Methodology

Activity-Based Costing and Time-Driven Activity-Based Costing for Assessing the Costs of Cancer Prevention, Diagnosis, and Treatment: A Systematic Review of the Literature

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ABSTRACT

Background: A review of the literature on economic analyses in cancer (prevention, diagnosis, and treatment) using activity-based costing (ABC) or time-driven activity-based costing (TDABC) for measuring costs and to examine how these approaches have been applied to assess and manage cancer costs. Methods: This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. We conducted a search for studies that used ABC or TDABC to calculate the cost of cancer in prevention, diagnosis, and treatment. Only English- and Portuguese-language articles were retrieved from Medline, Lilacs, ScieLO, and Embase (January 1990 to August 2016). Results: In total, 421 studies were evaluated. However, only 27 papers were included. The first publications were from the early 2000s, but most of the studies were published in 2016 (n = 10). Most of the studies were carried out in the United States (n = 6) and Belgium (n = 6). Cancer treatment was the major focus of all studies (n = 20), followed by screening programs evaluations (n = 4) and diagnosis (n = 3). Among treatment modalities, economic analysis of radiotherapy was the most common topic of study. Retrospective clinical data represented 57.6% of the studies. More than 50% of the studies presented unspecified economic analysis. The hospital perspective was the most prevalent perspective among the studies (46.1%). Conclusions: ABC and TDABC economic analyses are a promising area of studies in oncology costs. Keywords: TDABC, ABC, Cancer, Economic.

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Introduction

Cancer is a major public health problem worldwide. In 2012, for 27 countries of the European Union, 3.45 million new cases of cancer were estimated and 1.75 million people died of cancer in these countries [1]. In 2016, in the United States of America, 1.7 million new cases of cancer were expected [2]. Despite an increase in cancer incidence, deaths from cancer have declined in the last years. Death rates from cancer declined by 23% in the United States over the last 20 years [2]. In developing countries, cancer deaths have also declined due to several factors, including early diagnosis, improved diagnostic approaches, new cancer treatments, and lifestyle changes [3,4].

These advances in cancer diagnosis and treatment through new technologies and innovations have resulted from continued investments in health care. Cancer patient care demands use of new technologies, which are key to add value and to allow health organizations to provide qualified and reliable care services [5]. Improving financial management of health care organizations poses a significant challenge as they operate within a complex system composed of many devices, including health care, social factors, multiple clients, research, and teaching [6]. The multiplicity of stakeholders comprising patients, family members, and health care providers, among others, demands organizational systems that can effectively gather useful information for decision making [7]. It is thus of paramount importance to improve financial management performance of hospitals and to define...
approaches to better handle this complex environment in the current economic scenario guided by cost restraints and high standards of quality of care [8,9].

Economic analyses are required as part of the process for incorporating new health technologies [10]. These assessments entail identifying direct and indirect costs of a new technology. An accurate estimate of costs is central to determine the validity of an economic analysis in the decision-making process. This field of research employs economic assessment methods to estimate the value of health care products and services by comparing costs and outcomes [10].

Although the importance of precise cost assessment of health care services [7] has been tremendously recognized, its implementation has been a challenge in practice due to a lack of standard of cost calculation. In the last years, researchers have explored systems that can help determine health care costs based on specific activities or products, such as activity-based costing (ABC) and time-driven activity-based costing (TDABC).

ABC is a costing methodology proposed by Cooper and Kaplan [11] that assumes that multiple products consume the same activities and these activities require health care resources in different proportions. ABC methodology provides a more accurate estimative of the cost of a product or service, especially when it is composed of a portion of people-oriented activities and activities in a hospital setting. ABC methodology consists of mapping processes and identifying activities that add value to the process, the analysis of cost allocation to these activities, and the use of first-stage cost drivers [12]. This approach entails first an accurate process mapping, that is, a business process analysis (BPA) of the organization [12,13], and its application is quite relevant in settings where the largest portion of costs is allocated to skilled work force as in health care organizations. ABC is an appropriate methodology to understand the costs in high-complexity systems, but because it entails process mapping and identification of people-oriented drivers, it is slow to implement and difficult to update [14].

On the other hand, TDABC is a modified version of ABC that does not require interviews with employees of organizations for allocating costs to activities because it directly assigns the costs of resources from cost objects through a simple formula: hourly cost rate. The basic principle of this methodology is that it converts cost drivers into time equations, which represent time required to perform a given activity. Both ABC and TDABC can accurately correlate cost and activity, as both provide actual cost estimates, especially when microcosting approach is used.

In the light of increasing cancer spending and weak costing methodologies compared to more robust approaches for pharmacoeconomic analyses, the present study aimed to conduct a systematic review of the literature on economic analyses in cancer (prevention, diagnosis, and treatment) using ABC or TDABC for measuring costs and to examine how these approaches have been applied to assess and manage cancer costs.

Eligibility Criteria and Study Selection
The eligibility criteria for study selection included studies using ABC or TDABC methodology to estimate the costs of cancer prevention, diagnosis, or treatment. There was no year of publication limits and only articles in Portuguese and/or English were eligible for inclusion.

Search, Data Extraction, and Analysis
Pairs of reviewers (Vargas and Etges) conducted the search of studies and data extraction. Duplicates were excluded using the Mendeley Desktop Software (version 1.16.1). The reviewers screened titles and abstracts and reviewed the full text of the studies selected. Any disagreements between the pair of reviewers on the selection status were settled by a third reviewer (Balbinotto).

After selecting studies for review, data were extracted and classified in a standardized manner according to general and specific characteristics of studies. The following data were arranged in tables: the authors, year of publication, study population, factor under study, type of economic analysis, source of medical data, country of origin, main study objective, study site, and comments. Data were stored in Microsoft Excel 2010.

Methodological Limitations and Statistical Analysis
The scientific quality of the articles was not fully explored, because the aim of this study was to investigate how ABC or TDABC has been applied in the oncology field, and not the quantitative estimates of their results. Hence, there is a probability of inclusion of studies with methodological limitations and/or imprecise results.

Results and Discussion
A total of 421 studies were identified and evaluated, and 27 studies met the eligibility criteria and were included in this review. Figure 1 summarizes the study selection process, excluded studies, and criteria for excluding them. Table 1 presents consolidated results from the studies selected [16–42].

Over the years, the number of studies published on microcosting and cancer has increased. The number of publications by year using ABC and TDABC methodology for measuring cancer costs was 19 and 8, respectively. The first studies were published in 1999 (n = 2), but most of them were published in 2016 (n = 10). TDABC was developed in 2004; therefore, it has been used in research and put in practice in other markets only recently (2015) [43].

A larger number of publications were from the United States and Belgium (n = 6 each) and three were from Canada. Most of the studies were conducted in developed countries mainly because they had high-capacity data-processing systems and could apply advanced costing methodologies. As for the large number of studies from the United States, it is worth noting that ABC and TDABC were developed at Harvard University. In developing countries, given the scarcity of health care resources and low investments in health information systems, there is a need to bridge this gap in order to improve several areas of management, especially financial management.

The studies reviewed here mainly focused on cancer treatment (n = 20), followed by evaluation of screening/prevention programs (n = 4) and diagnostic approaches (n = 3). Concerning cancer treatment, radiation therapy and related treatment modalities stood out as the most common factor under study. It can thus be inferred that radiotherapy is part of a process with fewer variances because it is a machine-based treatment. Considering that the ABC method requires mapping processes to implement ABC,

Methods
We conducted a systematic literature review of health-related databases. This review study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [15]. We conducted comprehensive search of full-text publications in the PubMed/MEDLINE, LILACS, SciELO, and EMBASE databases using the following descriptors in English and Portuguese: “cancer,” “activity-based costing,” and “time-driven activity-based costing.” Our search strategy is detailed in the Appendix A (see Appendix A in Supplemental Materials found at 10.1016/j.vhri.2018.06.001). All search strategies were run on July 19, 2016, and updated on June 7, 2017.
its application in health care services with well-shaped processes is easier and provides results that are more accurate. In addition, machine-based procedures enable the collection and analysis of information about patient flow and treatment time, thus minimizing the time required for planning and implementing ABC.

Most studies presented results from hospitals' perspective (46.1%). Hospitals are expected to profit while undertaking their routine operations—either by adhering to a public budget (public sector) or by generating earnings (private sector). In a competitive market, organizations aim at a high-efficiency performance to reduce costs and become more competitive regardless of their market [44].

The pursuit of improved cost management is focused on becoming more competitive in flexible markets in the current global economy. Thus, the fact that hospital perspective prevailed in most studies may point to a need to increase profitability by reducing costs [7] through value added by improving cost management using costing methodologies such as ABC and TDABC [45]. It is clear how these methodologies are related with the health organization capability to prospect value and to be more efficient. However, some difficulties are present and need to be improved using different case studies [45,46]. The prospective value of a health organization is determined by quality and safety of medical services delivered to patient [47,48]. Porter et al. [33] stated that achieving a high value of health care delivery for patients must become the overarching goal of health organizations. The authors measured value as the health outcomes achieved per dollar spent [49]. Processes that contribute to managing an organization in a systemic and proactive way encourage efficient practices among the organization’s divisions, resulting in cost reduction and consequent improvement in future value [50].

The ways to deal with shared structures presents in health care and to identify precisely the activity times are examples of issues that need to be more explored by researchers and hospital financial managers. One suggestion to tackle this problem is to restrict the precise time estimation to activities that are more representative of the process care [51]. To precisely estimate time, chronanalysis, participant observation, and Delphi methodology are suggested [52].

Medical data were largely collected using a retrospective design (over half of the studies, 57.6%). The data collected were used for cost estimates of the amounts spent by a hospital with the delivery of care services and procedures. In the studies of Lievens et al. [36,38] and Bermúdez et al. [35], the authors strongly advocated for improving the accuracy of cost information by applying ABC as a costing method. It is noteworthy that there were no studies conducted in middle- and low-income countries. Using retrospective cost data from other countries reduces the accuracy of financial information. Countries have different organizational structures for health care, and their resource allocation, organizational values, and input assignment to patients vary considerably, which stresses the need of individual cost estimates for each country. The use of ABC to determine the cost of a specific treatment represents an advance in improving quality of information available for pharmacoeconomic analyses and consequent improvements in decision making.

In addition to supporting pharmacoeconomic studies, advanced costing methods such as ABC and TDABC are effective approaches for cost management studies in health care settings. Lievens et al. [37,38] underlined the importance of using ABC to improve resource allocation planning on prospective demand for health services. The use of advanced costing methods in health offers an opportunity for researchers to fully explore alternatives to improve allocation of public health care resources, especially in developing countries, which are often not capable of meeting the enormous demands from the population.

Both ABC and TDBAC are methods that can help to analyze the cost of value in health. Value is defined in terms of the value equation—health outcomes achieved per unit cost expended over the entire care delivery value chain (CDVC) [53]. The International Society for Pharmacoeconomics and Outcomes Research (ISPOR) presented a draft policy in 2017 on the appropriate definition and use of value frameworks [53]. The ISPOR identified and defined a series of elements that should be taken into consideration in assessing value of medical technologies, for instance, quality-adjusted life-years gained, labor productivity, fear of contagion, insurance value, and severity of disease. The American Society of Clinical Oncology (ASCO) [54] and the European Society for Medical Oncology (ESMO) [55] have also released frameworks to offer insight into the relation between treatment benefit and treatment
<table>
<thead>
<tr>
<th>Year of publication</th>
<th>Author [Ref.]</th>
<th>Method used</th>
<th>Study population or type of cancer studied</th>
<th>Technology assessed</th>
<th>Economic analysis</th>
<th>Source of data</th>
<th>Country of origin</th>
<th>Perspective</th>
</tr>
</thead>
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<tr>
<td>2016</td>
<td>Ilg et al. [16]</td>
<td>TDABC</td>
<td>Prostate</td>
<td>Brachytherapy</td>
<td>NA</td>
<td>NA</td>
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<td>TDABC</td>
<td>Colon</td>
<td>NA</td>
<td>NA</td>
<td>Retrospective</td>
<td>Netherlands</td>
<td>Hospital</td>
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<td>Colon</td>
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<td>Hospital</td>
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<td>CEA</td>
<td>Prospective</td>
<td>Australia</td>
<td>Public system</td>
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<td>NA</td>
<td>Prospective</td>
<td>United States</td>
<td>Public system</td>
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<td>Cervix</td>
<td>Screening testing</td>
<td>CUA + CEA</td>
<td>Prospective</td>
<td>Italy</td>
<td>Public system</td>
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<td>ABC</td>
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<td>Retrospective</td>
<td>Italy</td>
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<td>Prostate</td>
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<td>CUA + CEA</td>
<td>Prospective</td>
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<td>Hospital</td>
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<td>Prostate</td>
<td>Screening program</td>
<td>CEA</td>
<td>Retrospective</td>
<td>Spain</td>
<td>Hospital</td>
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<td>ABC</td>
<td>Risk of neutropenia</td>
<td>Prophylactic filgrastim</td>
<td>CEA</td>
<td>NA</td>
<td>Belgium</td>
<td>Hospital</td>
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<td>Breast</td>
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<td>CUA + CEA</td>
<td>Prospective</td>
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<td>ABC</td>
<td>Back pain</td>
<td>MRI</td>
<td>CUA + CEA</td>
<td>Prospective</td>
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<td>NA</td>
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<td>ABC</td>
<td>Risk of breast cancer</td>
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<td>Risk of cervical cancer</td>
<td>Screening testing</td>
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<td>Retrospective</td>
<td>England</td>
<td>NA</td>
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<td>ABC</td>
<td>Cervical intraepithelial neoplasia</td>
<td>Treatment programs</td>
<td>NA</td>
<td>NA</td>
<td>USA</td>
<td>NA</td>
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</table>

ABC, activity-based costing; CCA, cost-consequence analysis; CEA, cost-effectiveness analysis; CUA, cost-utility analysis; MRI, magnetic resonance imaging; NA, not available or not applicable; PET-CT, positron-emission tomography and computed tomography; TDABC, time-driven activity-based costing.
cost. However, the ISPOR policy and ASCO and ESMO frameworks as well as most discussion of value in health are centered in outcomes and not in costs. Little attention is paid to development of cost-estimating tools. A recent criticism on ASCO and ESMO frameworks [56] highlighted the weak association between their frameworks in terms of quantifying the benefits, but again there was little discussion on cost estimation.

Neglecting costs in health or adopting inaccurate methodologies for cost estimations can bias interpretations of pharmacoeconomics studies. Valid value-based comparisons are not possible without consensus around how to calculate costs of medical conditions. This consensus can help healthcare providers to estimate more accurately the cost of care delivery for medical conditions and reduce the variability of costs in different scenarios [57]. These positions contribute with the opportunity that activity-based cost methodologies can represent because they have the capability to show: how, when and with what intensity the resources are being used by different patients.

Kaplan and Porter [58] suggested that TDABC is a cost-accounting solution to be used in health care settings. To follow TDABC, Kaplan and Porter [58] suggested seven steps: 1) select the medical condition; 2) define the care delivery value chain, that is, chart all key activities performed within the entire care cycle; 3) develop process maps that include each activity in patient care delivery and incorporating all direct and indirect capacity-supplying resources; 4) obtain time estimates for each process, that is, obtain time estimates for activities and resources used; 5) estimate the cost of supplying patient care resources, that is, the cost of all direct and indirect resources involved in care delivery; 6) estimate the capacity of each resource and calculating the capacity cost rate; and 7) calculate the total cost of patient care. A recent systematic review on the use of TDABC in general health care also identified that use of capacity cost rate (used in TDABC) simplifies the application of ABC in complex environments such as health care [43]. These authors also suggest that the TDABC should be gradually incorporated in health care systems. These findings corroborate the fact that we found a higher number of publications on TDABC between 2015 and 2016 in our review (66% de TDABC). In fact, we believe that the TDABC product is the most accurate denominator to assess value in health for certain medical conditions, such as cancer.

Conclusions

Our review included studies on economic analyses using advanced ABC and TDABC methods for measuring cancer costs. These methodologies have the advantage of providing more accurate cost information in complex environments with resources focusing on skills and implicit knowledge. At the same time, the main challenge of these methods is that they require process mapping in different health care services. Mapping processes and identifying the flow of values can be challenging in hospital settings as they demand much effort and consume time in real case scenarios.

The present review study focused on cancer-related practices and did not investigate other diseases and overall hospital costing analyses. Thus, our findings cannot be generalized to other health settings. Because we reviewed only international studies, further investigations are needed to assess the application of these costing methods in other countries, especially in developing countries.

Our study pointed to a need to further exploration of the use of ABC and especially TDABC methodologies to support economic health analyses. We also recommend similar reviews on costing methods in different countries and in hospitals as well.

REFERENCES
