Clinical Oncology 25 (2013) 538–545

Contents lists available at SciVerse ScienceDirect

Clinical Oncology

journal homepage: www.clinicaloncologyonline.net

Original Article

The Malthus Programme: Developing Radiotherapy Demand Models for Breast and Prostate Cancer at the Local, Regional and National Level

C. Round *, T. Mee †, N.F. Kirkby †, T. Cooper ‡, M.V. Williams *, R. Jena *

* Oncology Centre, Addenbrooke's Hospital, Cambridge University Hospital NHS Trust, Cambridge, UK
† Faculty of Engineering and Physical Sciences, University of Surrey, Guildford, Surrey, UK
‡ Radiotherapy National Cancer Action Team, London, UK

Received 5 February 2013; received in revised form 11 April 2013; accepted 16 April 2013

Abstract

Aims: The Malthus Programme has delivered a tool for modelling radiotherapy demand in England. The model is capable of simulating demand at the local level. This article investigates the local and regional level variation in predicted demand with respect to Breast and Prostate cancer, the two tumour types responsible for the majority of radiotherapy treatment workload in England.

Materials and methods: Simulations were performed using the Malthus model, using base population incidence data for the period from 2007–2009. Simulations were carried out at the level of Primary Care Trusts, Cancer Networks, and nationwide, with annual projections for 2012, 2016 and 2020. Benchmarking was undertaken against previously published models from the UK, Canada and Australia.

Results: For breast cancer, the fraction burden for 2012 varied from 5537 fractions per million in Tower Hamlets PCT to 18 896 fractions per million in Devon PCT (national mean - 13 592 fractions per million). For prostate cancer, the fraction burden for 2012 varied from 4874 fractions per million in Tower Hamlets PCT to 23 181 fractions per million in Lincolnshire PCT (national mean - 15 087 fractions per million). Predictions of population growth by age cohort for 2016 and 2020 result in the regional differences in radiotherapy demand becoming greater over time. Similar effects were also observed at the level of the cancer network.

Conclusions: Our model shows the importance of local population demographics and cancer incidence rates when commissioning radiotherapy services.

Key words: Breast cancer; demand; modelling; prostate cancer; radiotherapy

Introduction

The Malthus Programme was commissioned by the National Cancer Action Team to provide tools for modelling radiotherapy demand at both local and national levels in England [1]. The tools are targeted at healthcare commissioners, radiotherapy service leads and all staff involved in the provision of radiotherapy. No previous knowledge of modelling is required to run the application. We know that significant local variation exists in cancer incidence and subsequent radiotherapy demand is driven by differences in stage, age, geography, performance status, comorbidities and the utilisation of other treatment modalities in the cancer pathway. Such differences mean that a national best fit model is unlikely to fit the requirements of every individual treatment centre.

Previous models of radiotherapy demand have been published from Canada, Australia, Scotland and England [2–5]. A difficulty encountered in any radiotherapy demand model is the curating of appropriate cancer incidence data and, where population data from their countries were unavailable, authors have used other retrospective sources of data, such as the American National Cancer Institute Surveillance, Epidemiology and End Results (SEER) database. The Malthus model uses high-quality incidence data from the National Cancer Intelligence Network, which tracks cancer registrations to the level of the Primary Care Trust (PCT) (population range from 91 500 to 1 282 384) and regional Cancer Network (population range from 710 174 to 4 024 508) in England. For details of stage and the use of surgery, we obtained data from the Eastern Cancer Registry and Information

Author for correspondence: R. Jena, Oncology Centre Box 193, Addenbrooke's Hospital, Hills Road, Cambridge CB2 0QQ, UK.
E-mail address: rjena@nhs.net (R. Jena).

0936-6555/$36.00
http://dx.doi.org/10.1016/j.clon.2013.05.006

Centre (ECRIC). These data enabled us to use the Malthus model to test the hypothesis that a single radiotherapy demand model at the national level is not representative of radiotherapy demand at more granular levels.

This article reviews the local- and regional-level models for breast and prostate cancer. These two sites were selected because they make up about 55% of the national radiotherapy workload and, thus, have important consequences for radiotherapy commissioning.

Materials and Methods

Model Configuration

The Malthus Workbench discrete event simulation tool was used for this analysis [1]. We used the model to produce both radiotherapy treatment fraction and access rate data for patients with breast and prostate cancer. Access rate is defined as is the proportion of all cancer patients who require radiotherapy at least once during the course of their illness [3].

The model was run using evidence-based decision trees and set to consider primary treatment episodes with either radical or palliative intent (to facilitate comparison with other studies). We used base population and cancer incidence data for the period from 2007 to 2009. Simulations were carried out at the PCT level and the Cancer Network level, as well as at the national level. Simulations were run for years 2012, 2016 and 2020.

Evidence Base and Decision Trees

Data for the discrete event simulation were encoded in a clinical decision tree. The highest level of evidence available for the role of radiotherapy and evidence for fractionation were established for breast and prostate cancer. This was based on the ranking of levels of evidence and incorporated into the decision tree branches [6]. These were ratified by a representative group of clinical oncologists. In addition to encoding information about treatment options, the decision trees also include information about the stage distribution of patients with a given tumour type (e.g. the proportion of breast cancer patients with stage II disease). This information was derived from national audits and the ECRIC. The trees also encode information regarding the proportions of patients considered for different treatment options on the basis of both tumour factors and patient factors (e.g. proportion of stage II breast cancer patients undergoing wide local excision versus mastectomy). These estimates were derived from ECRIC data and from peer review. The decision trees and underlying evidence are available for download at the project web site [7]. Key factors in the design of the decision trees for breast and prostate cancer, specifically where they differ from previous models, are outlined below:

Breast cancer decision tree

- Radiotherapy for ductal carcinoma *in situ* (DCIS) after breast-conserving surgery was included in the decision tree, on the basis of the Cochrane review and the Early Breast Cancer Trialists' Collaborative Group (EBCTCG) [8,9]. Conventional 2 Gy fractionation has been modelled as there is no current high-level evidence to support the use of hypofractionation in DCIS.
- Fractionation for radiotherapy in early stage invasive breast cancer is based on the Cochrane review and the EBCTCG [10–12].
- Stage data were acquired from ECRIC, whose estimates for breast cancer staging are 93% complete.
- Mastectomy rates were obtained from ECRIC.

Prostate cancer decision tree

- Clinical risk group stratification [13] was obtained from ECRIC, whose estimates for clinical risk grouping are 87% complete.
- Prostatectomy rates were obtained from ECRIC, and validated at a national meeting of 70 oncologists held in June 2011.

It should be noted that there is no evidence for low-risk prostate cancer that any of the options of active surveillance, surgery or radiotherapy (external beam or implant) is better than any other. It has been argued in a consensus statement that this stage of disease has been overtreated and that it should be reclassified as a premalignant condition [14]. This means that our decision tree is descriptive as there is no evidence on which to base management decisions and patient choice, influenced by clinician advice is dominant. Similar arguments regarding treatment choice apply to some degree for patients with higher risk prostate cancer.

Benchmarking

Our model of radiotherapy demand is calculated in treatment fractions rather than an access rate. The access rate does not directly reflect the radiotherapy workload in terms of radical and palliative treatment fractionation. Access rates were calculated to act as comparators against the previous studies. Here we have used the conventional term fraction, which for this purpose is equivalent to an attendance as recorded in the English radiotherapy data set [15].

Results

Breast Cancer

The overall access rate for breast cancer was simulated at 75.2%. Our simulations demonstrate marked variation in fraction burden at both the local and the regional level (see Table 1). The highest incidence of breast cancer in England was 0.36% annually (averaged over 3 years) in Devon PCT because of a higher proportion of older people. This results in a predicted demand of 18 896 fractions per million in 2012, rising to 19 744 fractions per million for 2016 and 20 827 fractions per million for 2020. The predicted demand for Devon PCT in 2012 was 139% of the national mean