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Original article

Estimating the healthcare costs of treating prostate cancer in Australia: A Markov modelling analysis

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Abstract

Purpose: To estimate the health system costs of prostate cancer by disease risk category and treatment type over 2016 to 2025 and to identify potential strategies to contain the cost increase.

Methods: A Markov cohort model was developed using clinical pathways from US prostate cancer guidelines and clinical expertise. Estimates of the probabilities of various treatments and outcomes and their unit costs were sourced from systematic reviews, meta-analyses, epidemiological publications and national cost reports. Estimated costs by stage of disease, by major treatments and by age at diagnosis were reported in 2016 US dollars. One-way and probabilistic sensitivity analyses assessed potential variation in the modeled costs.

Results: Australia-wide costs of prostate cancer were estimated at US$270.9 million in 2016 rising to US$384.3 million in 2025, an expected increase of 42%. Of this total increase, newly diagnosed low risk cases will contribute US$32.9 million, intermediate-risk US$56.8 million, high-risk US$53.3 million and advanced US$12.6 million. For men diagnosed at age 65 with low-risk disease, lifetime costs per patient were US$14,497 for surgery, US$19,665 for radiation therapies to the primary lesion, and US$9,234 for active surveillance. For intermediate- or high-risk disease, mean costs per patient were US$34,941 for surgery plus radiation and US$31,790 for androgen deprivation therapy plus radiation while advanced cancer therapies were at US$31,574 per patient. Additional costs for managing iatrogenic disease secondary to these treatments were excluded.

Conclusion: Strategies for identifying patients early before cancers have spread are critical to contain the estimated 42% increase in costs over the next decade. Increased uptake of active surveillance would also lead to substantial cost-savings in the management of low-risk prostate cancer.

Keywords: Prostate cancer; Cost analysis; Markov modeling; Active surveillance

1. Introduction

In 2012, an estimated 1.1 million men were diagnosed with prostate cancer throughout the world and a further 307,000 died of disease [1]. This condition is a significant public health issue for men and their families and will continue to be with a predicted 5-year global prevalence of 3.9 million [1]. Of all prostate cancers diagnosed in Australia, over 90% of men have clinically localized disease [2]. With an increase in the number of men living with this malignancy, it is important to plan for the resources and services needed to appropriately manage these patients. Healthcare costs are rapidly growing in many countries and one of the pressing issues for adopting promising new and expensive technologies is the health system's capacity to pay for them [3].

Using a mathematical model of the healthcare management of prostate cancer, we previously estimated the average cost to the Australian health system in 2016 for

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each case detected was US$18,825 (standard deviation [SD] = $3,118) [4]. Half of these costs were incurred in the first year following diagnosis (US$9,371). Mean patient costs were markedly higher with progressive disease; for very-low or low-risk cancer, were US$13,905, US$17,268 for intermediate-risk, US$26,387 for high-risk or locally advanced tumors, and US$32,130 (SD = $2,612) for advanced disease [4].

A significant proportion of men diagnosed with prostate cancer have clinically localized disease and it is important that these men are managed appropriately for this malignancy. The increased cost associated with additional interventions necessary for more advanced malignancy is apparent. However, less clear is the evidence for cost differences over time across alternative interventions for similar prostate cancer risk status. For example, for men with low-risk tumors, a regimen of regular biopsies and prostate specific antigen (PSA) testing while on active surveillance would incur costs over many years, which may exceed the costs of one-off prostatectomy [5]. Similarly, surgical vs. radiation therapies as first-line therapy may have different cost trajectories over time. The purpose of this study was to examine the health system costs by stage of disease at diagnosis and first-line treatment over the long term while accounting for secondary treatments if progression occurs and ongoing follow up and adverse sequelae.

2. Methods

2.1. Model structure

A Markov cohort health state transition model was constructed in *TreeAge Pro* (Version 2016) and we adhered to recent modeling guidelines [6,7]. The model was designed to describe initial management options, all subsequent adjuvant care related to prostate cancer, adverse events and associated costs over the long term. The treatments included surgery, radiation (external beam radiation therapy (EBRT) or brachytherapy), surgery plus radiation and, androgen deprivation therapy (ADT) and radiation. Watchful waiting and active surveillance were also included with the difference being that active surveillance leads to curative intent if disease progresses while symptom management is the aim if necessary with watchful waiting. Patients remain or move between 17 specified health states according to transition probabilities [4]. The health care costs for treatments, follow-up and sequelae associated with patient outcomes were assigned to the health states in the model.

The model accumulated costs over annual cycles. The starting age of the cohort was specified at 65 years [2] and a time horizon of 25 years was used for the base case. A man aged 65 could remain in the model for a maximum of 25 years; however, may die earlier, either of prostate cancer or other causes. Where relevant, as men age in the model over time, they face different outcomes for mortality and choices of treatment. Because the management decision is partly determined by the patient's life expectancy, age and existing comorbidities, we set the maximum age for receiving active surveillance at 74 years at which time we would expect that men would switch to watchful waiting. For example, a man diagnosed with low-risk prostate cancer at 76 years would be more likely to undertake watchful waiting while a man aged 62 with no comorbidities might be more likely to undergo active surveillance or radical prostatectomy. The model was tested over various age-at-diagnosis cohorts in 5-year groups from age 55 to 75 years.

The model structure is summarized in Fig. 1 and more details of the 17 mutually exclusive health states in the model are provided in our previous report [4]. Briefly, men are diagnosed with prostate cancer and categorized into National Comprehensive Cancer Network (NCCN) 2015 [8] staging of 1 of 4 health states defined by clinical staging (T score), Gleason and PSA markers:

(1) Very low and low risk (T1–T2a, Gleason ≤6, PSA < 10 ng/ml).
(2) Intermediate risk (T2b–T2c, Gleason 7, PSA10–20 ng/ml).
(3) High risk to locally advanced (T3–T4, Gleason 8–10, PSA > 20 ng/ml).
(4) Advanced disease (node positive and metastatic) [8].

"Very low" and "low risk" stages were combined because these men have the same treatment choices and

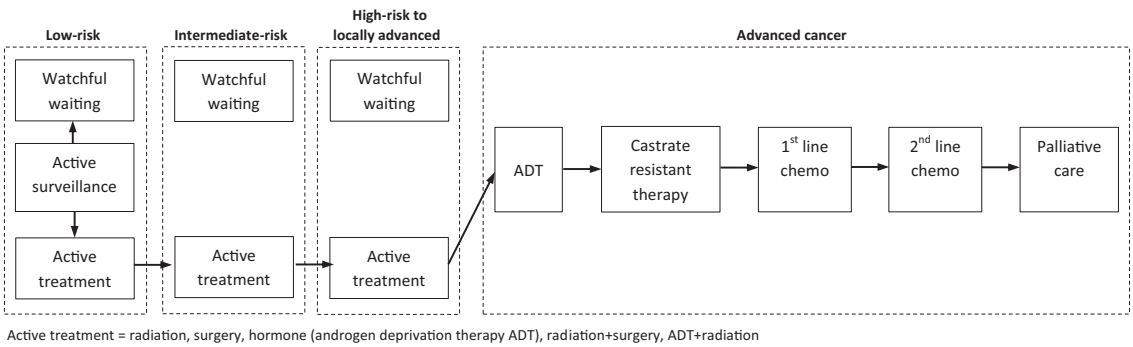

Fig. 1. Simplified model structure.