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Research Article

Real-Life Cost Estimation of Radiology and Radiotherapy Procedures in Patients with Breast or Prostate Cancer: A Single Greek Center Experience

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Abstract

Background: The cost estimation of radiology and radiotherapy procedures has been inadequately studied; therefore, the present study aimed to investigate real life cost estimation in patients with breast or prostate cancer undergoing imaging investigations and radical radiotherapy.

Methods: Data were extracted from the archives of the Radiotherapy Department of the University Hospital of Patras and included patients who underwent radical radiotherapy in the years 2017-2018. The cost for radiology tests performed three months before and after radiotherapy and the cost of radiotherapy, were calculated according to the reimbursement provided by the National Health Insurance Costing system.

Results: We included in the study 115 patients, 79 patients with breast and 36 with prostate cancer. Radiology mean cost was €191.5 and €311.1 for patients with prostate and breast cancer, respectively. We found a negative correlation between patient age, place of residence and radiotherapy cost in women treated for breast cancer. Patients older than 65 years or patients living in rural areas showed a lower radiotherapy cost (Spearman's rho, -0.421, p<0.001, Mann–Whitney U test U=105.5, p=0.03).-

Conclusion: Our findings contribute to the accumulation of pan-European financial data for radiology tests and radiotherapy, presently lacking and could help guide appropriate resource allocation toward the management of these patients in an equitable manner. We linked the histology of the tumor with treatment cost in Greece and showed that it may be influenced by other factors as well.

Keywords: *Breast Cancer; Prostate Cancer; Radiotherapy; Radiology; Cost; Greece*

Abbreviations:

CT: Computed Tomography

MRI: Magnetic Resonance Imaging

PSA: Prostate-Specific Antigen

Introduction

Among women, breast cancer is the most frequent cancer diagnosed and the fourth cause of death worldwide [1]. It is estimated that it affects approximately 2.1 million women every year and is the leading cause of cancer death. In 2018, 627,000 women died of breast cancer, which accounted for approximately 15% of the total cancer deaths among women [2].

Similarly, prostate cancer is the most frequently diagnosed cancer type in men. In Europe, with an average incidence of approximately 214 cases per 100,000 population, it accounts for 14% of all newly diagnosed cancers and 6% of total cancer deaths in men [1, 3, 4]. Health statistics predict the incidence to rise to 1.7 million new cases and 499,000 deaths by 2030 owing to the increase in the aged population and life expectancy [5]. Currently, the prevalence of both breast and prostate cancer appears to be increasing.

Apparently, prevention and early diagnosis, as well as effective treatment of these two cancer types is of great importance. Specifically, different types of clinical investigations are applied to early breast and prostate cancer diagnosis, such as mammography, magnetic resonance imaging (MRI), tumor needle biopsy, ultrasonography, and PSA test [6, 7].

Radiotherapy is an important treatment modality for cancer patients and is the primary non-surgical therapeutic approach. Nearly 60% of patients with cancer undergo radiotherapy at some point during the disease course. Of all patients with cancer, 49% are treated with surgery, 40% with radiotherapy, and 11% with chemotherapy alone or in combination with other therapeutic methods [8].

However, interventions related to cancer treatment options require significant financial resources. Information on the financial burden of each disease constitutes an important factor in the decision-making processes regarding the allocation of resources of the health system, as the allocation of resources to treat cancer deprives resources from the treatment of other diseases [9]. Especially in Europe, the largest share of current health expenditure is directed toward the treatment of circulatory system diseases (12.8%) followed by mental and behavioral (9.1%), digestive system (8.8%), and neoplastic conditions (6.9%) [10]. Furthermore, the amount assigned to each type of cancer depends on the severity of the disease. Switzerland has the highest per capita spending on cancer (€840), while Greece has a per capita spending of €188, below the European average, i.e., €378 [11].

Accordingly, it is evident that along with the increase in cancer prevalence, it is imperative to be aware of the cost of each treatment method, such as radiotherapy, and the cost of the necessary medical procedures (mainly radiology tests) to plan the therapeutic approaches and follow up the patient as well.

Given the concerns, cancer is of high priority among scientists and health professionals, and it is mandatory to develop a "tool" for resource allocation, ensuring their efficient use. The cost of radiotherapy has been inadequately reported in the literature and data are lacking regarding the cost of radiology tests in Greece; therefore, the present study aimed to investigate cost management in breast and prostate cancer in terms of radiology tests and radiotherapy.

Design and Methods

This retrospective study conformed to the ethical guidelines of the declaration of Helsinki as revised in 2013. Data were collected from patients with breast or prostate cancer who underwent radiotherapy during the years 2017 and 2018 at the Radiation Oncology Department of the University Hospital of Patras. For each individual patient, all data regarding radiology and radical radiotherapy procedures were retrieved from their medical records. The data collected included demographic characteristics (diagnosis, age, and place of residence) and radiology tests. The first radiotherapy session was declared as the reference date. The type and number of radiology tests, 3 months before and after the reference date, were retrieved. Through the National Health Insurance services, the total cost of medical care and radiotherapy for each patient were estimated. The number of radiotherapy sessions (fractions) performed per case in breast or prostate cancer ranged from 15 to 25, and from 34 to 37, respectively.

It is worth mentioning that all patients included in this study were treated by the same physician and this criterion was selected to ensure uniformity in patient management under common treatment breast and prostate protocols, according to the National Comprehensive Cancer Network (NCCN) guidelines [12, 13].

Statistical analysis was performed using the SPSS version 25 (IBM Corp., Armonk, NY, USA). Data are presented as mean and standard deviation unless otherwise specified. Normality checks were performed for the continuous variables with the Shapiro–Wilk test, and the assumptions were not satisfied. Accordingly, we used the chi-squared and Mann–Whitney U tests for the comparisons between groups, as appropriate, and Spearman's rho for the correlational analysis.

Results

A total of 115 patients, 79 with breast cancer and 36 with prostate cancer, were analyzed. Essentially, no correlation between sex and tumor location was feasible, as all patients with breast cancer were women and all patients with prostate cancer were men.

The mean patient age was 59.3 ± 12.02 years (range, 37–85 years) for patients with breast cancer and 71.75 ± 6.05 years (range, 60–84 years) for those with prostate cancer. Based on the age distribution, 27 patients with breast cancer and 30 patients with prostate cancer were older than 65 years. The mean cost of radiology tests performed three months before and three months after commencing radiotherapy was €191.5 and €311.1 for patients with prostate or breast cancer, respectively. The number of radiology tests performed in patients with breast cancer was higher than that in patients with prostate cancer. Breast cancer patients underwent mainly computed tomography of thorax, upper and lower abdomen, and bone scan, while prostate cancer patients underwent mainly MRI of the lower abdomen, bone scan and PSA testing. We found a mid-strength negative correlation between patient age and cost of radiotherapy in women (Spearman's rho, -0.421, $p < 0.001$). Specifically, the older the woman the lower the cost of radiotherapy. Analysis with Mann–Whitney U test showed that the cost of radiotherapy was significantly lower for women living in rural areas than for those living in urban areas (1371 ± 290.95 vs. 1715.92 ± 546.2, U = 105.5, p = 0.03) and this difference was independent of patient age. A summary of the results is shown in Table 1.

Mean ± standard deviation or number (percent). * $p < 0.01$

Table 1. Patient data for the whole sample by group

	Breast cancer (n = 79)	Prostate cancer (n = 36)
Age (years)	59.3 ± 12.02	71.75 ± 6.05
Place of residence		
Urban area	38 (48.1%)	16 (44.44%)
Suburban area	31 (39.2%)	16 (44.44%)
Rural area	10 (12.7%)	4 (11.11%)
Cost of imaging tests (€)		
Total	311.1 ± 345.23	191.55 ± 155.21
Urban area	302.53 ± 264.26	167.34 ± 190.83
Suburban area	358.62 ± 456.19	201.22 ± 126.57
Rural area	196.17 ± 171.33	254.56 ± 138.89
Cost of radiotherapy (per patient) (€)		
Total	1664.11 ± 498.96	4024.6 ± 1212.91
Urban area	1715.92 ± 546.20 *	4219.33 ± 1319.69
Suburban area	1695.16 ± 470.01	3881.39 ± 1168.52
Rural area	1371.00 ± 290.95	3910.00 ± 1207.97

(Mann–Whitney U test; rural vs. urban)

Discussion

Herein, we calculated the cost of radiology and radiotherapy procedures in patients with breast and prostate cancer in a tertiary Greek Hospital considering the reimbursement that the Greek Health System provides. Our findings will contribute to the accumulation of pan-European financial data for both radiology tests and radiotherapy, which are presently lacking and could help guide appropriate resource allocation toward diagnostic and treatment procedures across diseases in an equitable manner.

Our results showed that the total cost of radiology tests was higher for patients with breast cancer, whereas the cost of radiotherapy was higher for patients with prostate cancer. An explanation could be that patients with breast cancer prescribed CT scans of the thorax, upper and lower abdomen, and the average number of radiotherapy fractions (using three-dimensional conformal radiotherapy techniques) was reported to range from 15 to 25; in contrast, patients with prostate cancer required fewer imaging tests limited to the lower abdomen, but they prescribed fractions ranging from 34 to 37 (Volumetric Modulated Arc Therapy technique).

A possible explanation for the lower cost of radiotherapy found for women living in rural areas is that these women may often have more restricted access to hospital due to the distance from their residence; therefore, they have been treated with hypofractionated schemes (15 fractions), which are radiobiologically equivalent to schemes delivered in 25 fractions [14]. Hypofractionated schemes could be indicated for older patients and patients living in rural areas to reduce tiring daily hospital attendances [15, 16].

The economic crisis of the last decade has affected not only the Greek, but most of the European economies and has considerably limited the financial resources available to health; therefore, rational management of the available resources is of top priority. Radiotherapy constitutes a therapeutic option for the integrated treatment of cancer, not only confronting the disease but also relieving patient symptoms and improving the quality of life. Almost 60% of cancer patients will receive radiotherapy during their disease; in breast, lung, and prostate cancer patients the rates are even higher reaching 83%, 76%, and 60% respectively [17]. Radiology tests are essential tools for radiation oncologists to plan and perform the treatment, predict, and follow up the disease.

The estimation of the cost of radiology procedures and radiotherapy in cancer patients remains inadequate. Systematic-review findings have shown that there is no standardized means to evaluate costs by applying a shared methodology among different studies, complicating even more the evaluation process [18]. This estimation becomes more difficult in cases when a cancer patient needs re-irradiation, for a local recurrence or disseminated disease [19]. Also, in curative settings, it would be interesting to calculate the cost-effectiveness of an additional radiotherapy scheme compared to new adjuvant systemic therapies [20, 21].

According to Borras et al., the number of patients who will need radiotherapy at least once in the natural course of the disease is expected to increase by 16% in 2025. However, this increase is not expected to be identical among European countries. For example, Greece might present an increase of 13.8% by 2025; in contrast, in Ukraine and Bulgaria, the need for radiotherapy is expected to decrease [22]. Therefore, it is imperative to understand the necessity to expand and reinforce radiotherapy units as well as radiology departments in tertiary hospitals in the future.

Currently in Greece, 48 high-technology radiotherapy Units are in operation, 31 belonging to the public and 17 to the private sector, equipped with a total of 59 linear accelerators; however, based on the population and the geographical peculiarity, it is estimated that 22 additional units are required [23]. The largest number of radiotherapy units in the European Union are installed in Belgium. Five member states of the European Union have at least one radiotherapy unit per 100,000 inhabitants, i.e., Belgium (1.81), Denmark (1.37), Slovakia (1.24), Finland (1.04), and France (1.01). Inversely, there are nine Member States with fewer than 0.5 radiotherapy units per 100,000 inhabitants, including Romania (0.37), Estonia (0.38), Latvia (0.40), Poland and Portugal (0.42), Hungary (0.46), Cyprus (0.47), Spain and Austria (0.49) [24].

As part of the HERO study conducted in 2014, the European Union aimed to formulate an accurate and validated economic assessment for each country according to its needs in radiotherapy by completing a questionnaire of 84 items. Significant discrepancies were noted regarding the sufficiency of scientists, and 2,192 linear accelerators were recorded. Twelve countries possessed at least one cobalt machine. The average recorded number of radiotherapy units was 5.3 per million inhabitants; there was a sevenfold difference among European countries. Similarly, the average number of radiotherapists, nursing staff, and medical physicists was 12.8, 14.8, and 7.6 per million inhabitants, respectively. A twentyfold difference was observed regarding nursing staff among European countries [25].

It is important to note that in Eastern European countries with a low annual income, there is limited access to radiotherapy services, especially for modern, highly targeted radiotherapy techniques such as the intensity-modulated radiotherapy or image-guided radiotherapy. More actions to increase access to radiotherapy in Europe are needed, although the situation has markedly improved since the first comparative study on cancer radiotherapy, published in 2005 (QUARTS) [26].

Another study estimated the cost of radiotherapy for each country in relation to the type of radiotherapy equipment (cobalt and linear accelerators). Eleven countries participated in the study: three European (Croatia, Greece, and the Netherlands), one African (South Africa), three Latin American (Brazil, Cuba, and Peru), and four Asian (China, India, Indonesia, and Pakistan). Their radiotherapy–oncology units were using cobalt and/or linear accelerator systems. The results showed that the cost of purchase of the equipment significantly varied, with the cost of linear accelerators being 10 times higher. Furthermore, cobalt sources varied greatly in price. Particularly, the average cost of quality assurance and maintenance of a linear accelerator was $41,000, compared to the cobalt, which was only $6,000 per year. It is worth mentioning that a treatment session on a linear accelerator with functionality comparable to that of the cobalt, costs 50% more (cost per session for the linear accelerator $11.02 vs cobalt machine $4.87). According to this study, it is feasible to collect data prospectively and retrospectively on the economic factors that contribute to the total cost of radiotherapy for each patient [27]. However, this comparison (cobalt machine vs linear accelerator) risks being anachronistic, since the advantage in terms of cost-effectiveness and fewer side effects linked to the recent technological advances in radiotherapy, especially for prostate cancer patients, is undeniable [28]. Additionally, in the two clinical scenarios shown here, there is a need to understand when and if the use of the costly technological improvements achieved today is really justified and necessary in daily clinical practice [29].

Based on the above observations, and to obtain accuracy in cost estimation, it is necessary to establish a reliable national registry for cancer patients. This possibility is lacking in Greece and all available data come from small registries, collecting data from restricted areas [30]. Each patient's follow-up data can be prospectively used for the evaluation of the applied policies in the field of health care and confront the emerged needs. At the same time, these data are considered mandatory for the submission of policy proposals regarding the prevention, early diagnosis, and management of the disease; meanwhile, they can be useful for studies on various diseases or categories of diseases. Finally, the development of national guidelines and the exclusive use of treatment protocols for cancer and its subtypes may contribute to the improvement, effectiveness, and efficiency of health care for patients with cancer.

As treatment for various types of cancer is of primary concern to scientists and health professionals, especially for common cancers such as breast and prostate, it is imperative to develop a "tool" to ensure the fair allocation and efficient use of resources for the diagnosis and treatment of these diseases. Finally, additional interventions in the field of radiotherapy are also necessary, as the existing resources are not sufficient to meet the ever-increasing needs of patients with cancer.

The limitation of this study is that the data were collected from a single Radiation Oncology Unit and that the cost estimation was based on reimbursement amounts. The indirect additional costs (drugs, transport etc.) were not considered. Additionally, all patients were treated by the same radiation oncologist to minimize variations among different treatment protocols. Relevant future studies should include data from other Radiation Oncology Units and patients with other cancer diagnoses, to obtain a more comprehensive picture of the real cost of radiotherapy and radiology tests in this group of patients.

Conclusion

The real-life cost of treating cancer patients with radiotherapy hasn't been studied rigorously. This deficiency makes the allocation of existing resources difficult to calculate and more importantly holds back the implementation of health policies related to the control of cancer epidemic. The importance of this study lies in that it linked the tumor site with the cost of treatment in Greece and showed that it may be additionally influenced by other factors, such as patient age and place of residence; issues that warrant further investigation for optimal resource allocation. In the future there is the prospect of publishing the most recent data and comparing them with this article to draw safer conclusions.

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Contributions

KS, GK and DK conceived the study. MB and EJ are primarily responsible for data analysis. All authors read, revised, and approved the final version.

References

1. Bray F., Ferlay J., Soerjomataram I., Siegel RL., Torre LA., et al. (2018) Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin* 68: 394-424. [Crossref]

2. WHO (World Health Organization) (2006) Preventing cancer. *Nature* 442. [Crossref]

3. Boyle P., Ferlay J (2004) Cancer incidence and mortality in Europe. *Ann Oncol Off J Eur Soc Med Oncol* 16:481-488. [Crossref]

4. Jemal A., Siegel R., Ward E., Hao Y., Xu J., et al. (2009) Cancer statistics, 2009. CA Cancer J Clin 59: 225-249. [Crossref]
5. Ferlay J., Shin H-R., Bray F., Forman D., Mathers C., et al. (2010) Estimates of worldwide burden of cancer in 2008: GLOBOCAN 2008. *Int J cancer* 127: 2893–2917. [Crossref]
6. Moosavi L., Kim P., Uche A., Cobos E (2019) A Synchronous Diagnosis of Metastatic Male Breast Cancer and Prostate Cancer. *J Investig Med high impact case reports* 7: 2324709619847230. [Crossref]
7. Shariat SF., Roehrborn CG (2008) Using biopsy to detect prostate cancer. *Rev Urol* 10: 262-280. [Crossref]
8. Chao KSC., Perez CA., Brady LW (2002) Radiation oncology: management decisions. 2nd ed. *Lippincott Williams & Wilkins* 768.
9. Axelsson J., Norrlid H., Wilking U (2016) Innovative treatments for cancer in Europe-value, cost and access IHE Report.
10. Expenditure by disease, age and gender under the System of Health Accounts (SHA).
11. Hofmarcher T., Lindgren P., Wilking N., Jönsson B (2020) The cost of cancer in Europe 2018. *Eur J Cancer* 129: 41-49. [Crossref]
12. Lurie RH., Anderson BO., Abraham J., Aft R., Agnese D., et al. (2020) NCCN Guidelines Version 6. *Breast Cancer*.
13. Freedman-Cass D., Shead DA., Schaeffer E, Ω C, Antonarakis ES, Armstrong AJ (2021) NCCN Guidelines Panel Disclosures NCCN Guidelines Version 2. *Prostate Cancer*.
14. Prades J., Algara M., Espinàs JA., Farrús B., Arenas M., et al. (2017) Understanding variations in the use of hypofractionated radiotherapy and its specific indications for breast cancer: A mixed-methods study. *Radiother Oncol* 123: 22-28. [Crossref]
15. Kunkler I (2012) Radiotherapy issues in elderly breast cancer patients. *Breast Care (Basel)* 7: 453-459. [Crossref]
16. Ferini G., Molino L., Bottalico L., De Lucia P., Garofalo F (2021) A small case series about safety and effectiveness of a hypofractionated electron beam radiotherapy schedule in five fractions for facial non melanoma skin cancer among frail and elderly patients. *Reports Pract Oncol Radiother J Gt Cancer Cent Pozn Polish Soc Radiat Oncol* 26: 66-72. [Crossref]
17. Featherstone C., Delaney G., Jacob S., Barton M (2005) Estimating the optimal utilization rates of radiotherapy for hematologic malignancies from a review of the evidence: part I-lymphoma. *Cancer* 103: 383-392. [Crossref]
18. Defourny N., Dunscombe P., Perrier L., Grau C., Lievens Y (2016) Cost evaluations of radiotherapy: What do we know? An ESTRO-HERO analysis. *Radiother Oncol J Eur Soc Ther Radiol Oncol* 121: 468-474.
19. Shah C., Lanni TBJ., Ghilezan MI., Gustafson GS., Marvin KS., et al. (2012) Brachytherapy provides comparable outcomes and improved cost-effectiveness in the treatment of low/intermediate prostate cancer. *Brachytherapy* 11: 441-445. [Crossref]
20. Vadalà RE., Santacaterina A., Sindoni A., Platania A., Arcudi A., et al. (2016) Stereotactic body radiotherapy in non-operable lung cancer patients. Vol. 18, Clinical & translational oncology: official publication of the Federation of Spanish Oncology Societies and of the National Cancer Institute of Mexico. *Italy* 1158-1159.
21. Faivre-Finn C., Vicente D., Kurata T., Planchard D., Paz-Ares L., et al. (2021) Four-Year Survival with Durvalumab After Chemoradiotherapy in Stage III NSCLC—an Update from the PACIFIC Trial. *J Thorac Oncol* 16: 860-867. [Crossref]
22. Borras JM, Lievens Y, Barton M, Corral J, Ferlay J, Bray F, et al. (2016) How many new cancer patients in Europe will require radiotherapy by 2025? An ESTRO-HERO analysis. *Radiother Oncol J Eur Soc Ther Radiol Oncol* 119: 5-11. [Crossref]
23. Mountzios G., Gkiozos I., Stratakos G., Pissakas G., Charpidou A., et al. (2021) Lung Cancer in Greece. Vol. 16, Journal of thoracic oncology: official publication of the International Association for the Study of Lung Cancer. *United States* 1058-1066.
24. Radiation therapy equipment in the EU - Products Eurostat News – Eurostat.
25. Lievens Y., Dunscombe P., Defourny N., Gasparotto C., Borras JM., et al. (2015) HERO (Health Economics in Radiation Oncology): a pan-European project on radiotherapy resources and needs. *Clin Oncol (R Coll Radiol)* 2: 115-124.
26. Grau C., Defourny N., Malicki J., Dunscombe P., Borras JM., et al. (2014) Radiotherapy equipment and departments in the European countries: final results from the ESTRO-HERO survey. *Radiother Oncol J Eur Soc Ther Radiol Oncol* 112:155-164. [Crossref]
27. Van Der Giessen P-H., Alert J., Badri C., Bistrovic M., et al. (2004) Multinational assessment of some operational costs of teletherapy. *Radiother Oncol J Eur Soc Ther Radiol Oncol* 71: 347-3355. [Crossref]
28. Ferini G., Pergolizzi S (2021) A Ten-year-long Update on Radiation Proctitis Among Prostate Cancer Patients Treated with Curative External Beam Radiotherapy. *In Vivo* 35:1379-1391. [Crossref]
29. Ferini G., Tripoli A., Molino L., Cacciola A., Lillo S., et al. (2021) How Much Daily Image-guided Volumetric Modulated Arc Therapy Is Useful for Proctitis Prevention with Respect to Static Intensity Modulated Radiotherapy Supported by Topical Medications Among Localized Prostate Cancer Patients? *Anticancer Res* 41: 2101–2110. [Crossref]
30. E Petelos., D Sifaki-Pistolla., V Chatzea., P Kopsiafti., C Lionis (2018) The high-quality Cancer Registry of Crete (CRC) and lessons to inform policy and practice. *European Journal of Public Health* 28: 218-258.