Cost Centric Data Mining for Radiology Procedures at Teaching Hospital in Malaysia

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ABSTRACT

This study explored radiology procedure' cost across available units in the Radiology's Department UKMMC (University Kebangsaan Malaysia Medical Centre). In 2011, the total number of radiology procedures carried out in this department was 121,221. Nevertheless, the estimating expenses of offering these procedures are not known. An economic evaluation study was employed and cost centric data mining based on costing activity method was used to determine the charge of the procedure in every centre. Information on seven cost parameters was collected for each procedure: human resources, consumables, equipment, reagents, administration, maintenance and utilities. The results of the study show that the highest percentage of cost parameter for the human resource was Radiology (Mobile) 57.5%, the highest percentage of cost parameter for consumables and reagent was EIR (Endovascular International Radiology) Unit 75.8% and Medical Nuclear Unit 68.1% was the highest percentage of cost parameter for reagent. The MRI (Magnetic Resonance Imaging) Unit 81.4% was the highest cost parameter for equipment. The most top mean cost procedures were EIR MYR4330 and it was revealed that procedures with the highest difference ratio were procedures in EIR (18.50). Finding of this study is very useful to UKMMC management since it helps to enhance the efficiency of services and reduce unnecessary radiology procedures in patients' management.

Key Words: Cost Centric Data Mining, Activity Based Costing, Radiological Procedures, Cost Parameters.

1. INTRODUCTION

Presently, the effectiveness of the healthcare is not only being measured using the patient's health outcome as the metric but also the output of the cost as the core metric [1]. Due to the number of service activities carried out and intermediation services for methods of treating different diseases linked with each other, it is complicated and hard to make cost analysis [2].

Cost information usually is collected in the service unit and the bases of measurement issued in an organization [3]. Cost represents all sources involved in providing services or producing products. Basically, the higher the product or the service is, the higher the cost [4]. Costs are often assessed to illustrate financial performance in a department, imaging technique, imaging equipment or

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procedure. This step is vital to management in making policy decisions [5]. The type of cost can be classified as indirect cost, direct costs, fixed cost or variable cost. Direct costs can keep track of procedures or services with patient care, while indirect costs are irrelevant costs on procedures or services [6-7]. Variable costs are costs that vary directly with the amount or activity carried out, while the fixed cost is the cost that does not differ from the amount within the given time [6]. Overhead costs are all costs that are not directly related to the production of tests but included in the total procedures expenses. Fixed cost is the unchanged cost based on the number of tests.

Upon the establishment of UKMMC as a training hospital, study on cost of the radiology procedure is still lacking. Thus, this gap impedes the management to regulate the actual resources used and cost parameters involved. Further, UKMMC is also fronting obstacle to determine the cost of the radiology procedures and to fix the rate for charging. The expenditure shows an alarming increasing pattern that has reached RM408 million in 2010 from RM260 million in 2005[1]. Limited research was done on the expense of radiology procedures, most studies the radiology procedures' cost generally centered on the charge of equipment, consumables and employing cost centric data mining that focused on step down costing method. Very few studies employ cost centric data mining using activities based cost methods to calculate the costs of radiology procedures.

Department of Radiology is among the midway cost centers to support patient treatment in clinics and wards which has been operational since July of 1997 in UKMMC. The total procedure performed in 2011 is equal to 121,221 procedures. However, information on the concrete expense of conducting various radiology procedures for UKMMC is still unknown. In this study actual cost of

radiology procedures will be estimated that can be used for future financial planning and budgeting to support effort to become an autonomous entity.

The Ministry of Health Malaysia knows that the cost of the country's health services shows a trend of continuous improvement, but it is difficult to obtain estimates of treatment expenditure information for each illness as no detailed cost studies have been conducted [2].This cost study is essential to know the charges applied by the management of the UKMMC are still relevant or appropriate by time circulation. It hoped that this study would provide comparisons between the current charge rate and the cost of each of the radiology procedure. With this finding, management can efficiently distribute annual budget by cost parameters.

The paper is structured as follows: section 2 delivers research background. Section 3 describes the proposed methodology as well as the mathematical formula, parameters and metrics values for cost centric data mining. Section 4 is the results and analysis. The final section 5 is the conclusion.

2. RESEARCH BACKGROUND

The normal cost centric data mining for health procedure are the ABC (Activity Based Costing) and Step-Down costing. The top down costing and macro-costing are the other terms of step-down costing. Gross costing is for step-down and is defined as cost per unit. The step-down costing is favorable to be considered in a condition where there is insufficient data for the defined services [8]. In comparisons to other traditional costing methods, ABC is the most precise technique to ascertain cost information [9].

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Preceding studies highlighted that various industries employed the ABC technique with encouraging impact [9-13]. The growing expenditures in hospital need to be covered by developing a proper charging rate. The costing technique through ABC defines the genuine expenses related to the services according to its resources. With the purpose to calculate the cost of numerous products from the service industry and manufacturing sector, the ABC was introduced [14-17].

The ABC method can also improve quality and it is possible to use the ABC model to be more precise and minimize cost information [9]. The basic concepts of ABC are based on activity and resource use to produce production or products. Using the ABC to CT (Computed Tomography) procedure at the Radiology Department, all studies will be conducted on the activities involved in computing the CT procedure. The number of resources and cost can be found by knowing every activity carried out. By using ABC, the cost is more accurate according to the type of CT procedure performed [13].

The ABC also raises the awareness of medical staff on the importance of cost, as they will also be able to evaluate costs based on the activities carried out. The ABC refers to the micro cost system where it is more accurate and thorough. Each element of the resource used is assessed, identified and for example in CT Scan equipment or machine using a more detailed approach where the cost for all aspects in the CT Scan procedure includes consumables such as contrast liquid and film, technological or administrative [18]. The ABC model is usually used in business, economic, science and healthcare sectors where it involves the overall cost. Each activity is identified and evaluated to get the right value [19]. In cost centric data mining using the ABC the parameters involved can be summarized according to equation [12,19]:

Cost of activity involved = Cost of space + Cost of materials + Staff costs + Cost of equipment + Hospital infrastructure costs + Other indirect costs [11].

3. PROPOSED METHODOLOGY

The investigation was employed for all units in Radiology Center from January-December 2011. The cost of each procedure was analyzed using the Activity Based Costing. Seven cost parameters were gathered for each seven procedures listed below. All results were analyzed using SPSS version 22.0.

(i)   Human resources
(ii)   Consumables
(iii)   Equipment
(iv)   Reagents
(v)   Administration
(vi)   Maintenance
(vii)   Utilities

3.1 Sample selection

This study employed a Universal Sampling method whereby all the radiology procedures (n=121,221) that were performed using year 2011 data. Permission to conduct this research was obtained from the Ethics and Research Committee, Faculty of Medicine, UKM in February 2012 (UKM 1.5.3.5/244/SPP/FF-058-2012).This study examined the radiology procedures offered and performed as shown in Table 1.

Below is the equation used by this study to estimate the Cost :

Total cost (MYR) = Cost of human administrative + Cost of utility + Cost of reagent + Cost of equipment + Cost of resource + Cost of maintenance + Cost of consumable.

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There were two types of costs used in this study, direct cost and overhead cost. Table 2 highlights the activities involved in the MRI procedures, Consumables cost, Reagents cost, and Equipment cost. While the Overhead cost consists of Administrative cost, Maintenance costs and Utility costs are the parameter of direct costs. The evaluation was performed using Malaysia Ringgit (MYR) according to Central Bank of Malaysia rate, 2011 (USD 1=MYR3.058).

4. RESULTS AND ANALYSIS

The results highlight that for direct cost, four units concerning human resource cost reflected a higher cost. The units were Ultrasound Unit Radiology (Mobile), CT Scan Unit, and Radiology (General) Unit. The results also highlight that, the consumables cost was the highest only in EIR Unit and reagent cost was the highest only in Medical Nuclear Unit. On the other hand, three units

TABLE 1..TOTAL NUMBER OF PROCEDURES PERFORMED IN PATIENTS BY UNIT IN 2011

No.	Unit	Number of Procedures
1.	Magnetic Resonance Imaging	3,911
2.	Computerized Tomography Scan	13,289
3.	Fluoroscopy	1,250
4.	Endovascular Interventional Radiology	1,784
5.	Xray-General	73,777
	Xray-Mobile	11,965
6.	Ultrasound	12,221
7.	Mammogram	2,232
8.	Medical Nuclear	792
Total		121,221

TABLE 2. THE PROCESS OF MRI PROCEDURES

Location	Staff Involved	Year of Service	Activities	Average Time (min)
Counter	Clerk	10	Patients from ward or clinic register at the counter	15
			Register in the system and see the date of appointment	
			Give the number to the patient	
Changing Room	Assistant	10	Help patient to check the room	45
			Waiting for the patient to change clothes before and after the inspection procedure	
Treatment Room	Radiographer	5-10	Ensure the instrument is in good condition	45
			Helps patient to run the procedure	
			Assisting , Medical Officer to make an inspection	
	Medical Officer Specialist	1-5	Incorporate results in system procedures and discuss with physicians.	60
			Ensure stable patient condition	
		1-2	Assessing and verifying decisions and incorporating in the system	30

namely Mammogram Unit, Fluoroscopy Unit, and MRI Unit showed equipment cost as the highest cost. Table 3 shows the percentage of cost parameters by unit in the Department of Radiology.

Results conclude that parameters for overhead cost as shown in Table 3, i.e. administrative, maintenance and utility were the most minimum cost compared to other costs. The maximum cost was only 16.4% concerning administrative cost from Radiology (General) Unit. Nevertheless, compare to other direct cost parameters, this amount is considered small.

From Table 4, the five maximum cost radiological procedures can be identified. The dominant mean cost procedures were EIR was MYR4330 (SD: 5345), followed by MRI was MYR9843 (SD: 3), Medical Nuclear was MYR899 (SD: 911), Fluoroscopy was MYR738 (SD: 70) and CT Scan was MYR399 (SD: 188). The results revealed that procedures with the highest difference ratio were procedures in EIR was 18.50 followed by 10.70 for Fluoroscopy Unit.

The accuracy of cost units on medical services is very helpful in improving the efficiency and transparency

TABLE 3. THE PERCENTAGE OF COST PARAMETERS BY UNIT IN THE DEPARTMENT OF RADIOLOGY

	Cost Parameters (%)								
	MRI	CT Scan	Medical Nuclear	Fluroscopy	Mammogram	Ultrasound	Radiology (General)	Radiology (Mobile)	EIR
Human Resources	7.5	32.8	18.2	6.3	15.6	30.4	53.9	57.5	3.2
Consumables	0.4	10.8	2.4	11.2	19.4	0	0	0	78.5
Reagent	9	32	68.1	4.6	0	25.5	0	0	0
Equipment	81.4	20	9.5	75.8	60	23.6	17.2	18.8	17.9
Administration	0.9	2.7	1	1.2	2.8	11.6	16.4	13.3	0.2
Maintenance	0.5	1	0.5	0.6	1.4	5.7	8	6.6	0.1
Utility	0.3	0.7	0.3	0.3	0.8	3.2	4.5	3.8	0.1
Total (%)	100	100	100	100	100	100	100	100	100

TABLE 4. COMPARISONS BETWEEN COST OF ABC AND UKMMC CHARGES

Procedures in Unit	Cost from ABC Mean (SD)*	UKMMC Charges Mean (SD) *	Difference Ratio
Endovascular Interventional Radiology	4330 (5345)	234 (256)	18.50
Magnetic Resonance Imaging	984 (33)	708 (33)	1.39
Medical Nuclear	899 (911)	307 (293)	2.92
Fluoroscopy	738 (70)	69 (68)	10.70
Computed Tomography	399 (188)	383 (45)	1.04
Mammogram	342 (42)	100 (0)	3.42
Xray (Mobile)	68 (2)	23 (7)	2.96
Ultrasound	65 (32)	24 (17)	2.71
Xray (General)	55 (3)	17 (6)	3.23
*All amount are in MYR			

of the hospital. The evidence illustrated from the ABC methodology highlights that the management of the hospital can calculate the correct cost estimates as well as information from this method to increase the level of understanding of the use of the resources correctly and accurately. The output of this research highlights that the ABC technique could also showcase information for the performed activities. It is also gives the most accurate price estimation. The portion of involved and highest parameters can be known. The results showed that the human resource cost for the Department of Radiology was 57.5%, i.e. from Radiology Unit (Mobile). Human resource cost was the dominant parameter. Using the ABC method of human resource cost is one of the largest cost parameters of the total estimated cost of the Kashani Hospital [11]. The findings also illustrate that the equipment and materials's cost in the Radiology contributes to a significant portion of the estimated capital cost estimates in the study.

It is also found that high service costs will result in cost reductions in each of its services units. To identify the unused resource capacity at various departments such as time photography sinuses procedure used to produce the results is between 432 hours but has taken 2211 hours. Consequently, there are resources to be used properly. In other words, 1779 hours of resources are human resources, facilities and other equipment that are not fully utilized [20]. From the results of this study, overhead costs are low. Eight cost parameters are identified for the estimated cost for each of these procedures and more accurate estimates of the actual cost of the resource. The accuracy of the ABC system's methodology depending on the critical level of each stage of the detailed parameter. For the future research, energy management system is proposed for home which helps to schedule different loads on the basis of their types and charges can be used in hospital [21].

At UKMMC, updating the charge rate imposed on the patient is once every three years, therefore the department mostly only increases the rate of increase of only 10% regardless of other perspectives such as direct costs, indirect costs associated with related activities during the service process. From the results of this study, the deferent ratio is essential for the difference in charge rates from actual cost estimates. The UKMMC management may be able to quickly update charge rates for all the procedures offered. From this data, it is possible that the department at UKMMC makes budgetary management systematically and to have complete data where this information is useful. In addition, this method can reduce wastage. This method can also have an impact on resource composition and improvements will always be possible. The findings also provide useful information to determine the type and quantities of sources used and identify potential sources of cost reduction but will not affect the quality of services.

5. CONCLUSION

Due to the rise of global disease primarily in the healthcare industry has resulted in the health care cost as a crucial matter. The exact expense for each radiological procedure is done using Cost Centric Data Mining using Activity Based Costing method. The important cost parameters that contribute to each of the activities performed at each procedure can be further justified. Hence for improvement, medical specialists should be well-versed of these discoveries so that the right actions are taken to reduce unnecessary services in patient's management.

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REFERENCES

[1] University Kebangsaan Medical Centre Annual Report (UKMMC), 2012.

[2] Cots, F., Elvira, D., and Castells, X., "Relevance of Outlier Cases in Casemix Systems and Evaluation of Trimming Methods", Health Care Management Science, Volume 6, pp. 27-35, 2003.

[3] Finkler, S.A., Jones, C.B., and Kovner, C.T., "Financial Management for Nurse Managers and Executives", [ISBN 978-1-4557-0088-2], St.Louis Elsevier, 2013.

[4] Penner, S.J., "Introduction to Health Care Economics and Financial Management", [ISBN 0-7817-4019-3], Philadelphia, Lippincott Williams & Wilkins, 2004.

[5] Muchantef, K., and Forman, H.P., "Cost Accounting in Radiology: New Directions and Importance for Policy", American Journal of Roentgenology, Volume 185, pp.1404–1407, 2005.

[6] Dowless, R.M., "Your Guide to Costing Methods and Terminology, Nursing Management", www.nursingmanagement.com, pp. 52-57, 2007.

[7] Barnett, P.G., "Determination of VA Health Care Costs", Medical Care Research and Review, Volume 60, No. 3, pp. 124S-141S, 2003.

[8] Barnett, P.G., "An Improved Set of Standards for Finding Cost for Cost-Effectiveness Analysis", Medical Care, Volume 47, No. 7, pp. 82-88, 2009.

[9] Shander, A., Hofmann, A., Ozawa, S., Theusinger, O.M., Gombotz, H. and Spahn, D.R., "Activity- Based Costs of Blood Transfusions in Surgical Patients at Four Hospitals", Transfusion, Volume 50, pp. 753-763, 2010.

[10] Kuchta, D., and Zabek, S., "Activity-Based Costing for Health Care Institutions", 8th International Conference on Enterprise Systems, Accounting and Logistics, Thassos, Greece, 11-12 July, 2011.

[11] Javid, M., Hadian, M., Ghaderi, H., Ghaffari, S. and Salehi, M., "Application of the Activity-Based Costing Method for Unit-Cost Calculation in a Hospital", Global Journal of Health Science, Volume 8, No. 1, pp. 165-172, 2016.

[12] Nisenbaum, H.L., Bernard, A., Birnbaum, Melissa, M.M., Grossman, R.I., Gefter, W.B., and Lanlotz, C.P., "The Cost of CT Procedures in an Academic Radiology Department Determined by an Activity Based Costing Method", Journal of Computer Assisted Tomography, Volume 24, No. 5, pp. 813-823, 2000.

[13] Suthummenon, S., Omachom, V.K., and Akrin, M., "Applying Activity-Based Costing to the Nuclear Medicine Unit, Health Services Management Research", Health Services Management Research, Volume 18, No. 3, pp. 141-150, 2005.

[14] Laurila, J., Suramo, I., Brommels, M., Tolppanen, E.M., Koivukangas, P., Lanning, P., and Nordenstam C.G.S., "Activity-Based Costing in Radiology", Acta Radiologica, Volume 41, pp. 189-195, 2000.

[15] Atif, M., Sulaiman, S.A.S., Shafie, A.A., Saleem, F., and Ahmad, N., "Determination of Chest X-Ray Cost using Activity Based Costing Approach at Penang General Hospital, Malaysia", Pan African Medical Journal, [ISSN: 1937-8688], 2012.

[16] McDowell, J., "Using Activity-Based Costing to Aid in the Selection of Laboratory Equipment", Lab Medicine, Volume 36, No.5, pp. 278-280, 2005.

[17] Popesko, B.,and Tuækovã, Z., "Utilization of Process Oriented Costing Systems in Healthcare Organizations", International Journal of Mathematical Models and Methods in Applied Sciences, Volume 6, No. 1, pp. 200-208, 2012.

Mehran University Research Journal of Engineering & Technology, Volume 39, No. 1, January, 2020 [p-ISSN: 0254-7821, e-ISSN: 2413-7219]

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[18] Hollingworth, W., "Radiology Cost and Outcomes Studies: Standard Practice and Emerging Methods", American Journal of Roentgenology, Volume 185, pp. 833-839, 2005.

[19] Dalley, C., Basarir, H., Wright, J.G., Fernando, M., Paerson, D., Ward, S.E., Thokula, P., Krishnankutty, A., Wilson, G., Dalton, A., Talley, D., Barnett, D., Hughes, D., Poster, N.R., Reilly, J.T., and Snowden, J.A., "Specialist Integrated Hematological Malignancy Diagnostic Services: An Activity Based Cost (ABC) Analysis of A Networked Laboratory Service Model", Journal Clinical Pathology, Volume 68, pp. 292-300, 2015.

[20] Rajabi, A., and Dabiri, A., "Applying Activity Based Costing (ABC) Method to Calculate Cost Price in Hospital and Remedy Servicers", Iranian Journal of Public Health, Volume 41, No. 4, pp. 100-107, 2012.

[21] Mushtaq M.I., Siddiq A., Tariq, M.O., Ali, A., and Zahra, A., "Economically Effective and Intelligently Responsive Home Energy Management System", Mehran University Research Journal of Engineering and Technology, Volume 38, No. 3, pp. 599-608, Jamshoro, Pakistan, July, 2019.

Mehran University Research Journal of Engineering & Technology, Volume 39, No. 1, January, 2020 [p-ISSN: 0254-7821, e-ISSN: 2413-7219]

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