

Costs of CT Scan and Ultrasound Services Using the Activity-Based Costing Method

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Abstract

Background: The activity-based costing system allows organizations to estimate the exact cost of their services based on the consumed resources, which in turn translates into increased efficiency of healthcare organizations.

Objectives: The current study aimed to estimate the cost of ultrasound and CT scan services using the activity-based costing (ABC) method.

Methods: Following a descriptive-applied design, the total cost of the most commonly used ultrasound and CT scan services in Imam Khomeini Hospital of Ahvaz was calculated using the ABC method. Data were collected using special forms and a list of services' costs. To estimate the costs for different hospital sectors, first, the principles of determining cost proportion per service were set, and then using the direct cost approach, costs were estimated.

Results: The highest and lowest differences from government-approved medical tariffs were related to the facial (523,000 Rials) and lung (133,000 Rials) CT scans, respectively. Also, except for abdominal and pelvic CT scans, the estimated cost of services was higher than the tariffs. The highest and lowest share of costs were related to the depreciation of capital equipment (1,174,490,000 Rials) and energy consumed by activity centers (952,000 Rials), respectively.

Conclusions: For most of the investigated services, the total cost was significantly higher than the approved tariffs. To make medical tariffs more realistic and to continuously improve the provision of healthcare services, it is necessary to use costing techniques like ABC.

Keywords: Activity-Based Costing; Ultrasound; CT-Scan; Hospital

1. Background

The health sector is an important part of modern societies, as it not only maintains our health but also can promote our lives (1). Technological advancement, population aging, extended health insurance coverage, economic fluctuations, and increased awareness and expectations are mentioned as important factors that have contributed to soaring health expenditures (2-5).

Hospitals absorb 50 - 80% of health care resources (2, 6). According to the evidence, hospitals are faced with challenges in balancing the scarce resources to meet the demand for health services (1, 3). One of the main challenges of hospital managers is the development of information about costs for making decisions and setting appropriate prices for services (1). Some hospitals have problems in calculating the direct and indirect costs of medical services, which requires access to appropriate cost systems (1, 4, 6). Cost information is based on price decisions and financial strategies. Hence, understanding their changes

and measuring them have an important impact on organizational costs. Furthermore, healthcare organizations, such as hospitals, are more complex than manufacturing organizations. As a result, the need for designing appropriate cost systems has increased significantly (6).

Two approaches are introduced for the development of accounting systems: (1) traditional costing system (TCS); and (2) activity-based costing (ABC) approach (1). The latter, which was introduced in the 1980s in the US, was designed for cost analysis. In the mid-1990s, hospitals began to use this method to manage the costs and calculation of services cost. The activity-based costing technique allows organizations to identify the actual cost of services based on consumed resources. Unlike TCS, ABC is focused on activity level data rather than a comprehensive focus on the results. This method is a cost management model that not only can improve resource management but also increases the efficiency of health service organizations by focusing on value-adding interventions (4, 5, 7).



The activity-based costing approach allows hospitals to develop appropriate cost policies and to make detailed decisions about budgeting and planning (2). The main motivation for using this method is to provide an accurate estimate of the costs, particularly total cost (5).

Several studies have investigated the cost and prime cost of services. A study that used the ABC approach in Hamedan reported that most of the costs (65.2%) were related to human resources, while energy costs had the lowest share (0.4%). Also, the study reported that the total cost of the Logistic Department was 64,091,093,852 Rials (2). In another study that used the ABC approach, Bayati reported that the total cost of the MRI department was 400 746\$. Costs related to the Logistics Department accounted for 10% of total costs. The annual variable cost of the MRI Department is reported 295,904\$, while capital costs were reported as 104,842\$ (4). In a study intended to estimate laboratory costs using the ABC method, Dalley et al. concluded that this method is necessary for optimizing and enhancing the efficiency of service (8).

According to the evidence, diagnostic services account for the majority of costs (2). A study reported that individual expenditures accounted for about 55% of the total costs of the Radiology Department. This study also reported that direct costs accounted for more than 97% of total costs (4).

2. Objectives

Considering the critical role of appropriate costing of services for cost control in imaging services and the fact that CT scan and ultrasound, which are costly high-tech services, account for nearly 30% of demand for hospital services, the current study aimed to estimate the cost of these services using the ABC approach in Imam Khomeini Hospital in Ahvaz, Iran.

3. Methods

Following a descriptive-applied design, the total costs of the most commonly used ultrasound and CT scan services were calculated using the ABC method in Imam Kho-

meini Hospital of Ahvaz. The study population was all ultrasound and CT scan services provided at Imam Khomeini Hospital in the city of Ahvaz. In the present study, eight CT scan (i.e., abdomen and pelvis, orthopedics, face and sinus, and lungs) and ultrasound (kidney and urinary tract, pregnancy, abdomen, and soft tissue) services with the highest demand were selected (9). The total cost was calculated using the following formula:

$$\text{Total Cost} = \text{Direct Costs} + \text{Indirect Costs}$$

3.1. Data Analysis

The ABC approach was used to estimate the costs. Initially, activity centers (i.e., operational, diagnostic, and logistic) and outputs of services were identified separately, followed by the allocation of direct (consuming materials, energy, etc.) and indirect costs of other departments, including warehouse, administrative affairs, transportation, logistic, kitchen, accounting, call center, cleaning, and security. Eventually, the cost of each output was calculated.

3.2. Data Collection

Data were collected using forms and checklists on direct and indirect costs of ultrasound and CT scan services and other activity centers. After collecting direct and indirect costs, the costs were allocated to the services provided by the abovementioned activity centers separately.

The direct line method was used to calculate the depreciation of buildings. Besides, the depreciation of assets technique was used to calculate the cost related to the depreciation of equipment (both general and specialized equipment), which is one of the most logical methods developed for the estimation of fixed assets depreciation. In this line, initially, a price list of all equipment was prepared. Then, by using expert opinions and consultation with the Medical Equipment Department of the hospital and medical equipment office of the university, the residual value and useful life were estimated. Then, the following formula was used to estimate the depreciation cost:

$$\text{Depreciation} = \frac{\text{Annual Burden of Standard Use of the Equipment}}{\text{Real Annual Burden}} \times \frac{\text{Residual Price} - \text{Purchase Price}}{\text{Useful Life}}$$

To determine the exact cost of each service of CT scan and ultrasound center, based on the share of each of these services from the total service provided during 30 days, the "average time required to complete a service" was used. We collected cost information of the aforementioned center for one year. Also, data on revenue and costs of the CT scan and Ultrasound Department of the hospital were collected, and following the

ABC approach, the total cost of selected services was estimated in Excel software. The current study was approved by Ahvaz Jundishapur University of Medical Sciences (AJUMS. REC.1394.479).

4. Results

The basis for sharing costs in activity centers (either

main or sub) is provided in Table 1, which also contains the allocation of costs to final cost centers that provide

the activity. The most important basis for sharing costs was human resources.

Table 1. Determining the Basis of Cost-Sharing in Activity Centers

Basis of Cost-Sharing	Activity Center	Cost of Activity Center Based on the Shared Basis (Rials)
Cost of human resources	Ultrasound	862,017,843
Cost of human resources	CT scan	861,256,085
Number of human resources	Management	1,112,164,700
Number of human resources	Salary	66,849,536
Number of human resources	Assets	163,861,264
Number of human resources	Staff department	38,440,372
Area (M2)	Installations (heating, cooling, ...)	567,085,032
Number of distributed foods	Nutrition	131,779,604
Number of human resources	Call center	531,053,900
Number of computers	Computer	94,164,700
Number of human resources	Security	95,174,700
Number of services	Energy consumption of ultrasound and CT scan units	749,340,566

Cost information of the ultrasound activity center are provided in Table 2. As shown in the table, abdominal ultrasound accounted for the majority of the costs, while the least share was related to soft tissue ultrasound. Concerning CT scan services, the majority of the costs were related to orthopedic CT scans, while abdominal and pel-

vic CT scans accounted for the lowest share of the costs. Also, the depreciation cost of capital equipment had the highest share of the total cost, followed by consumables. Meanwhile, the lowest share was for the energy cost of the activity centers.

Table 2. Cost Information of Ultrasound Activity Center During the Study Period (Rials)

Service	Cost of Human Resources	Direct Cost of Consumables (Direct)	Depreciation Cost of Capital Equipment	Total Direct Costs	Cost of Consumables	Depreciation Cost of Administrative Equipment	Energy Cost of Consumables	Overhead Costs	Total Indirect Costs
Pregnancy ultrasound	25,311,731	40,553,000	167,500,000	233,364,730	203,000	309,000	50,000	135,000	697,000
Abdominal ultrasound	23,331,630	50,511,123	207,300,000	281,142,753	305,000	292,000	50,000	135,000	782,500
Kidneys ultrasound	20,321,830	35,123,000	127,700,000	183,153,830	402,000	551,111	100,000	270,000	1,323,111
Soft tissues ultrasound	20,326,530	25,450,000	117,500,000	163,276,530	601,000	400,500	200,000	540,000	1,741,500
Lung CT Scan	26,321,730	48,345,000	131,150,000	205,816,730	500,000	651,000	86,000	180,000	1,417,000
Orthopedic CT scan	26,212,120	50,123,000	161,100,000	237,434,120	405,000	450,000	66,000	180,000	1,101,000
Abdominal and pelvic CT scans	25,130,005	55,112,000	121,110,000	201,352,005	300,000	498,000	200,000	270,000	1,268,000
CT scan of the face and sinus	24,321,230	50,132,000	141,130,000	215,483,230	502,000	405,000	200,000	540,000	1,247,000

The total cost of the services and their difference with

government-approved medical tariffs of 2015 are pro-

vided in Table 3. For most ultrasound and CT scan services, the estimated cost was higher than the approved tariffs. It is worth noting that the highest difference was for facial and sinus CT scans, while the least difference was for lung CT scans. Also, for ultrasound services, the

highest and lowest deviations from the approved tariffs were related to soft tissue ultrasound and abdominal ultrasound. In general, except for abdominal and pelvic CT scans, the total cost was higher than the approved medical tariffs.

Table 3. Comparing the Costs of Eight Ultrasound and CT Scan Services with the Approved Medical Tariffs of 2015 (Rials)

Service	Total Cost (Which Includes the Depreciation Costs)	Medical Tariffs	Difference with the Approved Tariff
Pregnancy ultrasound	292,500	104,000	188,500
Abdominal ultrasound	376,000	191,000	185,000
Kidneys ultrasound	368,000	125,000	243,000
Soft tissues ultrasound	495,000	118,000	377,000
Lung CT scan	500,000	367,000	133,000
Orthopedic CT scan	571,200	301,000	270,200
Abdominal and pelvic CT scans	485,537	621,000	-135,463
Facial and sinus CT scan	1,085,000	562,000	523,000

5. Discussion

In this study, costs were classified into seven categories, and then their amounts and ratios were determined. Accordingly, the highest share of costs was related to the depreciation cost of capital equipments, followed by the cost of consumables. Some studies mentioned that medical equipment accounted for the highest share of hospital costs, which is in line with the findings of the present study (1, 2, 4, 5, 10). This issue can be attributed to several factors, such as equipment failure, installation of new equipment, use of specialized medical equipment, high costs of equipment maintenance, use of unnecessary medical equipment, and disproportionate and excessive use of equipment. Maintenance of fixed assets may either be routine or overhaul. The former is necessary for the normal function of equipment, and its costs are categorized as current costs. The latter adds to the cost of fixed assets and depreciates over the useful life of the device (11). Considering the high share of capital expenditures from the total cost, paying special attention to these resources and emphasizing their appropriate use can be a fundamental step towards increasing efficiency and saving hospital costs.

According to our findings, the third major cost category was human resources, which corroborates the findings of previous studies (1, 2, 5, 12, 13). Another study conducted in Iran also mentioned that human resources (65.2%) and cost of consumables (0.4%) had the highest and lowest shares of total costs, respectively. Rezapour et al. reported that among direct costs, human resources costs had the highest share (88%) (14). Although various studies reported different cost estimates for human resources, this category had the highest share in all studies. Therefore, strategic purchasing and human resource management can be optimal interventions to decline direct costs, including those related to human resources.

Consequently, the information provided by studies intended to calculate direct costs, separated by activity center, can help hospital managers to both control and track the costs. These costs are highly correlated with the volume of activity. However, this correlation was far less for indirect costs. Differentiating between direct and indirect costs is of crucial importance when making budgeting decisions for both activity centers and hospitals. The total cost of services is a critical tool for planning, monitoring, controlling, and evaluation, which results in decreased waste and omitting redundant activities.

5.1. Total Cost and Government-Approved Medical Tariffs

In the present study, for most of the ultrasound and CT scan services, the total cost was higher than the approved medical tariff, which for some services, a significant difference was observed. This finding indicates that the total cost is higher than the approved medical tariffs. In the same vein, a study conducted in Iran reported differences between the total cost of radiology services and approved medical tariffs (2). To make tariffs more realistic and continuously improve the provision of services, extensive use of costing techniques such as ABC is necessary. Therefore, initially, costing objectives should be clarified by hospital managers. Generally, the focus should be on areas with the highest cost burden. Then, using a precise scientific method, the prime price can be calculated.

In this study, only for abdominal and pelvic CT scans, the total cost was lower than the approved medical tariffs. It should be emphasized that these services were more prevalent during the study period. Thus, by providing more services, which means lower direct fixed costs (human resources and capital costs), the total costs of

each service had decreased and surpassed the tariffs. In the same vein, another study intended to estimate the total cost of radiology services in the city of Ahvaz reported that for most services, the total costs of services were higher than the medical tariffs, which were translated into financial loss in most departments (15). A study conducted in Ardabil (northwest of Iran) also reported similar results (16), which revealed a difference between the total price of radiology services and the approved medical tariffs, and this difference was directly associated with the number of hospital beds. However, some studies reported results that were not consistent with the findings of the present study. For instance, the study by Arab et al. reported a negligible difference between medical tariffs and prime costs (17). Although it seems that some wards, such as Surgery Department, have a higher contribution to the revenues, but diagnostic wards such as imaging are necessary and should be investigated using a long-term perspective. However, the total cost is necessary for profit and loss investigations. In addition, the total cost is of crucial prominence for outsourcing some services.

5.2. Cost Management

Information provided by costing studies can be used for making decisions regarding outsourcing medical wards to the private sector and/or how to manage wards (10). Therefore, if health sector policies are focused on increasing the participation of the private sector, then analyses such as ABC would be useful by both parts (the hospital and the private sector).

It should also be highlighted that currently, imaging departments are using more advanced equipment, while medical tariffs are developed for traditional devices, with the exception that public and private sectors that use such devices can charge an extra price of 30 and 25%, respectively. Regarding the limitations in providing services such as CT scans (e.g., in terms of healthcare facilities and the type of service), delayed payments of health insurance funds can lead to increased out-of-pocket expenditures for patients or more losses for hospitals. Therefore, it seems that adding services such as CT scans, provided by both simple and spiral devices, in a hospital in a manner that is in line with insurers' objectives to control the costs requires the contribution of health insurance funds in all costs, including those related to implementation and depreciation. This issue requires the estimation of the total costs based on activities. Otherwise, the difference between the total costs and the medical tariffs will be imposed on patients.

5.3. Limitations

One of the main limitations of the present study was related to access to the information necessary for ABC and calculating the total costs. We tried to address this limitation by cooperation with the authorities of the Financial Department of the hospital.

5.4. Conclusion

This study demonstrated that for most ultrasound and CT scan services, the total cost was higher than the medical tariffs. Hence, to improve the management of logistic and imaging departments, it is necessary to identify unrealistic tariffs, which will be useful for developing corrective interventions, particularly regarding human resources and consumables. On the other hand, due to the limitation of resources, effective control of costs and service delivery processes is needed. Therefore, having knowledge and information about the method of cost allocation of services plays a key role in controlling the price of provided services.

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References

1. Javid M, Hadian M, Ghaderi H, Ghaffari S, Salehi M. Application of the activity-based costing method for unit-cost calculation in a hospital. *Glob J Health Sci.* 2015;8(1):165-72. doi:10.5539/gjhs.v8n1p165. [PubMed:26234974]. [PubMed Central:PMC4803948].
2. Niasti F, Fazaeli AA, Hamidi Y, Viaynchi A. Applying ABC system for calculating cost price of hospital services case study: Beheshti hospital of Hamadan. *Epidemiology Glob Health.* 2019;7(3):496-9. doi:10.1016/j.cegh.2019.06.001.
3. Popesko B. Specifics of the activity-based costing applications in hospital management. *Int J Collab Res Intern Med Public Health.* 2013;5(3):179-57.
4. Bayati M, Mahboub Ahari A, Badakhshan A, Gholipour M, Joulaei H. Cost analysis of MRI services in Iran: An application of activity based costing technique. *Iran J Radiol.* 2015;12(4):e18372. doi:10.5812/iranjradiol.18372v2. [PubMed:26715979]. [PubMed Central:PMC4691520].
5. Janati A, Farough Khosravi M, Imani A, Javadzadeh A, Mazhar Gharamaleki M. Cost analysis of eye surgeries and comparison with approved governmental tariffs. *Health Scope.* 2016;6(2):e39948. doi:10.5812/jhealthscope.39948.
6. Etemadi S, Mohammadi B, Akbarian Bafghi MJ, Hedayati Poor M, Gholamhoseini MT. A new costing system in hospital management: Time-driven activity based costing: A narrative review. *Evidence Based Health Policy, Management and Economics.* 2018;2(2):133-40.

7. Jabbari A, Molavi Taleghani Y, Khadivi R, Hadian M. Calculating the total cost of services at one health center before and after assignment (2014-2016). *Iran J Health Sci.* 2019;**7**(4):29. doi:10.18502/jhs.v7i4.2205.
8. Dalley C, Basarir H, Wright JG, Fernando M, Pearson D, Ward SE, et al. Specialist integrated haematological malignancy diagnostic services: An activity based cost (ABC) analysis of a networked laboratory service model. *J Clin Pathol.* 2015;**68**(4):292-300. doi:10.1136/jclinpath-2014-202624. [PubMed:25631214].
9. Mobaraki H, Hadian M, Salemi M, Alizadeh A, Mohseni SH. [A survey on activity-based costing in Rudan health center, Hormozgan, Iran]. *Hormozgan Medical Journal.* 2012;**16**(1):34-41.
10. Karimi S, Yaghoubi M, Agharahimi Z, Hayati AH, Mohammadi Bakhsh R. [The viewpoints of managers about advantages, disadvantages and barriers in health care outsourcing in Isfahan]. *Health Information Management.* 2011;**8**(5 (21)):718-25.
11. Hada MS, Chakravarty A, Mukherjee P. Activity based costing of diagnostic procedures at a nuclear medicine center of a tertiary care hospital. *Indian J Nucl Med.* 2014;**29**(4):241-5. doi:10.4103/0972-3919.142627. [PubMed:25400363]. [PubMed Central:PMC4228587].
12. Bakhtiari P. [Accounting and financial management for managers]. 13th ed. Tehran, Iran: Industrial Management Institute; 2010.
13. Javanbakht M, Mashayekhi A, Salavati S, Mohammadzadeh A. [An application of activity based costing system in radiology ward: A case study of Hafez hospital]. *Journal of Medical Council of IRI.* 2013;**31**(1):15-22.
14. Bahador F, Mahmoudi G, Jahani MA. [Determining the price of services the cardiac care unite ward by activity-based costing]. *JNKUMS.* 2017;**8**(4):607-21. doi:10.18869/acadpub.jnkums.8.4.607.
15. Alipour V, Rezapour A, Hasanazadeh E. [Computing cost price by using activity based costing (ABC) method in radiology ward of Firooz Abadi hospital]. *Journal of Hospital.* 2019;**18**(3):87-96.
16. Torabi A, Keshavarz K, Najafpour Z, Mohamadi E. [Computing cost price by using activity based costing (ABC) method in radiology ward of Golestan hospital in Ahvaz university of medical sciences in 2009]. *Hospital.* 2011;**10**(2 (37)).
17. Ghiyasvan H, Zandiyan H, Zahirian Moghadam T, Naghdi S. [Cost of radiology services using the activity based costing (ABC) method]. *Payesh.* 2013;**12**(6):595-605.