulation-B3 Complex	Simulation using a CT Scanner with or without contrast using immobilisation devices, with or without utilising other imaging modalities
Planning	Planning-B1 Simple	Simple planning, pre-treatment documentation & checking of manual monitor unit calculation
	Planning-B2 Basic	Basic planning, pre-treatment documentation & checking of single site using TPS. Basic techniques such as single field or parallel opposed
	Planning-B3 Standard	Standard 3D-conformal planning using TPS (includes electrons), pre-treatment documentation & checking
	Planning-B4 Complex	Advanced planning, pre-treatment documentation & checking with advanced techniques with image fusion, QA measurements & dosimetry. Includes IMRT, VMAT, DIBH, SBRT, TOMO, TBI, Brachytherapy
Treatment and reviews	Treatment-B1 Simple	Simple single site treatments with no imaging. Incudes direct electron field, superficial/orthovoltage.
	Treatment-B2 Standard	Standard 3D conformal treatments with 2D/3D imaging
	Treatment-B3 Complex	Treatments using advanced techniques with 2D/3D imaging. Includes IMRT, VMAT, DIBH, SBRT, TOMO, TBI
	Treatment-B4 Brachy	Treatments for patients receiving Brachytherapy

Abbreviations: CT – computed tomography; TPS – treatment planning system; 2D – 2 dimensional; 3D – 3 dimensional; QA – quality assurance; IMRT – intensity modulated radiotherapy; VMAT – volumetric arc therapy; DIBH – deep inspiration breath hold; SABR – stereotactic ablative body radiotherapy; TOMO – tomotherapy; TBI – total body irradiation.

resources and the delivered courses may not be optimally aligned. For example, the resources may be underutilised if the delivered courses are lower, driving the cost higher. The cost comparison with the previous three studies [3,14,15] was based on the March 2019 exchange rate (1 Australian dollar is equals 0.71 United States dollar and 0.63 Euro), therefore any direct cost comparison is dependent on the exchange rate.

The estimated radiotherapy cost of AU$23,585 (EUR$14,738) per 5-yeal local control and AU$86,480 (EUR$54,037) per 5-year overall survival include the unavoidable costs for tumour sites with zero 5-year local control and overall survival benefit. This includes tumours of colon, gall bladder, kidney, liver, ovary, pancreas and unknown primary. The costs are unavoidable as radiotherapy is indicated for these tumour sites and is the standard of care. For this study, the outcome endpoints chosen were 5-year local control and overall survival. Radiotherapy can be recommended for some tumours despite there being no 5-year survival advantage. Instead, survival advantage might be observed at a different time-point such as 2-year survival or median survival. In addition, radiotherapy may be indicated for other meaningful endpoints such as organ preservation or palliative benefit which were not assessed in this analysis. This shows that there are more outcomes that inform value of radiotherapy than just overall survival and local control. Value in health care includes effectiveness and efficiency of care, its outcomes and the patient's experience. Porter [7] acknowledges that there is a hierarchy to outcomes, and survival is a top tier outcome which is one of the endpoints of our study. This study estimates the costs and outcomes of curative

radiotherapy with 5-year benefit but further work is needed to determine the value of radiotherapy interventions individually.

A number of costing techniques such as volume based costing, activity based costing and time-driven based costing all offer different opportunities and risks in the production of patient cost information. The hybrid approach using ABC-RVU costing technique may be a useful tool in accounting for the complexity associated with the costing of radiotherapy. The ABC-RVU model is a costing approach that blends the features of activity based costing with relative value unit costing. Within this model, some resources may be directly assigned to a service or procedure, whereas other resource costs may be estimated using the RVU costing approach [8]. This model is the standard approach of New South Wales (NSW) Health in Australia to examine the detailed service and cost inputs associated with radiotherapy. A recent review by Defourny et al. [16] demonstrated a considerable heterogeneity in the currently available literature on radiotherapy costing and suggests that a consistent methodology should be developed for performing such studies. The application of the time-driven (TD-ABC) [14] methodology could provide further input into a uniform and accepted approach.

A review of existing texts of cost analysis and of studies of traditional cost analysis methods reveals their limited usefulness, and highlights the need for the use of streamlined methods. Cost-effectiveness analysis (CEA) measures consequences in natural units, such as life-years gained, disability days avoided, or cases detected [17]. In a variant of CEA, often called cost-utility analysis, consequences are measured in terms of preference-based measures of health, such as quality-adjusted life-years, or disability-adjusted life-years [17]. In cost–benefit analysis, consequences are valued in monetary units [17]. This study is focused primarily on two stages: measurement of radiotherapy costs and measurement of radiotherapy outcomes (local control and overall survival), and may be referred to as cost-outcome analysis.

The methodology used in this study has several strengths including extraction of real data from the radiotherapy information and financial systems to make projections about actual costs. This is similar to the study reported by Hulstaert et al. [15]. Our study also estimated the cost and outcome for each individual tumour site thus provided useful input to evaluating the cost of radiotherapy by tumour site. While Hulstaert et al. [15] also reported cost per tumour (breast, lung, prostate, head & neck, rectum, other and palliative), no outcome measures such as local control or survival were reported.

There are limitations to the approach described in this study. Cost calculations were based on a single radiotherapy department as the base case and performed assuming similar design of the radiotherapy departments across Australia. Estimates for other departments and jurisdiction will be affected by the casemix of cancers treated by the individual departments, as well as the size and productivity of the department. However, preliminary analysis on current ongoing work showed comparable cost per fraction with two other radiotherapy departments in Australia (AU$257 and AU$236), and therefore we suggest our findings can be generalised to the larger population. Although this study grouped the simulation, planning and treatment activities by their complexity band, the costs involved by each complexity of technique within the individual band may vary. For example, the cost for intensity modulated radiotherapy and deep inspiration breath hold (both in the same complexity band listed in Table 1) may vary. This may also be relevant to other departments with different technique availability compared to the base case department. For example, some departments may still be using simple 3D conformal techniques for majority of patients while others may be using more advanced techniques. In Europe, the ESTRO initiated HERO-project (Health Economics in Radiation Oncology) showed a con-

Table 2
Local control and overall survival benefits of radiotherapy, and optimal number of fractions for all cancer.

	Optimal radiotherapy utilisation [11]	Whole cancer population [10]		Fractions per patient [11]	Patient population for whom radiotherapy was recommended		Fractions per treatment course
		Local control	Survival		Local control	Survival	
Bladder	47%	6%	4%	4.9	13%	9%	10.4
Brain	80%	9%	8%	23.3	11%	10%	29.1
Breast	87%	15%	2%	14.3	17%	2%	16.4
Cervix	71%	36%	20%	15	51%	28%	21.1
Colon	4%	0	0	0.1	0%	0%	2.5
Gall bladder	17%	0	0	4.1	0%	0%	24.1
Head & Neck	74%	34%	20%	20	46%	27%	27
Kidney	15%	0	0	0.3	0%	0%	2
Leukaemia	4%	1%	1%	0.3	25%	25%	7.5
Liver	0%	0	0	0	0%	0%	0
Lung	78%	9%	5%	12.1	12%	6%	15.5
Lymphoma	73%	11%	7%	10.4	15%	10%	14.2
Melanoma	21%	3%	0	3.9	14%	0%	18.6
Myeloma	45%	2%	1%	1.6	4%	2%	3.6
Oesophagus	71%	6%	2%	10	9%	3%	14.1
Ovary	4%	0	0	0.3	0%	0%	7.5
Pancreas	49%	0	0	10.3	0%	0%	21
Prostate	58%	25%	1%	16.3	43%	2%	28.1
Rectum	60%	13%	4%	14.4	22%	7%	24
Stomach	27%	2%	1%	5	7%	4%	18.5
Testis	15%	9%	9%	2.2	60%	60%	14.7
Thyroid	4%	1%	1%	0.5	25%	25%	12.5
Unknown primary	61%	0	0	0.9	0%	0%	1.5
Uterus	32%	6%	2%	7.1	19%	6%	22.2
Vulva	39%	10%	8%	9.4	26%	21%	24.1
Other cancers	19%	10%	3%	3.5	53%	16%	18.4
All cancer*	48%	11%	3%	9.4	23%	6%	19.4

* The values are weighted average of all cancer population instead of direct average of individual cancer types.

siderable variation in the access to modern radiotherapy equipment, available personnel and delivered courses per year [18,19]. This highlights the need for further radiotherapy costing investigation by including a large number of departments, nationally and internationally.

The calculated cost per fraction in this study accounts for cost of all activities involved in the treatment preparation. While this approach may be more comprehensive, it assumes that treatment costs scale linearly with the number of fractions, which may be incorrect. Inclusion of treatment preparation costs into the cost by fraction may give rise to a distortion of the costs of different fractionation schedules [16]. Hulstaert et al. [15] showed that percentile allocation of overhead cost by treatment course increased the cost of hypofractionated schedules, while allocation by fraction increased the costs for standard fractionation. This may be one of the reasons for the variability of the costs per cancer type as shown in Table 4. For example, cost per treatment course for testis is AU$5,603 for 14.7 fractions while the cost per treatment course for breast is $3,633 for 16.4 fractions. Therefore treatment preparation activities need to be spread over fewer fractions for testis when compared with breast. It may be more accurate to calculate the costs incurred in the treatment preparation stage separately [16], however the approach may be more challenging.

This study did not consider palliative endpoints of radiotherapy, including symptom control and quality of life. There were limitations in the availability of population-based epidemiological data required to estimate these endpoints. As a result, the cost analysis was limited to curative benefits only (1,095 radical cases from July 2016 to June 2017). This might give a false impression that the productivity of the base case department is low. In addition to the stated radical cases, the analysed department also treated 593 palliative cases in the specified time range. The model described in this study provides a framework where further estimates could be assessed for palliative endpoints. Although this study aimed to measure costs for curative cases, we acknowledge that the costs for palliative cases were included to a degree. The optimal number of fractions averages over both curative and palliative radiotherapy. However, this is a minor consequence of the methodology and would only have minimal effect on the optimal number of fractions.

It is acknowledged that the findings of this study may apply mostly to high income countries and cannot be directly extrapolated to low- and middle-income countries. It has been shown that while in high income countries, the bulk of costs of radiotherapy services are attributable to personnel salaries and the quality assurance associated with advanced technologies [20], in low and middle income countries the bulk of expenses are due to equipment. The Lancet Oncology report [3] indicated that the proportions of capital and human resources varies by income regions, for high income countries, total operating costs were divided between equipment (30%), facilities (6%) and salaries (64%), whereas in low income countries these were 81%, 9% and 10%, respectively.

Despite the limitations, this study represents the first estimate for costs of 5-year local control and overall survival benefits of radiotherapy. The cost of AU$86,480 per 5-year overall survival for all cancer would translate to AU$17,296 per 1-year overall survival. Decision-makers in Australia will consider interventions that cost less than $50,000 per quality-adjusted life-year (QALY) gained to be reasonably efficient. Therefore, radiotherapy is inexpensive if delivered optimally according to evidence based guidelines.

Table 3
Relative value unit model and its associated weighted cost, and cost per radiotherapy activity.

Category	Activity	Staff direct salary per activity[*]	Energy costs	Depreciation & maintenance costs	RVU specific cost per activity	Final cost per RT activity[**]
Entry to the service	RT Bookings	$40.93	$2.50	$23	$66.43	$47
Consultations	RO consult	$101.60	$2.50	$23	$127.10	$93
Care coordination	Case management	$145.40	$2.50	$23	$170.90	$121
	Clinic/service appointment	$79.99	$2.50	$23	$105.49	$73
	MDT discussions	$52.53	$2.50	$23	$78.03	$56
Pre-simulation	Patient coaching	$25.76	$2.50	$23	$51.26	$35
	Cannulation	$32.43	$2.50	$23	$57.93	$39
Simulation	Simulation-B1 Simple	$61.93	$2.50	$23	$87.43	$61
	Simulation-B2 Standard	$134.05	$2.50	$23	$159.55	$113
	Simulation-B3 Complex	$226.18	$2.50	$23	$251.68	$177
Planning	Planning-B1 Simple	$170.09	$2.50	$23	$195.59	$140
	Planning-B2 Basic	$507.64	$2.50	$23	$533.14	$382
	Planning-B3 Standard	$678.54	$2.50	$23	$704.04	$505
	Planning-B4 Complex	$1,025.74	$2.50	$23	$1,051.24	$754
Treatment and reviews per activity	Treatment-B1 Simple	$48.43	$27.79	$146	$222.22	$149
	Treatment-B2 Standard	$66.53	$27.79	$146	$240.32	$162
	Treatment-B3 Complex	$252.45	$27.79	$146	$426.24	$292
	Treatment-B4 Brachy	$293.05	$27.79	$146	$466.84	$322
	On-treatment reviews	$24.83	$2.50	$23	$50.33	$36
	RT nurse/AH review	$16.62	$2.50	$23	$42.12	$28
Follow-up consult, exit	Follow up consult	$33.13	$2.50	$23	$58.63	$42
	Exit, discharge, referral	$28.46	$2.50	$23	$53.96	$38

Abbreviation: RVU – relative value unit; RT – radiotherapy; RO – radiation oncologist; MDT – multidisciplinary team; AH – allied health.
  [*] Supplementary material 3 shows the staff time devoted to activities performed by radiotherapy personnel.
  [**] Supplementary material 4 demonstrates how the RVU cost per activity is used to generate final cost per RT activity.

Table 4
Cost of radiotherapy.

	Cost per fraction (A)	No of fractions per treatment course (B)	Cost per treatment course (A*B)	Local control (C)	Cost per local control (A*B)/C	Overall Survival (D)	Cost per overall survival (A*B)/D
Bladder	$295	10.4	$3,076	12.8%	$24,092	8.5%	$36,138
Brain	$284	29.1	$8,272	11.3%	$73,524	10.0%	$82,715
Breast	$221	16.4	$3,633	17.2%	$21,069	2.3%	$158,015
Cervix	$274	21.1	$5,789	50.7%	$11,417	28.2%	$20,550
Colon	$233	2.5	$583	0.0%	N/A	0.0%	N/A
Gall bladder	$269	24.1	$6,488	0.0%	N/A	0.0%	N/A
Head & Neck	$251	27.0	$6,784	45.9%	$14,765	27.0%	$25,100
Kidney	$216	2.0	$432	0.0%	N/A	0.0%	N/A
Leukaemia	$280	7.5	$2,100	25%	$8,400	25.0%	$8,400
Liver	$317	N/A	0.0	N/A	N/A	N/A	N/A
Lung	$300	15.5	$4,654	11.5%	$40,333	6.4%	$72,600
Lymphoma	$266	14.2	$3,790	15.1%	$25,149	9.6%	$39,520
Melanoma	$235	18.6	$4,364	14.3%	$30,550	0.0%	N/A
Myeloma	$196	3.6	$697	4.4%	$15,680	2.2%	$31,360
Oesophagus	$253	14.1	$3,563	8.5%	$42,167	2.8%	$126,500
Ovary	$237	7.5	$1,778	0.0%	N/A	0.0%	N/A
Pancreas	$299	21.0	$6,285	0.0%	N/A	0.0%	N/A
Prostate	$308	28.1	$8,656	43.1%	$20,082	1.7%	$502,040
Rectum	$299	24.0	$7,176	21.7%	$33,120	6.7%	$107,640
Stomach	$335	18.5	$6,204	7.4%	$83,750	3.7%	$167,500
Testis	$382	14.7	$5,603	60.0%	$9,338	60.0%	$9,338
Thyroid	$263	12.5	$3,288	25.0%	$13,150	25.0%	$13,150
Unknown primary	$363	1.5	$536	0.0%	N/A	0.0%	N/A
Uterus	$301	22.2	$6,678	18.8%	$35,618	6.3%	$106,855
Vulva	$269	24.1	$6,484	25.6%	$25,286	20.5%	$31,608
Other cancers	$241	18.4	$4,439	52.6%	$8,435	15.8%	$28,117
All cancer	$276	19.6	$5,405	22.9%	$23,585	6.3%	$86,480

Conflict of interest statement

The authors of this paper declare no actual or potential conflict of interests.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.radonc.2019.04.011.

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