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APPLICATION OF TDABC IN ASSESSING THE PROFITABILITY OF EXAMINATIONS AND THE LEVEL OF IDLENESS OF COMPUTED TOMOGRAPHY IN THE GYNECOLOGICAL ONCOLOGY SECTOR

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ABSTRACT

Gynecological malignancies represent one of the main factors of mortality for women, and imaging examinations are important instruments for diagnosis, staging, and surgical planning. Such examinations are conducted in the Imaging Diagnostic Centers (IDC), which, due to the use of sophisticated technology and skilled labor, have a high cost and impact on health systems. Given this context, this research aims to demonstrate how TDABC can be used to assess the profitability of examinations and the levels of idleness existing in the context of the computed tomography sector of the gynecological oncology unit. For this purpose, a methodology classifiable as qualitative and descriptive was used, and the case study format was adopted, with data collection through documentary research, informal interviews to learn the process, and estimates of the time of execution of the activities. The results showed that the tests performed were deficient since the cost of providing these services is higher than the prices paid by the Unified Health System (SUS), which resulted in a total loss of BRL -79,347.04 in the month. The idleness levels of the activities involved were also determined in terms of idle minutes and monetary values. Therefore, it was concluded that the total idleness of the tomography sector surveyed reached BRL 102,932.81 and is equivalent to 41.62% in the average of the activities covered (ranging between 3.66% in the case of equipment and 81.59% for the activity of nurses). As for the contributions arising, it should be noted that the information provided by TDABC can support actions aimed at reducing time between activities and optimizing the work of the employees involved, in addition to evidencing the adherence of TDABC within the scope of entities that perform diagnostic imaging services.

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From the results obtained, it is concluded that it is essential to optimize the processes to reduce the examination time and increase productivity, as well as to readjust the values of the SUS table to avoid compromising the investment of resources in other hospital sectors.

Keywords: TDABC. Tomography. Case study. Idleness.

1 INTRODUCTION

Gynecological neoplasms represent the main causes related to morbidity and mortality in women, with ovarian cancer being the main cause of death among gynecological malignancies. In these circumstances, imaging examinations are important tools for diagnosis, staging (evaluation of the degree of dissemination), surgical planning, and prognosis of gynecological neoplasms (Howard, & Soeters, 2010).

Computed tomography (CT) is a medical examination option for the initial staging of neoplasms, as it provides varied information (size of the primary lesion, absence or presence of peritoneal implants and their dimensions, development of lymph nodes, etc.) that are vital to determine the surgical treatment and verify which patients will require neoadjuvant chemotherapy before surgery (Kang et al., 2018).

Therefore, Imaging Diagnostic Centers (IDCs) play a relevant role in performing examinations in patients with gynecological neoplasms. Still, these centers require advanced technologies, which generates high costs in providing associated services. For this reason, it is interesting that there is control and standardization of expenses and processes to avoid errors and increased costs, prioritizing the effectiveness of available resources (Amaral et al., 2011). This is pertinent because cost management facilitates the analysis of the convenience of expenses, which can optimize processes and avoid waste in production, marketing, and service provision processes, regardless of the organization's activities, whether or not it is for profit (Rebouças et al., 2018). Moreover, the search for financial efficiency has always been one of the great challenges for any entity, and it is no different for hospital institutions (Zanin et al., 2018).

In this regard, Cardoso et al. (2023) argue that the COVID-19 pandemic has increased the need to better understand where and how costs are incurred in health organizations since decision-makers need to adapt quickly to the growing demand for hospital services and necessary diagnoses in patient care. Along the same lines, Abbas and Leoncine (2014) argue that calculating and controlling hospital costs represent a need in these organizations, serving as a tool to facilitate control and reduce undue costs. So, for a hospital to have adequate cost management, it is necessary to adopt a costing method that allows improving the evaluation of the performance of the various units that integrate it, as well as knowing the effective operating result of each of these market segments.

Likewise, identifying the level of idleness of an organization can be considered valuable information for managers and investors, which motivates its calculation internally (to optimize productive capacity) and externally, especially when there is a prospect of increased demand or feasibility studies for expansion (Afonso & Santana, 2016).

Among the possibilities recommended in the literature to obtain such information in the hospital context is *Time-driven Activity-based Costing* (TDABC), which can be considered an updated version of *Activity-based Costing* (Zanin et al., 2018; Shankar et al., 2020). However, because it is based on the unit of measure "time" of execution of the activities it covers, its applicability in the hospital segment may be impaired by aspects such as the unpredictability of the duration of certain procedures or the difficulty of collecting the necessary data.

With this, the research question that is intended to be answered in this study emerges: how to use TDABC to assess the profitability of examinations and the levels of idleness of the computed tomography sector of the gynecological oncology unit? Thus, this research aims to demonstrate

how TDABC can be used to assess the profitability of examinations and the levels of idleness existing in the context of the mentioned sector.

Previous research on TDABC in health organizations focusing on Imaging Diagnostic Centers (IDCs) has shown that: (*i*) medical labor has a high share of the total cost of this activity (Anzai et al., 2017); (*ii*) unnecessary procedures identified in process mapping increase these costs (Tibor et al., 2017); (*iii*) the increase in physician idle time waiting for the patient is an impacting factor on cost (Choudhery et al., 2020); and (*iv*) the storage of patient care material in distant locations may result in increased time to perform procedures and, consequently, increased inherent costs (Daroit et al., 2018).

Thus, when comparing the focus of the previous studies, it is pertinent to consider that the present research can be justified for two reasons. From a theoretical point of view, the first reason is based on the scarcity of similar studies that focus on the profitability of examinations and the levels of idleness of gynecological oncology computed tomography, indicating a research gap regarding the applicability of TDABC in Imaging Diagnostic Centers (IDCs). Also, as a practical contribution, this study can serve hospital organizations with similar Imaging Diagnostic Centers (IDCs) to use TDABC to improve the management of their costs.

A second reason to justify such an approach is the social contribution of this research that shows how the use of this management tool can be useful to managers' decision-making in improving financial performance and optimizing the management of public entities since TDABC makes it possible to improve the allocation of resources and control of expenses (Queiroz et al., 2022).

2 LITERATURE REVIEW

For an organization to better understand the financial results, it is necessary to know the costs involved in manufacturing the product, marketing the merchandise, or providing the service, as well as the selling price practiced (Sampaio & Pereira, 2020), which the complexity of each process can hamper.

Imaging Diagnostic Centers (IDCs), due to the multiple activities performed (radiography, ultrasound, densitometry, computed tomography, magnetic resonance, and positron emission tomography), require using high technology and are characterized by high complexity in the performance of services. This makes managing associated processes even more necessary, especially due to the high cost value (Amaral et al., 2011).

Among the various artifacts available to managers is *Time-driven Activity-based Costing* (TDABC), which is pointed out by Etges et al. (2019) as a useful management tool in organizations that work providing complex services, such as clinical-hospital. That means such a method tends to be suitable for productive environments characterized by difficulty identifying the flow of costs throughout the process, especially when labor and equipment can operate in different productive segments (Ganorkar et al., 2019).

TDABC was formatted based on the principles that guided *Activity-based Costing* (ABC), as mentioned by Kaplan and Anderson (2007). This managerial tool can be qualified as a costing method based on time and activity drivers to calculate and manage costs and increase organizational efficiency (Choudhery et al., 2021).

This method can be considered an improvement of the ABC because it directly estimates the resources consumed based on the time of each activity that integrates the production process (Choudhery et al., 2020; Kaplan & Anderson, 2007). In this direction, TDABC tends to be more easily implemented (and less expensive) than ABC, as it can use data already available or quickly collectible, allowing it to be integrated with existing cost systems and providing a systemic view of the organization's processes (Cabral et al., 2022; Alaoui & Lindefors, 2016).

It is worth noting that TDABC is based on the principle of bottom-up evaluation, which means part of a specific process for the broadest, with resource allocation according to the cost per

unit produced and the time associated with this process (Rubin, 2017). This characteristic may support one of the results of this study related to idleness, as will be discussed in a later section.

The TDABC is a tool that provides management data for decision-making, helping to control costs, either in monitoring results or in introducing technologies to optimize processes (Kaplan & Anderson, 2007; Keel et al., 2017). It also allows the continuous measurement of the time spent to conduct the activities, as well as the measurement of the costs of the processes per unit of time and the practical capacity of the resources (employees, structure, and materials), which can serve as indicators in the cost management process of the organizations (Santana & Afonso, 2015).

As for the applications of TDABC in the context of hospital procedures, some recent research has accentuated the benefits of using this costing tool. In this sense, Wei et al. (2022) mention that TDABC can be useful for assessing costs in the health area, including in the context of new treatment approaches.

Thaker et al. (2022) state that TDABC makes it possible to measure the use of resources throughout the care cycle, which contributes to improving the efficiency of the workflow and minimizing the costs of medical procedures. That means it can complement traditional management initiatives to reduce expenses by quantifying the steps with higher costs, which facilitates the prioritization of initiatives to reduce expenses and improve efficiency.

Fidanza et al. (2022) add that TDABC can be considered an innovative approach to measuring costs with greater accuracy, as it estimates the amount of time and the cost per unit of time of the resources used during a service or examination. Furthermore, according to Bernstein et al. (2023), TDABC provides an instrument capable of calculating the costs associated with medical procedures more accurately.

Cardoso et al. (2023) consider that TDABC makes it possible to understand the cost factors along the patient care path, providing interesting information to support decisions on process improvement and resource optimization. Thus, it improves the quality of the information used to develop reimbursement strategies for the amounts spent on medical procedures.

For Sethi et al. (2024), combining TDABC with other tools can help disclose costs associated with hospital care, as it indicates potential cost savings in several situations. This encourages physicians and administrators to allocate resources to improve patient care, reducing complications and costs.

Sangha et al. (2024) mention that TDABC is useful for comparing hospital procedure costs because it requires process mapping to list all activities and resources (personnel, equipment, and materials) required at each stage of the care provided.

As for the phases for applying the TDABC, Keel et al. (2017) argue that they may involve: (*i*) selecting the procedure one wants to evaluate; (*ii*) defining the activities in the entire care chain related to the targeted procedures; (*iii*) developing the process map involving all activities; (*iv*) obtaining the time estimate for each activity; (*v*) estimating the cost for each activity in the process; (*vi*) calculating the productive capacity used; (*vii*) calculating the cost related to this capacity; and (*viii*) calculating the total cost.

Thus, in order to apply TDABC, it is necessary to measure the available productive capacity, understood as the amount of time that employees work in the execution of activities (Choudhery et al., 2020). It should be noted that, in determining the work capacity rate effectively installed, it is assumed that such capacity represents about 80% of the total theoretical capacity for employees (because of rest breaks, entry and exit time, training, meetings, etc.) and 85% for machines (due to downtime derived from *setups*, maintenance, and repairs), according to Kaplan and Anderson (2007).

According to these authors, this effective capacity is one of the components of calculating the "capacity cost rate," along with the amounts spent to perform a given activity. In other words, this rate can be defined as the result of dividing (*i*) all expenses with resources provided to departments or processes (people, equipment, technology, and infrastructure) for the execution of

the activity by (*ii*) the time consumed of the respective effective work capacity (Kaplan & Anderson, 2007).

Therefore, the capacity cost rate of each organization's activities will represent the cost value of the activities per minute of execution (BRL/min.). Based on this rate, the costs of products/services are determined considering the expenditure of time in the interaction with personnel, machines, or infrastructure, adding later the cost with material (Kaplan & Anderson, 2007).

2.1 Previous Similar Research

A systematic literature review by Cabral et al. (2022) showed a large participation of research in the health area among the most recent publications on TDABC. However, this article prioritized studies focused on using TDABC in the context of diagnostic imaging centers, as highlighted below.

Anzai et al. (2017) mapped the processes of computed tomography (CT) abdomen and pelvis examinations in a university hospital for tertiary care using TDABC. CT scans of the abdomen and pelvis represented most of the scans performed in IDCs, and patients were stratified according to the place of origin, considered patients from the emergency, hospitalization, and outpatient clinics. The costs of performing these examinations were identified, and the results showed that 80% of the costs of CT of the abdomen and pelvis were related to labor costs. The authors observed that reducing the time between examinations would be a way to reduce the costs associated with services.

Tibor et al. (2017) implemented TDABC in an imaging diagnostics center (IDC) to measure the costs of magnetic resonance enterography examination, considering the costs of personnel, equipment, maintenance fees, and materials used to perform the examination. They observed an increase in the effectiveness of processes by mapping them and identifying that some steps were unnecessary, which allowed them to reduce costs by 13%. They concluded that it is essential to understand the costs so that the organization can develop in a competitive market in which patients want to be served with quality services. At the same time, providers seek to add value to the services provided.

Choudhery et al. (2020) used TDABC in the mammography sector for ultrasound-guided breast biopsies in an IDC. After analyzing the process mapping, they found that the physician's idle waiting time for the patient had high participation in the final cost of the examination. After solving problems related to examination scheduling, the physician's idle time waiting for the patient was reduced, which allowed a decrease in the amount of associated costs.

Daroit et al. (2018) used TDABC to measure the cost of services provided by an IDC of a highly complex private hospital in Rio Grande do Sul. They evaluated the cost of the examinations performed by the IDC compared to the transfer price of the Unified Health System (SUS) table. The resulting findings showed that it was possible to reduce the time of the process related to the identification of materials and where they should be stored. Thus, there was reduced displacement and time spent by the nursing team in preparing the patient, optimizing the costs of providing services.

In summary, the previous studies showed that mapping the processes is valid for tracking and understanding the possible aspects that impair patient care and/or that increase costs (such as unnecessary activities or those that increase idleness). These studies also indicate that TDABC, by using the time and cost of each procedure, allows one to know the productivity of the processes and facilitates the analysis of possible improvement actions to reduce the use of resources in order to minimize costs and improve value generation. Therefore, they spoke only indirectly about measuring the profitability of the examinations (as they focused on the respective costs) and did not prioritize the aspect of idleness existing in the contexts covered. Based on the above, it is

appropriate to assume that this research differs from the previous ones in that it aims to measure the profitability of the examinations performed and the levels of idleness of an IDC.

3 METHODOLOGICAL ASPECTS

As for the methodological approach, it should be noted that the nature of the research objective is characterized as "descriptive" because the organization's management and accounting reports were used to describe the process and costs of providing IDC services. The study approach is "qualitative," considering that the processes and costs of providing services were interpreted and measured by applying the TDABC costing method. The research method is the "case study" because the research object was circumscribed to the tomography sector of a public hospital.

As for the data considered in the research, they were obtained through documentary sources (balance sheet to verify the period, payroll, physical inventory, etc.), other accounting information from the management software (absolute — V.3.2), control spreadsheets (Excel) maintained by the hospital management, informal (unstructured) interviews to know the details of the process of execution of the examinations and observation of the time of execution of the activities.

Regarding the research object, it covered the Computed Tomography (CT) sector of the IDC of a tertiary public hospital specialized in gynecological oncology, headquartered in the state of Rio de Janeiro (whose name was omitted at the request of the entity's administrator), based on January 2023. This hospital organization is a reference in cancer treatment in Brazil, and the IDC is responsible for performing all examinations of patients with gynecological cancer in the unit.

It should be mentioned that the IDC of this hospital institution is subdivided into sectors (conventional radiology, ultrasound/echocardiography, and computed tomography), with employees specifically allocated to related activities. However, for the purposes of this research, the computed tomography sector was selected because the respective examinations are the main tool for staging gynecological neoplasms. In other words, examinations are performed on several segments of the patients' bodies (with or without venous contrast), but mainly computed tomography of the chest, abdomen, and pelvis, representing more than 90% of this hospital unit's monthly volume of examinations.

4 DATA PRESENTATION AND RESULTS DISCUSSION

The first step in applying TDABC in the computed tomography sector was to learn how to perform the examinations. After this step, the data collection phase related to the activities necessary for the procedures performed and the respective monthly costs was conducted. Information was collected on the composition of the staff, which involves a multidisciplinary team formed by radiologist physicians, nurses, nursing technicians, radiology technicians, and administrative support (receptionist and secretary) and the respective compensation and social charges (vacation, annual Christmas bonus salary, extra night work and unhealthy conditions rates, etc.), as summarized in Table 1.

Table 1
Sector Payroll

Activities	Salaries and Charges (BRL)	Number of Employees	Total Cost Monthly (BRL)
Receptionist	1,480.00	2	2,960.00
Secretary	1,980.00	1	1,980.00
Radiologist Physician	16,500.00	5	82,500.00
Radiology Technician	5,800.00	7	40,600.00
Nurse	16,500.00	2	33,000.00
Nursing technician	4,200.00	4	16,800.00
Total		21	177,840.00

Source: Prepared by the authors.

In the research, it was decided to consider the "positions" of the professionals as representative of "activities" to facilitate the grouping of the various services that each type of professional performs, even if such an initiative may be misaligned with the theoretical conception of what is an "activity" in the TDABC scope.

The monetary values in Table 1 were provided by the human resources sector of the researched hospital, which chose to make available only the total values (rounded) by type of positions and the respective numbers of employees. Also, information was obtained regarding the sector's opening hours and the employees' working hours. Therefore, it was found that most IDC professionals work on a "weekly shifts" scale of eight hours (nursing technicians and nurses), twelve hours (doctors), or 24 hours (radiology technicians). Thus, to calculate the total work capacity of the sector, the standard of four weeks per month was adopted to estimate the employees' workload.

In the third stage of implementing the TDABC method, the monthly expenses related to the infrastructure made available to the sector to conduct the targeted operational activities were calculated, whose relevant components are listed in Table 2.

Table 2
Monthly Spending on Sector Infrastructure Equipment

Items	Parameter	Amount Unit. BRL	Amount Monthly BRL
E. E. – Tomograph	36,708 kWh/month	0.79	28,999.32
E. E. – Computer	253 kWh/month	0.79	199.87
E. E. – Lighting	759 kWh/month	0.79	599.61
E. E. - Air Conditioning	11,645 kWh/month	0.79	9,199.55
Tomograph depreciation	120 months	-	23,333.00
Air-cond. maintenance	BRL/monthly	-	1,800.00
Maintenance of the infusion pump	BRL/monthly	-	875.00
Phone	BRL/monthly	-	850.00
Dosimeter	Unit	18.00	396.00
Equipment loan for use	BRL/monthly	-	1,680.00
Total			67,932.35

Source: Prepared by the authors.

For equipment that consumes electricity (tomograph, computer, lighting, and air conditioning), the volumes of kilowatt/hour (kWh) consumed by these items during a month were estimated (second column of Table 2, first four items), which were multiplied by the price (BRL) of the kWh (disregarding the price variation per hour).

The useful life of 120 months was considered to calculate the tomograph's depreciation, totaling BRL 23,333.00 per month. Except for the tomograph, all other equipment in the sector is exchanged annually by an outsourced company, according to the loan-for-use agreement, which costs BRL 1,680.00 monthly. Regarding the costs related to telephone and loan for use services of computers, printers, and air conditioning, the respective values were obtained in management reports of the financial area, making an apportionment according to the square footage (m^2) occupied by the sector compared to the total hospital area.

In the fourth phase of the TDABC implementation process, the survey of the available (or installed) work capacity of each subdivision/activity of the Tomography sector was prioritized, as described in Table 3.

Table 3
Functional and infrastructure characteristics of the tomography sector

Items	Main activities	Shift Weekly (h)	Shift Monthly (min.)	Number of employees	Capacity available (min.)
Receptionist	Scheduling of patients.	40	9,600	2	19,200
Secretary	Completions of spreadsheets, management of schedules, reception, and printing of reports.	40	9,600	1	9,600
Physician Radiologist	Patient care, opinions to attending physicians, guidance to the radiology technician, and issuance of reports.	24	5,760	5	28,800
Radiology Technician	Positioning of patients, manipulation of equipment, and sending of examinations to the system.	24	5,760	7	40,320
Nurse	Inventory control, organization of nursing technicians, and patient interviews.	24	5,760	2	11,520
Nursing technician	Assistance to patients during and after examinations, peripheral venipuncture, and manipulation of the infusion pump.	24	5,760	4	23,040

Source: Prepared by the authors.

The total monthly workload considers the weekly workload in the employee's hours, multiplied by the number of weeks of the month and then by the number of employees. For example, the 24 hours per week of "nursing technicians" total 5,760 minutes/month, which is multiplied by four employees, indicates that 23,040 minutes of capacity were available in this group of activities related to these professionals.

4.1 Measurement of the costs of activities and examinations

After collecting the necessary data, the resulting results were calculated and analyzed. Table 4 describes the procedure adopted to determine the "capacity cost rate (BRL/min.)" underlies the TDABC method.

Table 4
Capacity cost rate (BRL)

Type of expense	Expense Monthly BRL (a)	Capacity total in minutes (b)	Estimate use (%) (c)	Capacity effective (min.) (d=b x c)	Capacity cost rate BRL/min. (e=a / d)
Receptionist	2,960.00	19,200	85.0%	16,320	0.1814
Secretary	1,980.00	9,600	85.0%	8,160	0.2426
Radiologist Physician	82,500.00	28,800	85.0%	24,480	3.3701
Radiology technician	40,600.00	40,320	85.0%	34,272	1.1846
Nurse	33,000.00	11,520	85.0%	9,792	3.3701
Nursing technician	16,800.00	23,040	85.0%	19,584	0.8578
Equipment	67,932.35	40,320	100.0%	40,320	1.6848
Total	245,772.35	172,800	-	152,928	-

Source: Prepared by the authors.

To reach the values in the last column of Table 4, in the case of the "Receptionist," the amount of monthly expenditure (BRL 2,960.00) was divided by the effective capacity in minutes (16,320 minutes), which resulted in BRL 0.1814 per minute. It should be clarified that the total

capacity of this activity was 19,200 minutes. However, only 85% of this amount (16,320 minutes) was considered as a way to cover the effects of unworked hours caused by various reasons (such as snacks, absenteeism, conversations, trips to the bathroom, etc.), which is in line with what was defended by Kaplan and Anderson (2007). The same calculation was adopted for the other activity groups (Secretary, Radiologist Physician, Radiology Technician, Nurse, and Nursing Technician), while in the case of "Equipment," the total capacity (100%) was considered. Thus, the unit costs of capacity varied between BRL 0.1814 per minute (Receptionist) and BRL 3.3701 per minute (Radiologist Physician and Nurse).

The next step was to survey the average execution time of the types of prioritized examinations (with and without venous contrast), as shown in Table 5.

Table 5

Time to perform each examination activity

	Chest		Abdomen		Pelvis	
Items	**W/o Contr.**	**W/ Contr.**	**W/o Contr.**	**W/ Contr.**	**W/o Contr.**	**W/ Contr.**
Receptionist	5	5	7	7	5	5
Secretary	3	3	5	5	3	3
Radiologist Physician	20	20	28	30	20	20
Radiology technician	10	10	15	15	10	10
Nurse	-	3	-	5	-	3
Nursing technician	-	12	-	12	-	12
Equipment	38	53	55	72	38	53

Source: Prepared by the authors.

It should be noted that the interaction time of the patients with the employees and the use of the infrastructure was timed without the knowledge of the participants, calculating the median time spent in each stage of the process mapping estimated through the observation of five patients for the chest Computed Tomography (CT) examination, five patients for the abdomen examination, and five patients for the pelvis examination. The median was used since divergent measurement values due to patient limitation and the low number of cases could strongly interfere with the correct measurement of the measured value.

It was found that the patient has the longest interaction time with the infrastructure since it includes using physical space and equipment to perform the examinations, considering the moment of their arrival until the departure from the IDC. Next, we highlight the interaction with the radiologist physician who interviews the patient to decide the need for venous contrast, guidance to the radiology technician, and issuance of examination reports. On the other hand, receptionist, secretary, and nurse activities are the least time-consuming within the mapping of processes since they conduct interview actions that are more directed to patient care to perform the examination.

With the available data, it was possible to determine the cost of each examination considering the time spent with each employee's activity and the capacity cost rate per minute (BRL), as shown in Table 6.

Table 6

Calculation of the cost of the examinations

Type of examination	**Chest**		**Abdomen**		**Pelvis**	
Contrast	**W/o Contr.**	**W/ Contr.**	**W/o Contr.**	**W/ Contr.**	**W/o Contr.**	**W/ Contr.**
A) TIME TAKEN BY THE ACTIVITY (MINUTES)						
Receptionist	5	5	7	7	5	5
Secretary	3	3	5	5	3	3
Radiologist Physician	20	20	28	30	20	20
Radiology technician	10	10	15	15	10	10
Nurse	-	3	-	5	-	3
Nursing technician	-	12	-	12	-	12

Equipment	38	53	55	72	38	53
B) CAPACITY COST RATE (BRL/MINUTE)						
Receptionist	Secretary	Rad. Physician	Rad. Tech.	Nursing	Nursing technician	Equip.
0.1814	0.2426	3.3701	1.1846	3.3701	0.8578	1.6848
C = A x B) COST OF examination EXECUTION						
Receptionist	0.91	0.91	1.27	1.27	0.91	0.91
Secretary	0.73	0.73	1.21	1.21	0.73	0.73
Radiologist Physician	67.40	67.40	94.36	101.10	67.40	67.40
Radiology technician	11.85	11.85	17.77	17.77	11.85	11.85
Nurse	-	10.11	-	16.85	-	10.11
Nursing technician	-	10.29	-	10.29	-	10.29
Equipment	64.02	89.30	92.67	121.31	64.02	89.30
Total execution cost	144.91	190.58	207.28	269.81	144.91	190.58

Source: Prepared by the authors.

As shown in Table 6, the cost of performing the examinations accounted for the time (in minutes) spent on each activity to interact with the patient, which was multiplied by the respective capacity cost rate (BRL/minute). To exemplify this reasoning, it should be assumed that the examination of the "Pelvis with contrast" (last column of Table 6) consumed 20 minutes of the radiologist physician in the interaction with the patient, whose capacity cost rate is BRL 3.3701 per minute. Thus, only with this activity will BRL 67.40 (20 minutes X BRL 3.3701 per minute) be spent to perform such an examination. Doing this for the other "Pelvis with contrast" examination procedures, the total execution cost amounted to BRL 190.58.

In the set of examinations covered, the values ranged from BRL 144.91 (Chest without contrast and Pelvis without contrast) to BRL 269.81 (Abdomen with contrast), only with the cost of performing the tomography examinations, without considering the supplies used. It should be noted that this more significant share of labor expenses in the execution of the examinations (greater than 53% in all types evaluated) partially corroborates the research by Anzai et al. (2017), in which the level found was 80%.

Subsequently, to calculate the final cost of the examination, the amount spent on consumables and the volume of venous contrast used in each procedure were added, considering the value of 01 (one) milliliter per/kg of patient weight. It is worth emphasizing that the decision to use contrast is up to the radiologist physician, guided mainly by the need to better observe the neoplastic lesions that may have spread to other parts of the body (such as the liver, peritoneum, and bones), as the contrast aims to better highlight these lesions for a more accurate diagnosis by the radiologist physician.

The costs of contrast-enhanced examinations are higher due to the participation of nurses and nursing technicians in their performance, in addition to the fact that the use time of the apparatus tends to be longer and implies additional expenses. That means, in this situation of contrast use, there is a need for an interview to be conducted by the nurse to collect more accurate information (such as patient weight, use of medications that can interact with venous contrast, research on risk factors, such as diabetes and renal function, etc.) to support the prescription of the correct dose of contrast to the patient. Also, the nursing technician must perform the venipuncture of the patient for contrast administration.

Hence, Table 7 lists the total values of each of the three types of examinations with venous contrast, considering the execution and consumption of material.

Table 7
Cost of CT scan with venous contrast after using consumables (BRL)

Supplies/examinations	Chest	Abdomen	Pelvis
examination execution cost (with contrast)	190.58	269.81	190.58
Glove	0.35	0.35	0.35
Needle 40	0.45	0.45	0.45
Equipment	0.80	0.80	0.80
Syringe 100 ml	2.50	2.50	2.50
Jelco	1.50	1.50	1.50
Venous contrast (BRL 1.12 per milliliter)	56.00	78.40	56.00
(=) Total (examination + material)	252.18	353.81	252.18

Source: Prepared by the authors.

As seen in Table 7, using venous contrast strongly increases the final price of the examination, especially in the case of the procedure performed in the abdomen, due to the use of a greater volume of this type of drug.

4.2 Profitability of the types of examinations

Once the total costs of each type of examination were known, it was possible to evaluate the profitability of these services based on the price paid by the federal government, based on the Unified Health System (SUS) table. In this sense, Table 8 presents the unit and total profitability based on data collected in January 2023.

Table 8
Profitability of examinations (reference period: January 2023)

	Chest		Abdomen		Pelvis		
Items	W/o Contr.	W/ Contr.	W/o Contr.	W/ Contr.	W/o Contr.	W/ Contr.	Total
a) SUS Listed Price BRL	136.41	136.41	138.63	138.63	138.63	138.63	-
b) Execution cost w/ contrast BRL	-	190.58	-	269.81	-	190.58	-
c) Execution cost w/o contrast BRL	144.91	-	207.28	-	144.91	-	-
d) Material consumed BRL	-	61.60	-	84.00	-	61.60	-
e=a-b-c-d) Result BRL	-8.50	-115.77	-68.65	-215.18	-6.28	-113.55	-
f=e/a) Result (%)	-6.23%	-84.87%	-49.52%	-155.22%	-4.53%	-81.91%	-
g) Number of examinations/month	67	143	77	171	79	173	710
h=a x g) Total revenue BRL	9,139.47	19,506.63	10,674.51	23,705.73	10,951.77	23,982.99	97,961.10
i=b x g) examination w/ contr. BRL	-	27,253.45	-	46,137.13	-	32,970.96	106,361.54
j=c x g) examination w/o contr. BRL	9,708.75	-	15,960.63	-	11,447.63	-	37,117.01
k=d x g) Total Consumables BRL	-	8,808.80	-	14,364.00	-	10,656.80	33,829.60
l=h-i-j-k) Total result BRL	-569.28	-16,555.62	-5,286.12	-36,795.40	-495.86	-19,644.77	-79,347.04

Source: Prepared by the authors.

In other words, in the case of the "Abdomen with contrast" examination, the amount paid by SUS (BRL 138.63), the values of the cost of execution with contrast (BRL 269.81), and the material consumed (BRL 84.00) were discounted, resulting in a result of BRL -215.18 per examination (equivalent to -155.22% of the sale price). As 171 examinations of this modality were conducted in the period covered, the total revenue reached BRL 23,705.73, while the total execution cost reached BRL 46,137.13, and the total material consumption was BRL 14,364.00. Thus, the result was a deficit of BRL -36,795.40 only with the "Abdomen with contrast" examinations.

When comparing the result per examination unit (line "f" of Table 8), it is found that all types of procedures are deficient, with oscillations between -4.53% (Pelvis without contrast) and -155.22% (Abdomen with contrast). Comparing the total result at the end of the month (line "l"), the examinations had total results between BRL -495.86 and BRL -36,795.40. These deficient results of the examinations covered are in line with those evidenced by Daroit et al. (2018) since, in that research, it was also found that the SUS Table did not cover the cost of most examinations performed.

The last column of Table 8 (in lines "h" and "l") contains the statement of the result for the month, considering the total number of examinations (710 procedures), the prices of the SUS table (BRL 97,961.10), the execution costs measured by TDABC (BRL 106,361.54 with contrast and BRL 37,117.01 without contrast), and the consumption of material (BRL 33,829.60). Therefore, it was concluded that the result for the period was BRL -79,347.04. This statement indirectly showed that the compensation of services by the SUS Table is very outdated compared to the amounts effectively spent on the examinations performed by the sector, especially the examination of the abdomen with venous contrast. This reality tends to impact the result of the hospital unit, which has to support the deficit of this sector, probably reducing contributions in other departments of the institution.

4.3 Measurement of idleness (idle time and respective monetary value)

One of the informative benefits that TDABC provides is the evaluation of the idleness of each costing object, as it allows comparing between the "installed," "used," and "idle" production capacities (Wernke et al., 2019). Thus, unlike previous studies that focused on the hospital environment, this study measured idleness related to the activities covered. To do so, the capacities used (or total time consumed) were initially identified, as detailed in Table 9.

Table 9
Idle time

Items	Chest		Abdomen		Pelvis		Total
	W/o Contr.	W/ Contr.	W/o Contr.	W/ Contr.	W/o Contr.	W/ Contr.	
A) TIME TAKEN BY THE ACTIVITY (MINUTES)							
Receptionist	5	5	7	7	5	5	-
Secretary	3	3	5	5	3	3	-
Radiologist Physician	20	20	28	30	20	20	-
Radiology technician	10	10	15	15	10	10	-
Nurse	-	3	-	5	-	3	-
Nursing technician	-	12	-	12	-	12	-
Equipment	38	53	55	72	38	53	-
B) NUMBER OF examinations PERFORMED IN THE MONTH							
Number of examinations/month	67	143	77	171	79	173	710
C = A x B) TOTAL MINUTE CONSUMPTION (CAPACITY USED)							
Receptionist	335	715	539	1,197	395	865	4,046
Secretary	201	429	385	855	237	519	2,626
Radiologist Physician	1,340	2,860	2,156	5,130	1,580	3,460	16,526
Radiology technician	670	1,430	1,155	2,565	790	1,730	8,340
Nurse	-	429	-	855	-	519	1,803
Nursing technician	-	1,716	-	2,052	-	2,076	5,844
Equipment	2,546	7,579	4,235	12,312	3,002	9,169	38,843

Source: Prepared by the authors.

The calculation of the total consumption of minutes was performed by multiplying the (*i*) time (in minutes) consumed by an examination by the (*ii*) respective number of examinations performed in the period. For example, if the non-contrast chest examination consumes (on average) 38 minutes in the equipment, multiplication by 67 examinations indicates that 2,546 minutes were consumed with this type of laboratory procedure in that activity. When making this

calculation for the other examinations, it was concluded that 38,843 minutes of the monthly installed (or effectively available) capacity of the equipment were consumed.

From this information, it was possible to determine the idle capacity in the parameters "time" and "monetary value (BRL)," as summarized in Table 10.

Table 10
Idleness cost

Items	Capacity Available (min.) (a)	Capacity Used (min.) (b)	Capacity Idle (min.) (c=a x b)	Cost rate of Capacity BRL (d)	Cost of Idleness BRL (e=c x d)
Receptionist	16,320	4,046	12,274	0.1814	2,226.17
Secretary	8,160	2,626	5,534	0.2426	1,342.81
Radiologist Physician	24,480	16,526	7,954	3.3701	26,805.76
Radiology technician	34,272	8,340	25,932	1.1846	30,720.10
Nurse	9,792	1,803	7,989	3.3701	26,923.71
Nursing technician	19,584	5,844	13,740	0.8578	11,786.76
Equipment	40,320	38,843	1,477	1.6848	2,488.49
Total	152,928	78,028	74,900	-	102,293.81

Source: Prepared by the authors.

Regarding the "Equipment," as the installed capacity (available) was 40,320 minutes (previously calculated in Table 4) and the use time in the month was 38,843 minutes, the resulting idle capacity was 1,477 minutes (40,320 – 38,843). By multiplying these idle minutes by the respective "Capacity cost rate" (BRL 1.6848), the idleness value in the period (BRL 2,488.49) was reached within the scope of this activity. When performing the same calculation procedure for the other activities, it was found that the sector surveyed had a total idle time of 74,900 minutes. This level cost is the equivalent of BRL 102,293.81 (considering the costs attributed by TDABC).

Another focus for the manager's analysis concerns the convenience of the structure made available to the Computed Tomography unit, which can be facilitated by identifying the percentages and values related to the activities, as seen in Table 11.

Table 11
Comparison of idleness by sector

Items	Total costs Monthly BRL	Consumption by TDABC BRL	Idle time Monthly BRL	Idle time Monthly %
Receptionist	2,960.00	733.83	2,226.17	75.21%
Secretary	1,980.00	637.19	1,342.81	67.82%
Radiologist Physician	82,500.00	55,694.24	26,805.76	32.49%
Radiology technician	40,600.00	9,879.90	30,720.10	75.67%
Nurse	33,000.00	6,076.29	26,923.71	81.59%
Nursing technician	16,800.00	5,013.24	11,786.76	70.16%
Equipment	67,932.35	65,443.86	2,488.49	3.66%
Total	245,772.35	143,478.54	102,293.81	41.62%

Source: Prepared by the authors.

The evaluation of Table 11 can be done from two angles. By the parameter of the value (in BRL) of the monthly idleness, the activity that stands out the most is that of "Radiology technician," as it participates with BRL 30,720.10 of the total idleness of the period (BRL 102,293.81) of this tomography unit. Also noteworthy are the activities of "Nurse" (with total idleness of BRL 26,923.71) and "Radiologist Physician" (with BRL 26,805.76).

From the perspective of the percentage of idleness (last column), the activity of "Nurse" is the one with the highest idleness (81.59%), followed by the activities of "Radiology technician" (75.67%) and "Receptionist" (75.21%). However, on average, this examination unit has 41.62% idleness regarding the monthly monetary value allocated to employees and equipment structure.

The existence of idleness and its impact on the value of the examinations was also mentioned by Choudhery et al. (2020) when they showed that the physician's idle time could be a factor that overloads the cost of the procedures performed.

Another aspect that deserves to be highlighted is that the total cost of the Computed Tomography sector is BRL 245,772.35 (see Table 1 of the previous section). However, only BRL 143,478.54 were allocated by TDABC. In other words, there is a difference of BRL 102,293.81, which is equivalent to total idleness, as shown in Table 11.

However, what causes this difference between the amount effectively allocated to the examinations and the total amount spent for the sector? The answer to this question can be associated with how TDABC is configured. In this direction, Wernke et al. (2022) add that TDABC goes on a path that can be considered contrary to that followed by other costing methods (such as the Production Effort Units — PEU method, for example). That means the TDABC requires calculating the capacity cost rate of each sector per minute (BRL) to subsequently reach the value of the total cost allocated to the products prepared in the period (BRL). Thus, TDABC assumes that the value of the total cost of production for the month (BRL) is determined based on the number of minutes consumed by the respective production (the capacity effectively used). As this tends to be less than the installed capacity, this method is characterized by adopting the principle of "Ideal Absorption," which, according to Bornia (2010), causes the portion of idleness to be disregarded in the final cost of costing objects.

4.4 Analysis of the Results

Regarding the use of TDABC to assess profitability, the possibility of knowing the unit cost of performing the examinations provided a more accurate analysis of the individual performance of sectors or employees. This aspect is corroborated by Campanale et al. (2014) when they comment that the TDABC provides more accurate information about the allocation of indirect costs, which allows managers to improve the decision-making process and optimize the allocation of resources to increase the efficiency of the enterprise.

When associating the costs calculated by TDABC with the consumption of material and the prices paid by the Unified Health System (SUS), it was found that all the examinations covered were deficient. The comparison with the compensation of the price list of the federal government was also conducted by Daroit et al. (2018), who used TDABC to measure the cost of IDC services provided in a highly complex private hospital in Rio Grande do Sul and compared the cost of the examinations performed by the IDC with the transfer price of the SUS table. The authors also found that SUS transfers are insufficient to pay for the services provided.

In this direction, the use of TDABC to assess the profitability of business units (such as Computed Tomography in this case) is in line with the opinion of Everaert et al. (2008) since it allows the individual analysis of the various sectors of a hospital unit. Adigüzel and Floros (2020) corroborate this thought by adding that TDABC tends to be more accurate than ABC in profitability analyses because it enables sectored evaluation, which qualifies business cost information and increases the chances of more correct decisions.

As for the aspect of evaluating idleness, the allocation of a value less than the total monthly cost of the tomography sector was associated with the configuration of TDABC, according to Wernke et al. (2022). This reasoning is similar to the position of Rubin (2017), when stating that TDABC is based on the principle of bottom-up evaluation, meaning part of a specific for the broadest process, with resource allocation according to the cost per unit produced and the time associated with this process.

In this research, the estimate of effective use of 85% of the monthly work hours available in the sectors that involve labor (Receptionist, Secretary, Radiologist Physician, Radiology Technician, Nurse, and Nursing Technician) was adopted, as recommended by Kaplan and Anderson (2007), in order to discount any hours not worked. When considering such an index, the

productive context of the Imaging Diagnostic Center (IDC) is simplified. Therefore, an accurate understanding of the configuration and times of the inherent activities is necessary as a mechanism to avoid (or mitigate) the simplification of measurements in this regard, especially because they can compromise the informational quality of the results, as mentioned by Thaker et al. (2022), Fidanza et al. (2022), and Bernstein et al. (2023). In the case of the Imaging Diagnostic Center (IDC) investigated, the estimate of effective use was used as a way to discount any hours not worked, which in the daily life of the IDC usually occur for various reasons (intervals for eating, stops for adjustments or maintenance of equipment, non-attendance of patients, etc.).

Also, it should be noted that the segregation of inefficiencies in production processes (such as idle capacity) is recommended to improve the calculation of production costs, as recommended by Beber et al. (2004), Tse and Gong (2009), and Wernke et al. (2020) in research within different industries.

Bornia (2010) discusses the need to measure the unused portion of the installed capacity in order to disregard such value in the cost of transformation of the product (or the provision of services, in this case, the IDC). In other words, identifying idle capacity can avoid the transfer of this type of inefficiency in the organization when determining the costs of the examinations and respective sales prices (which could cause a loss of competitiveness). In the present case, a significant level of idleness was found (an overall average of 41.62%, but reaching 81.59% in the case of the "Nurse"), which corroborates the relevance attributed by the authors mentioned regarding the need to evaluate the inefficiencies of the production process.

In short, the research results advance the literature on costs in hospital organizations by highlighting the steps of measuring profitability and idleness through TDABC in an Imaging Diagnostic Center (IDC) of a public hospital. The evidence in the case shows that the allocation of costs to the services provided, based on production capacity, may present relevant distortions (especially regarding the treatment given to hours not effectively worked in the production process) in the procedure for calculating the costs of the examinations conducted within the scope of the TDABC.

Thus, by emphasizing the relevance of identifying the level of idle hours and assigning monetary value to the idleness level in the hospital context of an imaging diagnosis center, this research contributes differently from previous studies (Anzai et al., 2017; Choudhery et al., 2020; Daroit et al., 2018; Tibor et al., 2017), which did not highlight this aspect.

5 FINAL CONSIDERATIONS

Hospital entities need cost information so management actions to reduce expenses can be implemented to optimize organizational performance. The TDABC method is an appropriate tool to estimate costs, even in highly complex sectors, such as hospital organizations performing various health services, hospitality, nutrition, clothing, etc.

Therefore, this research aimed to demonstrate how TDABC can be used to assess the profitability of examinations and the levels of idleness existing in the context of the computed tomography sector of gynecological oncology. Based on what was reported in the previous sections, the authors consider that this objective was achieved since the profitability of the six types of examinations covered was identified. The idleness levels associated with the related activities were measured.

Some of the main results derived from this study are worth highlighting. The first is that the adherence to TDABC was evidenced in the assessment of profitability in the researched context, as the necessary data were collected, and the calculations that supported the allocation of cost values to the examinations performed were conducted. Thus, it was found that all six types of procedures are deficient, with emphasis on the "Abdomen with contrast" examination, as it presents a unit result of BRL -215.18 (equivalent to -155.22% of the price paid for the service in the SUS Table). Also, considering the number of tests performed in the period, the same type of

test resulted in a loss of BRL -36,795.40. It contributed significantly to the undesired result of BRL-79,347.04 obtained performing the 710 tests in January 2023 in the sector in question.

The second relevant result concerns the measurement of idleness linked to the activities performed, both from the point of view of the volume of idle time and the respective monetary value. From the comparison of the available capacities for producing examinations with the capacities effectively used during the study period, it was found that three activities stand out in terms of idleness by the parameter of unused time (Radiology technician, with 25,932 idle minutes; Nursing technician, with 13,740 minutes of idleness; and Receptionist, with 12,274 idle minutes). However, the activities with the highest level of idleness considering the respective monetary value were Radiology Technician (BRL 30,720.10), Nurse (BRL 26,923.71), and Radiologist Physician (BRL 26,805.76), which, together with the other activities, totaled BRL 102,293.81 of idleness.

The third result to be highlighted is that an amount lower than the monthly effective cost of labor and equipment in the tomography area was allocated by TDABC to the examinations performed, the difference of which is explainable by the idleness identified and resulting from how such a method is configured. In other words, it is noted that TDABC is formatted so that the allocation of costs occurs in the bottom-up mode, starting from a specific for the broadest process, with the allocation of resources according to the cost per unit produced and the respective time spent in this process.

As for the contributions of the research, in the practical scope, it is pertinent to consider that the information provided by TDABC can encourage management actions with regard to:

a) Review of processes to reduce the time of execution of activities (or between them), which can be achieved with initiatives such as the implementation of prior online scheduling of examinations, for example;

b) Optimization of the work of the employees involved in the activities with the use of equipment that facilitates the visualization of the patients' veins for intravenous puncture by nurses or the use of voice recognition technology to issue medical reports on the examinations performed;

c) Development of policies to prevent the non-attendance of patients, which may involve prior confirmation by telephone, *WhatsApp*, *email*, or text message (SMS).

Notably, the cost reduction policy may be relevant for hospital cost management, mainly because it is not possible to negotiate the values of the examinations determined by the SUS Table, leaving the administrators to work to minimize the associated costs.

Regarding theoretical contributions, the research results corroborate the cost literature by presenting empirical evidence on the applicability of TDABC in hospital organizations that perform diagnostic imaging services, such as computed tomography. The findings of this study expand the knowledge about cost management, especially in identifying and measuring idleness, based on TDABC, in hospital organizations that deal with examinations on gynecological neoplasms. Also, the results reveal that idleness can be a preponderant factor in the cost of imaging examination services since the hospital structure of the IDC is available for "on-demand" care of the requesting physicians of these specialized procedures.

Regarding the limitations of the research, it is appropriate to emphasize the relevance of using the estimate of 85% of the production hours as the parameter indicative of the capacity effectively installed, as Kaplan and Anderson (2007) recommended. As this level of capacity is considered in the calculation of the capacity cost rate of productive sectors (BRL per minute or hour, for example), such an estimate can distort both the monetary values of the costs allocated to the products or services and the level of idleness (by "discounting" 15% of the workday in advance). Although this estimate is widely used in several organizational contexts, as in the case investigated, it is necessary to critically reflect on the ideal estimate representing each productive context, especially considering the intervening specificities of the organizational environment.

Another limitation of the research is the data collection since these were obtained in the organization's documents and internal control systems, having been considered representative of

the reality in force at the time of the study. However, they did not undergo specific audits and/or checks to ensure the relevance of the values considered in the calculations of this research. Also, as it involves only the context of the computed tomography sector, the conclusions derived must, a priori, be circumscribed to that hospital unit. Nonetheless, the details exposed in the previous sections allow us to replicate this study in other similar realities and probably reach similar results.

As suggestions for future studies, it is recommended: (*i*) to continue the research with an extension of the analysis period to consolidate the results, (*ii*) to apply the TDABC in other hospital organizations and/or imaging diagnosis centers to compare results and identify aspects of improvement in cost management, and (*iii*) to research alternatives to determine the factors to be disregarded in the estimate of effectively installed capacity, to improve the estimate of effective use of 85% of the available capacity, as proposed by the TDABC creators.

REFERENCES

Abbas, K., & Leoncine, M. (2014). Cálculo dos custos dos procedimentos médicos hospitalares em hospitais brasileiros. *Revista de Administração Hospitalar e Inovação em Saúde, 11*(1), 1-11. https://doi.org/10.21450/rahis.v11i1.1697

Adigüzel, H., & Floros, M. (2020). Capacity utilization analysis through time-driven ABC in a small-sized manufacturing company. *International Journal of Productivity and Performance Management, 69*(1), 192-216. https://doi.org/10.1108/IJPPM-11-2018-0397

Afonso, P. S. L. P., & Santana, A. (2016). Application of the TDABC model in the logistics process using different capacity cost rates. *Journal of Industrial Engineering and Management, 9*(5), 1003-1019. https://doi.org/10.3926/jiem.2086

Alaoui, S., & Lindefors, N. (2016). Combining time-driven activity-based costing with clinical outcome in cost-effectiveness analysis to measure value in treatment of depression. *Plos One, 11*(10), 1-15. https://doi.org/10.1371/journal.pone.0165389

Amaral, C. S. T., Rozenfeld, H., Costa, J. M. H., Magon, M. de F. de A., & Mascarenhas, Y. M. (2011). Improvement of radiology services based on the process management approach. *European Journal of Radiology*, *78*(3), 377-383. https://doi.org/10.1016/j.ejrad.2010.12.025

Anzai, Y, Heilbrun, M.E., Haas, D., Boi, L., Moshre, K., Minoshima, S., Kaplan, R., & Lee, V. S. (2017). Dissecting costs of CT study: application of TDABC (Time-driven Activity-based Costing) in a Tertiary Academic Center. *Academic Radiology*, *24*(2), 200-208. https://doi.org/10.1016/j.acra.2016.11.001

Beber, S. J. N., Silva, E. Z., Diógenes, M. C., & Kliemann Neto, F. J. (2004). Princípios de custeio: uma nova abordagem [Apresentação de Trabalho]. *Encontro Nacional de Engenharia de Produção – ABEPRO*, Florianópolis, SC, Brasil.

Bernstein, D. N., Wright, C. L., Lu, A., Kim, C., Warner, J. J. P., O'Donnell, E. A. (2023). Surgeon idiosyncrasy is a key driver of cost in arthroscopic rotator cuff repair: a Time-Driven Activity-Based Costing (TDABC) analysis. *Journal of Shoulder and Elbow Surgery*, 3212, e616-e623. https://doi.org/10.1016/j.jse.2023.05.008.

Bornia, A. C. (2010). *Análise gerencial de custos*: aplicação em empresas modernas (3a ed.). Atlas.

Cabral, P. H. D., Viegas Neto, C., & Souza, A. R. L. (2022). Time-driven activity-based costing (TDABC): uma revisão sistemática da literatura. *Revista ABCustos, 17*(1), 103-131. https://doi.org/10.47179/abcustos.v17i1.633

Campanale, C., Cinquini, L., & Tenucci, A. (2014). Time-driven activity-based costing to improve transparency and decision making in healthcare. *Qualitative Research in Accounting & Management, 11*(2), 165-186. https://doi.org/10.1108/QRAM-04-2014-0036

Cardoso, R. B., Marcolino, M. A. Z., Marcolino, M. S., Fortis, C. F., Moreira, L. B., Coutinho, A. P., Clausell, N. O., Nabi, J., Kaplan, R. S., Etges, A. P. B. da S., & Polanczyk, C. A. (2023). Comparison of COVID-19 hospitalization costs across care pathways: a patient-level time-driven activity-based costing analysis in a brazilian hospital. *BMC Health Services Research, 23*(1), 198-198, Article 198. https://doi.org/10.1186/s12913-023-09049-8

Choudhery, S., Hanson, A. L., Stellmaker, J. A., Ness, J., Chida, L., & Conners, A. L. (2021). Basics of time-driven activity-based costing (TDABC) and applications in breast imaging. *The British Journal of Radiology, 94*(1119). https://doi.org/10.1259/bjr.20201138.

Choudhery, S., Stellmaker, J. A., Hanson, A. L., Ness, J., Chida, L., Johnson, B., & Conners, A. L. (2020). Utilizing Time-Driven Activity-Based Costing to increase efficiency in ultrasound-guided breast biopsy practice. *Journal of the American College of Radiology, 17*(1), 131-136. https://doi.org/10.1016/j.jacr.2019.06.016

Daroit, N. B., Ruschel, K. B., Tarrago, F. C., & Etges, A. P. B. S. (2018). Custeio Baseado em Atividade e Tempo (TDABC) em um departamento de radiologia hospitalar no sul do Brasil. *Jornal Brasileiro de Economia da Saúde, 10*(3), 302-307. https://doi.org/10.21115/JBES.v10.n3.p302-7

Etges, A. P. B. S., Cruz, L. N., Notti, R. K., Neyeloff, J. L., Schlatter, R. P., Astigarraga, C. C., Falavigna, M., & Polanczyk, C. A. (2019). An 8-step framework for implementing time-driven activity-based costing in healthcare studies. *The European Journal of Health Economics, 20*(8), 1133-1145. https://doi.org/10.1007/s10198-019-01085-8

Everaert, P., Bruggeman, W., Sarens, G., Anderson, S. R., & Levant, Y. (2008). Cost modeling in logistics using time-driven ABC: experiences from a wholesaler. *International Journal of Physical Distribution & Logistics Management, 38*(3), 172-191. https://doi.org/10.1108/09600030810866977

Fidanza, A., Schettini, I., Palozzi, G., Mitrousias, V., Logroscino,G., Romanini, E., & Calvisi, V. (2022). What is the inpatient cost of hip replacement? A Time-Driven Activity-based Costing pilot study in an italian public hospital. *Journal of Clinical Medicine, 11*(23), 6928. https://doi.org/10.3390/jcm11236928

Ganorkar, A. B., Lakhe, R. R., & Agrawal, K. N. (2019). Methodology for application of Maynard Operation Sequence Technique (MOST) for time-driven activity-based costing (TDABC). *International Journal of Productivity and Performance Management, 68*(1), 2-25. https://doi.org/10.1108/IJPPM-06-2017-0156

Howard, B. R., & Soeters, R. P. (2010). Imaging in gynaecological oncology follow-up. *Southern African Journal of Gynaecological Oncology*, *2*(2), 43-48. https://doi.org/10.1080/20742835.2010.11441159

Kang, S. K., Reinhold, C., Atri, M., Benson, C. B., Bhosale, P. R., Jhingran, A., Lakhman, Y., Maturen, K. E., Nicola, R., Pandharipande, P. V., Salazar, G. M., Shipp, T. D., Simpson, L., Small, W., Jr, Sussman, B. L., Uyeda, J. W., Wall, D. J., Whitcomb, B. P., Zelop, C. M., & Glanc, P. (2018). ACR Appropriateness Criteria® staging and follow-up of ovarian cancer. *Journal of the American College of Radiology*, *15*(5), 198-S207. https://doi.org/10.1016/j.jacr.2018.03.015.

Kaplan, R. S., & Anderson, S. R. (2007). *Custeio baseado em atividade e tempo*. Campus.

Keel, G., Savage, C., Rafiq, M., & Mazzocato, P. (2017). Time-driven activity-based costing in health care: a systematic review of the literature. *Health policy (Amsterdam, Netherlands)*, *121*(7), 755-763. https://doi.org/10.1016/j.healthpol.2017.04.013

Queiroz, K. F. F., Silva, M. V. D. de C., Pesente, R., & Cerqueira, A. J. F. de. (2022). Adoção do sistema de custos no município de Salvador: um estudo das concepções sobre a importância da Informação de custos pelos agentes públicos. *Revista ABCustos*, *17*(3), 1-31. https://doi.org/10.47179/abcustos.v17i3.632

Rebouças, L. S., Rocha, E. M., Silva, J. D., Costa, W. P. L. B., Silva, S. L. P. S., & Nascimento, Í. C. S. (2018). Práticas de gestão de custos nas indústrias salineiras do Estado do Rio Grande do Norte. *Caderno Profissional de Administração da UNIMEP*, *8*(2), 95-114.

Rubin G. D. (2017). Costing in Radiology and Health Care: rationale, relativity, rudiments and realities. *Radiology*, *282*(2), 333-347. https://doi.org/10.1148/radiol.2016160749

Sangha, K., White, T., Boltyenkov, A. T., Bastani, M., Sanmartin, M. X., Katz, J. M., Malhotra, A., Rula, E., Naidich, J. J., & Sanelli, P. C. (2024). Time-driven Activity-based Costing (TDABC) of direct-to-angiography pathway for acute ischemic stroke patients with suspected large vessel occlusion. *Journal of Stroke and Cerebrovascular Diseases*, *33*(3), Article 107516. https://doi.org/10.1016/j.jstrokecerebrovasdis.2023.107516

Sampaio, F. J. C. de S., & Pereira, M. K. G. de L. (2020). Repasses do SUS x custos de tomografias computadorizadas em uma clínica de radiologia no alto oeste potiguar. *Management Control Review*, *4*(2), 19-34. https://doi.org/10.51720/mcr.v4i2.3061

Santana, A., & Afonso, P. (2015). Analysis of studies on Time-driven Activity-based Costing (TDABC). *The International Journal of Management Science and Information Technology*, 133-157.

Sethi, R., Louie, P., Bansal, A., Gilbert, M., Nemani, V., Leveque, J.-C., Drolet, C. E., Ohlson, B., Kronfol, R., Strunk, J., Cornett-Gomes, K., Friedman, A., & LeFever, D. (2024). Monthly multidisciplinary complex spine conference: a cost-analysis utilizing Time-driven Activity-based Costing. *Spine Deformity*, *12*(2), 433-442. https://doi.org/10.1007/s43390-023-00798-4.

Shankar, P. R., Hayatghaibi, S. E., & Anzai, Y. (2020). Time-driven activity-based costing in radiology: an overview. *Journal of the American College of Radiology*, *17*(1), 125-130. https://doi.org/10.1016/j.jacr.2019.07.010

Thaker, N. G., Kudchadker, R. J., Incalcaterra, J. R., Bathala, T. K.,Kaplan, R. S., Agarwal, A., Kuban, D. A., Frank, B. D., Das, P., Feeley,T. W., Frank, S. J. (2022). Improving efficiency and reducing costs of MRI-Guided prostate brachytherapy using Time-Driven Activity-Based Costing. *Brachytherapy*, *21*(1), 49-54. https://doi.org/10.1016/j.brachy.2021.05.012.

Tibor, L. C., Schultz, S. R., Menaker, R., Weber, B. D., Ness, J., Smith, P., & Young, P. M. (2017). Improving efficiency using Time-Driven Activity-Based Costing methodology. *Journal of the American College of Radiology*, *14*(3), 353-358. https://doi.org/10.1016/j.jacr.2016.11.014

Tse, M. S. C., & Gong, M. Z. (2009). Recognition of idle resources in Time-Driven Activity-Based Costing and Resource Consumption Accounting Models. *Journal of Applied Management Accounting Research*, *7*(2), 41-54.

Wei, C., Boeck, M., Qian, P. C., Vivenzio, T., Elizee, Z., Bredfeldt, J. S., Kaplan, R. S., Tedrow, U., Mak, R., & Zei, P. C. (2022). Cost of cardiac stereotactic body radioablation therapy versus catheter ablation for treatment of ventricular tachycardia. *Pacing and Clinical Electrophysiology*, *45*(9), 1124-1131. https://doi.org/10.1111/pace.14512

Wernke, R., Junges, I., & Zanin, A. (2019). Mensuração da ociosidade fabril pelos métodos ABC, TDABC e UEP. *Revista Contemporânea de Contabilidade*, *16*(38), 185-206. https://doi.org/10.5007/2175-8069.2019v16n38p185

Wernke, R., Zanin, A., & Ritta, C. de O. (2022). Ociosidade fabril pelos métodos UEP e TDABC: valores monetários diferentes para volumes de horas ociosas iguais? *Revista ABCustos*, *17*(3), 121-148. https://doi.org/10.47179/abcustos.v17i3.654

Wernke, R., Junges, I., & Ritta, C. de O. (2020). Aplicação do Time-Driven Activity-Based Costing (TDABC) por etapas produtivas ou por linha de produção. *Revista ABCustos*, *15*(3), 78-107. https://doi.org/10.47179/abcustos.v15i3.580

Zanin, A., Schio, N. da S., Corazza, F., & Wernke, R. (2018). Custos hospitalares: aplicação dos métodos de custeio ABC e TDABC no processo de consulta médica. *Revista de Administração Hospitalar e Inovação em Saúde*, *15*(4), 16-35. https://doi.org/10.21450/rahis.v15i4.5189

AUTHOR CONTRIBUTIONS

Roles	1st author	2nd author	3nd author
Conceptualization	♦	♦	♦
Data curation	♦	♦	♦
Formal analysis	♦	♦	♦
Funding acquisition	♦		
Investigation	♦		
Methodology	♦	♦	♦

Project administration			♦
Resources	♦		
Software			
Supervision		♦	♦
Validation		♦	♦
Visualization	♦	♦	♦
Writing – original draft	♦	♦	♦
Writing – review & editing	♦	♦	♦

CONFLICT OF INTEREST

The authors assert that there is no conflict of interest related to this submitted work.