



Income generated by women treated with magnetic resonance imaging-based brachytherapy: A simulation study evaluating the macroeconomic benefits of implementing a high-end technology in a public sector healthcare setting

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ABSTRACT

PURPOSE: To estimate the difference in income generated if all women presenting in our institute over a 5-year period were treated with MRI-based image-guided brachytherapy (MR-IGBT) instead of conventional radiograph-based brachytherapy (CR-BT).

METHODS AND MATERIALS: Outcome data from 463 patients (94 treated with MR-IGBT) treated in our institute was used to simulate cumulative women-days of work and cumulative income over 5 years for 5526 patients expected to be treated in this period. The average daily income for a woman was derived from the National Sample Survey Organization (NSSO) survey data. Outcomes from both unmatched and propensity score-matched data sets were simulated.

RESULTS: The cumulative income in 5 years ranged between Rs 101–168 million if all patients presenting at our institute underwent MR-IGBT. The simulated excess income ranged from Rs 4–45 million after 5 years, which represented 6–66% of the expenditure incurred for acquiring the required equipment and manpower for practicing exclusive MR-IGBT.

CONCLUSIONS: Using outcome data from a prospective cohort of patients treated with MR-IGBT in our institute, we demonstrated that significant economic gains may be realized if MR-IGBT was used instead of CR-BT. © 2017 American Brachytherapy Society. Published by Elsevier Inc. All rights reserved.

Keywords:

Carcinoma cervix; MRI-based image guidance; Image-guided radiotherapy; Macroeconomics; Income gained

Introduction

MRI-based image-guided brachytherapy (MR-IGBT) in cervical cancers may result in an improvement in locoregional control (1–7), and reduction in late toxicities (3, 6, 7). The cost of acquisition of MRI machines as well as MRI compatible applicators is a major impediment to wider adoption of MR-IGBT in developing nations (8). Unfortunately, patients in these settings often present with advanced disease, (9, 10) and may derive the greatest benefit from the dose escalation that MR-IGBT allows (7).

Although capital expenditure that is required for wider use of MR-IGBT in our setting is a concern, improved outcomes and its impact on the financial gain for the country needs to be evaluated. It can be assumed that women who are cured can potentially return to their previous occupation, especially in affluent economies. However, as only 35% of the women in India are engaged in activities that generate a quantifiable wage, the extent of this contribution not clear.

Our institute is one of the largest tertiary cancer care center in India and facilities as well as expertise for both basic X-ray-based and image-based brachytherapy (CT and MRI) are available. Although most manpower resources for practicing MR-IGBT is already available, lack of availability of a dedicated MRI in the department as well as an adequate number of MR-IGBT applicators limits routine implementation of MR-IGBT in our institute. Being

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a publicly funded institute, the capital intensive nature of acquisition and operation of these devices prompted this study. The objective of the present study was to simulate the income generated by women treated at our institute, if all of them were treated with MR-IGBT instead of conventional radiograph-based brachytherapy (CR-BT) over a period of 5 years. In addition, we wanted to see how this income generated compared with the expenditure that would be required for implementation of MR-IGBT.

Methods

Settings and location

The study was carried out at Tata Memorial Hospital, an apex tertiary care institute in India. Outcomes of patients treated with conventional radiograph-based high-dose-rate brachytherapy (CR-BT) were obtained from the analyses published in the year 2013 (11), whereas outcome data for patients treated with MRI-based brachytherapy were obtained from the patients enrolled in the EMBRACE study (12).

Study perspective

The annual excess expenditure incurred toward transitioning to an exclusive MR-IGBT practice was calculated from the perspective of a healthcare system in which the expenditure of the treatment as well as capital investment was borne by the government. It was assumed that the number of physicians and physicists required would not be increased as a result of the implementation of MRI-IGBT. These assumptions are reasonable as the procedure of MR-IGBT is same as that of CR-BT with the exception of MRI image acquisition. While delineation of volumes on MRI is expected to take additional time on the part of the physician, the same is being done currently for all patients undergoing CT-based planning also in our Institute.

The income generated was calculated from the perspective of the women's contribution toward the Gross National Income (GNI). GNI is defined as the sum of the value added by all producers who are residents in a nation, in addition to the product taxes, income received from property and income received from abroad (13). Any expenditure that is borne by the government is actually derived from the GNI. We assumed that women who are alive and disease free after their treatment would be able to join back their previous occupation and contribute to the GNI.

Income estimation methodology

Calculation of the average daily income

Although we record the monthly income of the family when a patient is registered in Tata Memorial Hospital, the income earned by the patient herself is not captured. Hence, we used data regarding the income earned by

women in India from the National Sample Survey Organization report—Women and Men in India: 2014 (14).

We calculated an average daily income per patient after accounting for the variabilities in the income across the nation and accounting for the workforce participation rate. The weighted average daily income (ADI) thus provided a single amount in Indian rupees that took into account the three following sources of income variability in addition to the workforce participation rate:

1. Setting: urban versus rural.
2. Employment type: regular wage earners, casual laborers, and self-employed.
3. State of origin

The final calculated ADI for a patient treated in Tata Memorial Hospital was INR 20.98 (USD 0.32). As incomes are expected to increase over this period, we factored in a wage increase of 2.5% per annum to account for wage inflation to arrive at a more realistic estimate of the income generated. This wage was discounted at a nominal rate of 6% per annum from the second year onward to account for the effect of inflation and consequent erosion in the value of money.

Calculation of the cumulative woman-days of work

For a given number of patients treated over 5 years, the proportion of patients surviving at any day in this 5-year interval can be estimated from the cumulative survival probability tables of survival generated using a Kaplan-Meier analysis. The cumulative woman-days of survival can then be calculated for all women surviving till this day in this 5-year time interval.

We hypothesized that women who were alive and disease free would be able to join back their work after the completion of treatment. After deducting 84 days from the disease-free survival at each time point (to account for treatment and convalescence of 12 weeks), we estimated the cumulative woman-days of work for the period of 5 years. Multiplying these woman-days of work with the ADI allowed us to generate an estimate of the total income earned by the women over the period of 5 years. These figures were generated for two scenarios—one assuming all patients were treated with CR-BT and other assuming all patients underwent MR-IGBT. The cumulative income generated over the period of 5 years could thus be calculated as if patients were treated exclusively with CR-BT or MR-IGBT. As can be understood, this difference was essentially a function of the difference in the hazard of disease recurrence or death in the two groups over this period of time.

Expenditure estimation methodology

We obtained the average price for a new 1.5 T wide bore MRI machine from three vendors which included the price of a complete turnkey project including the costs of bunker

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