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Applying activity-based costing to determine the final costs of radiology services in Shiraz, Iran: a concurrent equations approach

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Abstract

The Activity-Based Costing (ABC) method possesses the capability to identify the costs accurately and provide non-financial information for improving system function and increasing its efficiency. The present study aimed to calculate the final costs of radiology services to determine the final costs deviation from the enacted tariffs. This study was a retrospective cross-sectional analysis of radiology final costs for 19 different types of radiology services (1077 stereotypes) at the hospital in Shiraz, Iran. The required data was collected through reports, specified forms, interviewing with hospital personnel and authorities as well as direct observation of hospital activity centers. The final costs of the radiology services were determined using the activity-based costing method as well as the cost sharing of activity centers through concurrent equations technique. The results showed a great amount of loss for all provided services in this center. The Mean tariff of the services equaled 625,626 Rials while the mean final cost of the provided services equaled 3,036,390 Rials. So, the findings of this study show an average loss of 2,410,764 Rials for each service.

Keywords: Cost Allocations, Cost-Benefit Analysis, Cost Sharing, Health Care Costs, Hospital Costs, Hospital Radiology Department

Introduction

Undoubtedly, all the people have has the right to be healthy and this fact has been inevitably accepted by everyone, especially health policy-makers [1]. However, providing health services regardless of their predicted final costs has raised the challenging question of whether it is possible to provide services with less resources in the world today [2]. Besides, a shortage of information resources, reliance on governmental budget, as well as lack of transparency in the actual amount of service expanses lead to inefficiency and waste of resources [3]. To adapt efficient and effective decisions, managers need an accurate and real-time amount of the expanses in hospitals. This information which are considered as the output of accounting systems in hospitals are of great importance in calculating the final costs of the provided services [4].

Currently, the final costs of health services is calculated by fixed tariffing in most countries such as Iranwhile it is not an appropriate method because it does neither provide enough information for health decision-makers nor present the final costs of the services accurately. Therefore, it is essential

to design a system which compensate the pitfalls of the present method. During past decades, the costing methods such as activity-based costing have developed a lot. Activity-based costing method is used in hospitals for several reasons including its advantages over the tariffing method in calculating the final costs of the services, its ability to identify the idle resources and capacities in the hospital and adopting appropriate approaches for optimal of the existing resources [5]. Furthermore, activity-based costing system provides more useful information on service provision, support activities and the service/product costs which help the managers to increase the profit by focusing on pivotal services and processes [6]. The activity-based costing method which is one of the costing systems for products was presented by Caplan and Johnson for the first time. This method is not a substitution for job costing or process costing methods, but it can be applied along with them [7].

Method

This study was a cross-sectional research conducted in the radiology department of Ordibehesht hospital, Shiraz, Iran. In the current study, he final costs of 19 types of provided services in the form of 1077 radiology stereotype, were calculated using the activity-based costing method and compared to the approved governmental tariffs. Data was collected through the expanse tables and forms, studying the related documents, as well as observation and interviews. Overall, this study was designed and conducted as the following:

A) Identifying the hospital activity centers (the hospital wards in where an activity is performed) and categorizing them based on the kind of their activity into; 1) operational centers; 2) supporting/administrative centers; and 3) diagnostic centers.

1) Operational centers: These centers are directly involved in providing healthcare services to patients, like surgery, neurology and heart units.

2) Supporting/administrative centers: These centers are not directly involved in providing healthcare services to patients but perform public services to support the activities of operational and diagnostic centers, like accounting or security units.

3) Diagnostic centers: These centers are responsible for providing diagnostic services, like laboratory or radiology department.

B) Next, using the existing documents and reports, the expenses of each supporting/ administrative center (including the costs of human resources, materials, depreciation and overhead costs) were calculated separately.

C) Then, given that the supportive centers are used for costing operations in the activity-based costing system, the costs of each supportive center had to be identified and allocated to the service-receiving units. In fact, the expenditures of each supportive center consisted of two main parts; the direct costs of that activity center as well as the costs which are allocated from other activity centers. Therefore, the costs of each center were calculated according to the following formula:

The costs of each activity center= the share of this center out of the costs of other centers + the related costs of each center (directly or indirectly)

Where, b is the direct costs of each activity center and $\sum_{j=1}^{n}$% (Xi) is the allocated costs from other activity centers to this center. To allocate the costs, at first the activity centers were defined in the form of a matrix in which the percentages (calculated based on the allocation basics of each activity center) of services, either provided or received by each center, were included by vertical and horizontal. After that, the above-mentioned equation was repeated for all support centers of the hospital. Each equation, includes a constant variable (the cost of the activity centers which was calculated at the stage B) and several algebraic variables (the percentages of the support centers services to this activity center). For example, in order to calculate the costs of the management activity center using the concurrent equations we had:

The costs of management activity center=Z +

the cost of security center (n%) + the cost of computer center (n%) + …..
Accordingly, such an equation was repeated for all supportive centers. Given that solving such an equation with too many algebraic variables was difficult, time-consuming and confusable MATLAB Software was used to calculate the final costs of the activity centers using the concurrent equations approach.
D) First, the final costs of each activity center were allocated to the costing centers using the concurrent equations approach and considering the matrix of provided services percentage using Excel Software.
E) Then, the final costs were determined based on each output. To do so, after specifying the final costs of activity centers or the centers with outputs, the final cost for each output was calculated by dividing the total allocated costs to each activity center by the number of defined outputs for each activity center.

Results

In Table 1, the final costs of radiology services for each stereotype in the Ordibehesht Hospital are presented. The final costs of the services included the consuming materials costs (film + film cover) + annual salary and bonus + the maintenance and repair cost of equipments + building accumulated depreciation+ equipment depreciation + share of hospital information system (HIS) costs + physicians per case + energy (water, electricity, gas and telephone) costs + the allocated costs from other units.
The final costs of radiology services, as well as the governmental tariffs of the provided services are presented in Table 2. According to this results, not only all the provided services had no profit but also created losses of which the maximum was related to cervical spine radiography (20,516,501 Rials) and the minimum was related to brain CT Scan (1,198,927 Rials).

Discussion

The findings of the present study showed that the final costs of provided services in the radiology department were consisted of the following components:
The equipment depreciation (53.233%); the allocated costs from other uints (15.475%); annual salary and bonus (14.320%); maintenance and repair costs (7.085%); physicians per case (4.096%); buildings depreciation (3.657%); energy costs (1.599%); the unit share of HIS costs (0.345%); and the consuming materials costs (0.189%)
However, the findings of Javan Bakht et al revealed that the personnel costs (55.7% of unit total costs) had the highest share of the expanses, while the costs of consuming materials accounted for 7.57% and energy (water, electricity, telephone and gas) for 0.32% of the total unit costs. Their results also showed that the unit depreciation costs (208,824,509 Rials) formed 14.96% of the unit total costs [8].
Lievens et al. showed that the best possible way for calculating the real costs of radiotherapy services is using the activity-based costing approach [9]. In 1997, West. T.D. and West. D.A. examined the efficiency of the activity-based costing system in the dialysis unit. The findings of their study which showed a significant difference between the final costs calculated by the activity-based costing system and that of the traditional approach, would be important in management decision-makings [10]. Cohen at al found that academic staffs spent 72% of their time on clinical activities. In addition, they found that radiology image reading had the highest costs in clinical expanses (almost 23% of the total costs) [11]. Olukoga showed that personnel cost which was the major expanse was accounted for 73% to 82% of the unit costs [12]. Demeere et al. also attempted to analyze and examine the relevance and managerial impacts of time-driven activity-based costing on five separate units of an outpatient clinic. Their results suggested that the final costs of the provided services was significantly different from the governmental tariffs [13].
Moreover, according to Torabi et al, the actual costs to each radiography service was as follows: human resources (43.3%), the

Table 1 *The final costs of each service in Rials*

Type of Service	Total cost of consuming materials	Annual salary and bonus	Building accumulated depreciation	Equipment depreciation	Share of HIS costs	Anergy costs	Physician's per case	Equipment maintenance and repair	the allocated cost from other units
Brain CT Scan	4,700	345,457	18,065	1,284,179	8,253	27,687	130,020	170,916	76,450
Chest CT Scan without Injection	4,700	345,457	285,532	1,284,179	8,253	70,967	90,090	170,916	1,208,330
High Resolution CT Scan	4,700	575,762	1,142,128	2,140,298	8,253	226,084	101,640	284,860	4,833,318
Lung Mediastinum CT Scan without Injection	4,700	1,727,287	734,225	6,420,893	8,253	242,626	78,450	854,579	3,107,133
Spinal Back, Face and Profile Radiography	2,500	575,762	1,284,894	2,140,298	8,253	249,186	38,895	284,860	5,437,483
Lateral Elbow Radiography	4,700	287,881	2,055,831	1,070,149	8,253	353,297	17,775	142,430	8,699,973
Lateral Orbit CT Scan without Injection (Eye)	8,400	345,457	151,164	1,284,179	8,253	49,224	88,770	170,916	639,704
Open 3D CT Scan of all Body Parts	8,400	690,915	354,454	2,568,357	8,253	106,883	187,050	341,831	1,499,995
2 Vertebrae Disc CT Scan without Injection (Lumbar)	4,700	403,034	3,426,385	1,498,208	8,253	583,325	70,620	199,402	14,499,955
Cervical Spine Radiography	4,700	403,034	3,426,385	1,498,208	8,253	583,325	18,840	199,402	14,499,955
Lateral Hand Fingers Radiography	2,500	287,881	934,469	1,070,149	8,253	51,089	16,680	142,430	3,954,533
Pelvis Radiography	4,700	345,457	277,815	1,284,179	8,253	69,718	20,280	170,916	1,175,672
Frog-Hip Bilateral View Radiography	4,700	345,457	1,284,894	1,284,179	8,253	232,676	20,280	170,916	5,437,483
Bilateral Ankle Radiography	2,500	287,881	1,142,128	1,070,149	8,253	205,448	25,110	142,430	4,833,318
Knee Radiography	2,500	287,881	1,284,894	1,070,149	8,253	228,549	20,775	142,430	5,437,483
Lateral Shoulder Radiography	2,500	287,881	541,008	1,070,149	8,253	108,179	18,360	142,430	2,289,467
Abdominal and Pelvic Pyelography	4,700	345,457	122,371	1,284,179	8,253	44,565	33,330	170,916	517,856
Anterior Sinuses Radiography	2,500	287,881	68,988	1,070,149	8,253	31,800	31,875	142,430	291,945
Lumbar Spine Radiography	4,700	345,457	1,284,894	1,284,179	8,253	232,676	39,600	170,916	5,437,483

Table 2 *Comparison of the final services cost of radiology department with governmental tariffs in 2012.*

Type of service	The final cost of the service	Governmental tariff	Total deviation for each service
Brain CT scan	2,065,727	866,800	-1,198,927
Chest CT scan without injection	3,468,423	600,600	-2,867,823
High resolution CT scan	9,317,044	677,600	-8,639,444
Lung mediastinum CT scan without injection	13,178,147	523,000	-12,655,147
Spinal back, face and profile radiography	10,022,131	259,300	-9,762,831
Lateral elbow radiography	12,640,288	118,500	-12,521,788
Lateral orbit CT scan without injection (Eye)	2,746,067	591,800	-2,154,267
Open 3D CT scan of all body parts	5,766,139	1,247,000	-4,519,139
2 Vertebrae disc CT scan without injection (Lumbar)	20,693,881	470,800	-20,223,081
Cervical spine radiography	20,642,101	125,600	-20,516,501
Lateral hand fingers radiography	6,467,984	111,200	-6,356,784
Pelvis radiography	3,356,990	135,200	-3,221,790
Frog-hip bilateral view radiography	8,788,839	135,200	-8,653,639
Bilateral ankle radiography	7,717,217	167,400	-7,549,817
Knee radiography	8,482,914	138,500	-8,344,414
Lateral shoulder radiography	4,468,226	122,400	-4,345,826
Abdominal and pelvic pyelography	2,531,627	222,200	-2,309,427
Anterior sinuses radiography	1,935,821	212,500	-1,723,321
Lumbar spine radiography	8,808,159	264,000	-8,544,159

allocated costs from other units (30.5%), the specialized consuming materials (12.1%), specialized equipment depreciation (9%), building depreciation (3%), office equipment depreciation (0.5%), energy costs (0.8%) and general consuming materials (0.3%). In their study, the highest and the lowest costs were allocated to human resources (2,510,287,740 Rials) and general consuming materials (20,211,884 Rials) with the amount of and [14]. Nik Pajooh et al also indicated that the personnel costs of radiology department (1,788,100,000 Rials) had occupied the largest share of the operating expanses (66.19%) and unit total costs (62%) Other costs consisted of consuming materials and repair /maintenance (16.61%), equipment depreciation of radiology unit (6.34%), energy and general costs (9.72%). Besides, the share of this unit from other support centers was 9.72% [15].

Mousavi et al reported the final costs for most of selected outputs in radiology centers more than those of governmental tariffs. Besides, the highest and lowest deviations from the tariffs of 2008 in the radiology department were related to bilateral view arm radiography (45,469 Rials) and bilateral lumbosacral radiography (2,052 Rials) [16].

In addition, Ghiasvand et al. (2013) found the highest level of deviation as a loss in front chest radiography (31,496 Rials) for Alavi Hospital and in upper GI radiography (129,685 Rials) for Imam Khomeini Hospital [17].

Conclusion

Due to low activity of radiology department (providing 3 services per day), it was assumed to bring loss instead of benefit. The findings of the current study support this assumption, as well. Some causes of this loss might be as follows: the low activity of this center, high transmission costs from other centers as well as the accumulated depreciation costs of the equipments.

It is worth mentioning that 1077 stereotypes had been provided over a year in the radiology department of Ordibehesht Hospital, Shiraz, Iran. The total income of these services were equal to 673,799,400 Rials and their final costs were equal to 3,249,387,355 Rials. Hence, it

is revealed that this center loss has been equal to 2,575,587,955 Rials over the course of one year.

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Authors' contributions

Study design: HKH
Data Collection and Analysis: HKH
Manuscript preparation: HKH
All authors have read and approved the final version

Conflict of Interest

"The authors declared that they have no competing interests."

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Availability of data and materials

The datasets used and/or analyzed during this study are available from the corresponding author on reasonable request.

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