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Original article

Estimating the demand for radiotherapy from the evidence: A review of changes from 2003 to 2012

Michael B. Barton [a,b,c], Susannah Jacob [a,b,c,*], Jesmin Shafiq [a,b,c], Karen Wong [a,b,c], Stephen R. Thompson [c,d], Timothy P. Hanna [a,b,c], Geoff P. Delaney [a,b,c]

[a] Ingham Institute for Applied Medical Research; [b] Collaboration for Cancer Outcomes Research and Evaluation; [c] Faculty of Medicine, University of NSW; and [d] Prince of Wales Hospital, Sydney, Australia

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ABSTRACT

Background and Purpose: In 2003 we estimated that 52.3% of new cases of cancer in Australia had an indication for external beam radiotherapy at least once at some time during the course of their illness. This update reviews the contemporary evidence to define the optimal proportion of new cancers that would benefit from radiotherapy as part of their treatment and estimates the changes to the optimal radiotherapy utilisation rate from 2003 to 2012.

Materials and Methods: National and international guidelines were reviewed for external beam radiotherapy indications in the management of cancers. Epidemiological data on the proportion of new cases of cancer with each indication for radiotherapy were identified. Indications and epidemiological data were merged to develop an optimal radiotherapy utilisation tree. Univariate and Monte Carlo simulations were used in sensitivity analysis.

Results: The overall optimal radiotherapy utilisation rate (external beam radiotherapy) for all registered cancers in Australia changed from 52.3% in 2003 to 48.3% in 2012. Overall 8.9% of all cancer patients in Australia have at least one indication for concurrent chemo-radiotherapy during the course of their illness.

Conclusions: The reduction in the radiotherapy utilisation rate was due to changes in epidemiological data, changes to radiotherapy indications and refinements of the model structure.

The planning of radiotherapy services and facilities on a population basis requires a reliable estimate of the demand for radiotherapy for that population. There are large variations in radiotherapy utilisation between countries [1]. Radiotherapy utilisation benchmarks can be derived from evidence-based guidelines [2–4], criterion-based [5,6] or based on retrospective examination of actual practice [7,8].

In 2003 we estimated the optimal external beam radiotherapy utilisation rate (RUR) for all cancers in Australia from a review of evidence-based guidelines [2,9–19]. The proportion of new cases of registered cancer in Australia that should receive megavoltage external beam radiotherapy at some time during the course of their illness, based upon the best available evidence was 52.3% [2]. This radiotherapy benchmark was used as a basis for planning radiotherapy services in Australia and Scotland and as additional evidence in planning radiotherapy services in the European Union [1,20,21]. This study updates the 2003 review with contemporary evidence, using the approach followed in the initial study. This paper reports the results for external beam radiotherapy only; brachytherapy will be described in a separate paper. This paper is a summary of a 578 page report for the Australian Government; the full report is available from http://tinyurl.com/pwkua34.

The objectives of this study were to (1) review and update all the indications for first treatment by radiotherapy based on the latest guideline recommendations (2) update the epidemiological data in the existing model of CCORE optimal radiotherapy utilisation 3) identify indications for concurrent chemo-radiotherapy in the updated model and 4) estimate the range of uncertainty around the benchmark optimal utilisation rates.

Materials and methods

The methodology for this updated review is based on that used in our original review of optimal radiotherapy utilisation [2] and is outlined in brief below.

* Corresponding author at: Ingham Institute for Applied Medical Research, 1 Campbell St, Liverpool, Sydney, NSW 2170, Australia.
E-mail address: Susannah.Jacob@sswahs.nsw.gov.au (S. Jacob).

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The study population included all cancer cases notified to Australian Central Cancer Registries as reported by the Australian Institute of Health and Welfare (AIHW) in Australia in 2008 (the most recently available year) [22]. An indication for radiotherapy was defined as a clinical situation for which radiotherapy is recommended as *the treatment of choice* because there is evidence that radiotherapy has a superior clinical outcome compared to alternative treatment modalities (including no treatment). The superiority of radiotherapy over other treatment options could be due to better survival, local control, quality of life or toxicity profiles. In clinical situations where radiotherapy had an equal outcome to other treatment options such as surgery or chemotherapy, all the treatment options were included in the model and sensitivity analysis was conducted to determine the range of proportion of patients for whom radiotherapy may be indicated.

The indications for radiotherapy for each cancer site were derived from evidence-based treatment guidelines issued by reputed national and international organisations. The epidemiological data in the model were updated. An optimal radiotherapy utilisation model or tree was developed for each cancer site by combining clinical scenarios and epidemiological data using TreeAge Pro™ software. Patients requiring radiotherapy were counted only once even if they subsequently developed repeated indications for radiotherapy.

The proportions of patients in whom external beam radiotherapy would be recommended (RUR) were calculated for each cancer site and for all cancers overall by merging the evidence on the efficacy of radiotherapy and the epidemiological data on the occurrence of indications for radiotherapy. Indications where radiotherapy is recommended in conjunction with concurrent chemotherapy were identified and the proportion of all patients who have an indication for combined chemotherapy and radiotherapy was calculated. As an example we have described the changes to the radiotherapy utilisation model for oesophageal cancer.

Sensitivity analyses were undertaken to assess changes in the recommended radiotherapy utilisation rate that would result from variations in epidemiological data or where there was conflict in radiotherapy recommendations between treatment guidelines. Multivariate analysis with Monte Carlo simulation was used for the sensitivity analysis of the whole tree.

Results

The optimal RUR by tumour site calculated in 2003 and the revised rates calculated in 2012 are shown in Table 1, which also reports the number of changes to the radiotherapy indications for each cancer site. The overall optimal RUR for all registered cancers in Australia changed from 52.3% in 2003 to 48.3% in 2012.

The 2012 optimal RUR decreased by more than 5% compared to the optimal rate estimated in 2003 for cancers of the bladder, brain, colon, kidney, oesophagus, pancreas, stomach, uterus, vagina, testis, thyroid and "other" cancers, representing 31% of all cancer patients. The optimal RUR increased by more than 5% in 2012 as compared to 2003 for cancers of the cervix, lymphoma and myeloma.

As an example of the approach used in this review, the revised model for oesophageal cancer is shown in Fig. 1. The changes to radiotherapy indications and to epidemiological data resulted in an optimal RUR of 71% in the revised model as compared to an RUR of 80% in the original model. The change is due to update of RT indications and changes in the proportions of stage data for oesophageal cancer.

The original radiotherapy utilisation model for oesophageal cancer has been described previously [11]. In this review, nine new or revised guidelines were identified [23–31]. Two new indications for radiotherapy were added to the model: (i) preoperative concurrent chemo-radiotherapy to downstage tumours and facilitate complete resection and (ii) concurrent chemo-radiotherapy

Table 1
Comparison of original (2003) and revised (2012) optimal radiotherapy utilisation rates (RUR) by cancer site.

Cancer site	Proportion of all cancers in Australia (1998) (%)	Proportion of all cancers in Australia (2008) (%)	Original RUR* (2003) (%)	Revised RUR* (2012) (%)	Number of changes to radiotherapy indications
Bladder	3.0	2.0	58	47	0
Brain	2.0	1.4	92	80	Tree changed
Breast	13.0	12.2	83	87	0
Cervix	1.0	1.0	58	71	+6
Colon	9.0	8.4	14	4	−1
Gall bladder	1.0	0.6	13	17	0
Head and neck	4.0	3.3	74	74	Tree changed
Kidney	3.0	2.3	28	15	−1
Leukaemia	3.0	2.3	4	4	Tree changed
Liver	1.0	1.2	0	0	0
Lung	10.0	9.0	76	77	0
Lymphoma	4.0	4.2	65	73	+2
Melanoma	11.0	9.9	23	21	+3
Myeloma	1.0	1.2	38	45	+3
Oesophagus	1.0	1.2	80	71	+1
Ovary	1.5	1.1	4	4	0
Pancreas	2.0	2.1	57	49	Tree changed
Prostate	12.0	18.4	60	58	Tree changed
Rectum	5.0	4.2	65	60	0
Stomach	2.0	1.8	68	27	+1
Testis	1.0	0.8	49	7	Tree changed
Thyroid	1.0	1.8	10	4	Tree changed
Unknown primary	4.0	2.4	61	61	0
Uterus	1.8	1.8	46	38	Tree changed
Vagina	0.1	0.1	100	94	−2
Vulva	0.2	0.3	34	39	Tree changed
Other	2.00	5.0	50	19	New tree
Total (all cancers)	100.0	100.0	52.3	48.3	

* RUR – radiotherapy utilisation rate (external beam).

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