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Research Article

Activity-Based Costing Of Radiology Services Provided By High-Value Equipment In A Tertiary Care Hospital In Goa State Of India.

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Abstract

Increasing growth and development of medical technology and procedures has raised radiology costs, thereby increasing healthcare costs. Technology upgradations are inevitably accompanied by the cost of procuring such technologies to health care organizations, in terms of both capital costs and operating costs. These costs can have very significant impacts on the financial health of healthcare systems. This has lead to a rising interest of administrators from healthcare organizations. Cost awareness has become vital even in radiology departments. Having details of costs incurred related to the resources used in procedures to define their actual price and to plan future investments in the department. Hence a healthcare organization needs to estimate and control the costs while monitoring the revenue generated. Since the investments are huge, it is important to consider the cost of spare parts and labour charges as a vital constituent of operating cost. The last three decades have brought major changes in radiology services with the introduction of many complex services. Further, the equipment for the two major processes ie the CT and the MRI scans are a costly investment. Hence many researchers have highlighted the need for analyzing the efficiency, effectiveness and the costs related to these type of equipment. The reviews revealed few such studies have been conducted about CT and MRI. This study performs Activity Based Costing of the services provided by CT-scan and MRI machine in the radiology department and estimates the break-even point. Activity-based cost (ABC) accounting has been used in industrial and service-providing units. In the literature, there is scant information about the use of ABC accounting in health care and radiology. There is particularly scarce information about the cost structure of today's transitional period in radiology.

Key words: Activity-based costing, Radiology services

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Introduction

Increasing growth and development of medical technology and procedures has raised radiology costs, thereby increasing healthcare costs. Technology upgradations are inevitably accompanied by the cost of procuring such technologies to health care organizations, in terms of both capital costs and operating costs.[1] These costs can have very significant impacts on the financial health of healthcare systems.[2]. This has lead to a rising interest of administrators from healthcare organizations. Cost awareness has become vital even in radiology departments. Having details of costs incurred related to the resources used in procedures to define their actual price and to plan future investments in the department. Hence a healthcare organization needs to estimate and control the costs while monitoring the revenue generated. Since the investments are huge, it is important to consider the cost of spare parts and labour charges as a vital constituent of operating cost.[3] The last three decades have brought major changes in radiology services with the introduction of many complex services. Further, the equipment for the two major processes ie the CT and the MRI scans are a costly investment. Hence many researchers have highlighted the need for analyzing the efficiency, effectiveness and the costs related to these type of equipment.[4] The reviews revealed few such studies have been conducted about CT and MRI. This study performs Activity Based Costing of the services provided by CT-scan and MRI machine in the radiology department and estimates the break-even point. Activity-based cost (ABC) accounting has been used in industrial and service-providing units. In the literature, there is scant information about the use of ABC accounting in health care and radiology. There is particularly scarce information about the cost structure of today's transitional period in radiology.[5]

Activity-Based Costing :

Activity-Based Costing identifies activities through process mapping, identifies the cost drivers for the same and calculates the related costs

Steps in Activity Based Costing are:

1. Identification of the service
2. Identification of the activities and the process mapping
3. Identification of resources being used
4. Identification of cost drivers
5. Allocation of indirect costs
6. Computation of the costs per unit
7. Computation of indirect costs per unit
8. Computation of total costs by addition of direct and indirect cost Why Activity Based Costing :

1. Accurate costing of products and services
2. A better understanding of the overhead costs
3. Calculates unit costs than the total cost
4. Identifies waste and non-value adding steps
5. Costs the process based on the usage of resources

Need for study

Radiology houses expensive equipment and it is important to perform the costing of these services to have better revenue generation and utilisation of the equipment. Activity-Based

Costing improves the understanding of cost drivers and identifies

wastes in the processes helping managers to eliminate the non-value adding steps in a process. The hospital under study is a multi-speciality hospital with 280 beds, that houses a radiology department which previously operated equipment on lease. The hospital procured new equipment in the year 2019 and wished to understand the costing related to it.

Research design

Aim: To perform activity based costing of radiology services provided by high-value equipment in a tertiary care hospital in coastal India.

Objectives:

a. To analyse the unit cost for radiology services of high-value equipment (CT, MRI) using Activity Based Costing Method.

b. To perform Break-even analysis for the high-value radiology equipment.

Study design: Prospective study

Study area: Radiology department of a tertiary care hospital on the west coast of India

Study period: February 2019-March 2020

Review of literature

A study of Newbrander et al. in 1992stated cost analysis to be an important input for hospital administrators for better management.[6] A report studying the costing methods in Healthcare of Thailand, recommended methodologies for unit cost analysis.[7] Riewpaiboon A., Malaroje S., Kongsawatt S in their study stated that the unit costs are vital in estimating the prices, payment negotiations, for reimbursements and the revenues generated should cover the capital costs to aid in equipment replacement in future.[8]

Among the two types of micro-costing methods, the bottom-up and the top-down method, few studies have investigated the efficiency, identified a study performed by Chapko MK, Liu CF, Perkins M, Li YF, Fortney JC, et al. in 2009. A study developed a simple-ABC method by limiting cost heads to four and concluded that ABC methods can obtain accurate results is simpler to perform if the number of cost drivers is reduced.[9]

Like the above studies, few studies evaluated the efficiency of the bottom-up and top-down method.[10] These comparisons revealed that the bottom-up methodology effectively identified the costs for services in the hospitals as compared to the top-down method.[11]Additionally, a study by Mercier G, Naro G in 2014, identified the top-down costing method failing to consider factors such as nursing staff levels, intervention duration etc causing ineffective identification of costs and losses over time and that a more reliable estimate would be provided by the bottom-up method.[12]

It is seen that the costing method used affects the cost estimation of the services.[13].A study by Cooper R, Kaplan RS in 1988, stated that the ABC is an effective method which is widely used in the service sectors.[14] Whereas another study studying utilization concluded that ABC efficiently accounts the cost of hospital services by estimating the resources utilized, the only drawback being the difficulty and cost of implementing it in the hospital sector.[15]

A review by MR, Schulz et al in 2004 identified MRI as a vital tool for promoting minimal invasive therapy and surgical procedures with the guidance of IMRI but highlighted higher investments and importance of related cost to achieve cost-effective services.[16]

A study in academic radiology department estimated the costs of CT services and found ABC

method more efficient for the analysis of actual usage.[17] Similarly another study analyzed a pediatric radiology department to estimate resource usage and found the costing more detailed and precise, and diminished percentage of unspecified allocated overhead costs when ABC is employed.[18]

Cohen *et al.* (2000) implemented ABC method for monitoring the effect of a teaching paradigm on clinical productivity and concluded that ABC analysis gave a better understanding of the cost structure in different areas.[19]

A comparative study between traditional costing and ABC accounting in departmental budgets stated that the process-oriented cost analysis is feasible for radiology departments, and it shall be helpful in decentralized controlling functions.[20]

Methodology

1. Observation of the workflow of the area under study
2. Informal interviews of the staff for process mapping, workflow understanding and process function understanding
3. Activity analysis after identification of cost heads and cost drivers.
4. Break-even analysis after estimating fixed costs from 12 months data February'19-January'20

Calculations involved in the study :

1. The equipment being studied was identified and their expected life span was identified after informal interviews with the experts and technician staff.
2. The depreciation calculated as straight-line depreciation of 10% every year
3. The life span of equipment in this study was provided by the Department of Biomedical Engineering, American Society of Hospital Engineers Guidelines.

Formulae used:

1. Cost of equipment/year = $\frac{\text{Total cost of equipment}}{\text{Number of life years}}$
2. Cost of equipment/day = $\frac{\text{cost of equipment per day}}{\text{number of hours the equipment can}}$ number of minutes in an hour
3. Cost of equipment/hour = $\frac{\text{Cost of equipment per day}}{\text{Number of hours equipment can be used per day}}$
4. Cost of equipment/minute = $\frac{\text{Cost of equipment per hour}}{60}$

Table no:1 Cost of equipment

Machine	Cost of machine	Annual cost	Cost/ Month	Cost / Day	Cost/ Hour	Cost/ Minute
CT	15083526	3016705.2	2513 92.1	8379 .736 667	349. 1556 944	5.8 1926 2
MRI	45330 000 0	906 000 0	7555 00	2518 3.33 33 3	1049 .305 556	17. 4884 3
Film Printer	10000 0	20000	1666 .666 667	55.5 555 556	2.31 4814 815	0.0 3858
C			58	19	0.	0

omputer	350000	70000	3.33333333	.44444444	8101851 85	.0135035
Printer	350000	70000	58.33333333	1.9444444 4	0.0810185 19	0.0013535

The equipment gets depreciated over time and the market value of the equipment reduces as new technology immerges. Such cost needs to be considered while calculating the break-even.

Straight-line depreciation = Total cost of the equipment – Salvage value

Estimated useful life

Salvage value = Total cost of equipment –(10% of cost x estimated life in years)

The formula for calculating straight-line depreciation :

Table no:2, Total cost, salvage value and depreciation

Machine	Cost	Salvage value	Cost - Salvage	Depreciation	Monthly Depreciation
CT	15083526	7541763	7541763	1508352.6	125696.05

			63		
MRI	4533000	2266500	226650000	4533000	377750
Film Printer	1000000	50000	5000000	10000	833.3333333
Computer	35000	17500	1750000	3500	291.6666667
Printer	3500	1750	175000	350	29.16666667

To calculate the per-minute cost of employee utilisation the formulae are :

Salary of employee per day =	The total salary of an employee / working days in a month
Salary of employee per hour =	salary of employee per day / working hours per day
Salary of employee per minute =	salary of employee per hour / number of minutes in an hour

Table no:3, Salary of the human resources involved

Human Resources	Monthly Salary (rupees)	Salary/ day (rupees)	Salary/ Hour (rupees)	Salary (rupees)
Billing Executive	15000	576.9230769	72.11538462	1.201923077
Typist	15000	576.9230769	72.11538462	1.201923077
Technician	25000	961.5384615	120.1923077	2.003205128
Radiologist	150000	5769.230769	721.1538462	12.01923077
Housekeeping	12000	461.5384615	57.69230769	0.961538462
Staff Nurse	15000	576.9230769	72.11538462	1.201923077

Observations

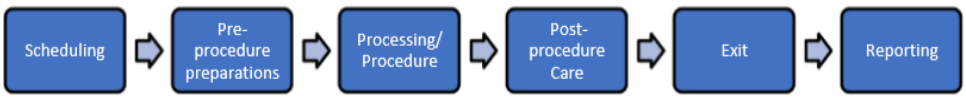
Process mapping :

Process mapping was performed by observing the steps involved in two types of procedures(plain and contrast scan) of the CT and the MRI Scan on Out-patient basis.
The identification of activities performed, the resources involved were done and the time frame for which these resources are used was captured. Further, the same time frames were multiplied by its unit costs and the total cost was calculated.
Process of the CT and MRI procedure is explained ae as follows:
Table no:4, Process of performing OP based CT/MRI with/without contrast

Plain CT/MRI	Contrast CT/MRI
The patient pays the bill	The patient pays the bill
Registration at the Radiology Counter	Registration at the Radiology Counter
The technician takes consent	The technician takes consent
The patient changes into a gown	The patient changes into a gown
The patient is positioned on the gantry couch	The patient receives IV contrast as advised
The scan starts	The patient is positioned on the gantry couch
Scan ends and the patient changes back to his clothes	The scan starts
Patient exit	Scan ends, IV cannula removed, the patient changes back to his clothes
Radiologist reports the scan	Patient exit
Report and CD is handed over with the film in 24 hours	Radiologist reports the scan
	Report and CD is handed over with the film in 24 hours

Activity map

The process of Activity Based Costing starts by preparing an activity map for the CT/MRI procedures. The process is listed below.
Activity Analysis:



During activity analysis, each resource used in the procedure is identified which further leads to the identification of cost pools of each resource.

Table no:5 Cost Pools

Equipment with	Consumables	Human resource	Other resources
CT machine	IV Cannula	Doctors	Electricity
MRI machine	Syringe	Technicians	Cleaning agents
Film printing	Contrast	Typists	Film processing chemicals
Computer	CD	Staff nurses	
Printer	Films	Housekeeping	
Machine	Tissue		
	Paper		
	Envelop		

Assigning cost categories:

After identification of the resource utilized, the related costs are assigned.

The direct costs are directly related to the performance of the service and indirect costs, which have to be allocated to multiple services and are not directly related.

Cost Categories:

Table no: 6 Cost categories for the activities

Component Activities	Categories
Pre-procedure :	
Billing	Indirect Cost
Registration at the CT / MRI counter	Indirect Cost
Consent	Indirect Cost
IV cannula	Direct Cost
Syringe	Direct Cost
Contrast	Direct Cost
Processing:	
Technician	Direct Cost
Housekeeping	Direct Cost
Staff Nurse	Direct Cost

Radiologist	Direct Cost
Typist	Direct Cost
Billing executive	Direct Cost
Procedure:	
MRI machine	Direct Cost
CT machine	Direct Cost
Power consumption/ electricity	Indirect Cost
Post-procedure:	
Film	Direct Cost
CD	Direct Cost
Paper	Direct Cost
Envelop	Direct Cost
Cleaning Cost	Indirect Cost
Lighting Cost	Indirect Cost

Analysis and results

The following are the selling prices of the procedures which were process mapped during the tenure of the study. The mean selling price of plain and contrast procedures is used to estimate the contribution margin. The procedures which could not be mapped are excluded.

Table no: 7, Pricing of procedures in the hospital

	Procedures	**Plain Procedure Selling Price**	**Contrast Procedures selling price**
CT	Brain	3500	4860
	LS-Spine	4400	5760
	CS-Spine	44	57

		00	60
	Whole-spine	2000	
	KUB	4840	5320
	Chest	4400	
	Neck	3960	4500
	Thorax	4400	4400
	Thoracic Spine	4400	-
	Upper	5940	-
	Abdomen		6750
	Pelvis	5390	
	Neck(CECT)*	-	4500
	Thorax(CECT)	-	4400
MRI	LS-Spine	6820	
	DL-Spine	6820	
	Whole Spine	130900	144000
	Brain	7500	103900
	Abdomen	7380	103000
	Pelvis	6490	
	Knee Joint	6800	
	Shoulder	6800	7590

	Brain	-	10,390
	Thorax(CEMRI)**	-	10630
	Both Ankle (CEMRI)	-	13000
	Lower Legs (CEMRI)	-	12000

*Contrast Enhanced CT

**Contrast Enhanced MRI

The mean selling price of plain and the contrast CT scan is Rs. 4330 and Rs. 5139, respectively, whereas for the MRI scan is Rs. 7712 and Rs. 11087 respectively.

Cost Drivers for CT SCAN

a. Plain CT

Table no:8a, Cost drivers and associated cost for Plain-CT

Process	**Sub-Process**	**Cost Driver**	**Category**	**Equipment**	**Human Resource**	**Total Cost**	~~%~~
Pre-Pr							

ocedure							
	Billing	Minutes Used: 4	Direct Cost	Computer	Billing Executive	0.147	0.021482
	Registration	Minutes Used: 3	Direct Cost	Computer	Billing Executive	0.11	0.016075
	C	Mi	Di		Te		0

	onsent	nutes Used: 4	rect Cost		chnician		
Processing	Labour	Minutes Used: 10	Direct Cost		Technician	20.032	2.927341
	Labour	Minutes Used: 10	Direct Cost		House-Keeping	9.615	1.405071

	Labour	Minutes Used: 15	Direct Cost		Typist	18.028	2.63449
	Labour	Minutes Used: 7	Direct Cost		Billing Executive	8.413	1.229419
	Labour	Minutes Used	Direct Cos		Radiologis	360.57	52.691226

		: 3 0	t		t		
Procedure	CT Scan	Minutes Used: 5	Direct Cost	CT Machine		73.25	10.70426
Post-Procedure	Film Printing	Minutes Used: 3	Direct Cost	Film Printer		0.721	0.105362
	Film	Unit Cost	Direct Cost			144	21.043199

	Film processing chemical	1/Month	Indirect Cost			1.23	0.179744
	CD burning	Minutes Used: 5	Direct Cost			0.178	0.026012
	CD	Unit Cost	Direct Cos	Computer		30	4.383997

			t				
	Report Printing	Minutes Used: 2	Direct Cost	Computer		4.013	0.586433
	Paper	Unit Cost	Direct Cost			1	0.146133
Other	Tissue	Unit	Direct			8	1.16906

	Paper	Cost	Cost				6
	Envelop	Unit Cost	Direct Cost			5	0.730666
Total Cost						684.307	100
Total Variable Cost						229.142	
Total Fixed Cost						455.165	

b. Contrast CT

Table no:8b, Cost drivers and associated cost for Contrast-CT

Process	**Sub-Process**	**Cost Drivers**	**Category**	**Equipment**	**Human Resource**	**Total Cost**	%
Pre-Procedure							
	Billing	Minutes Used	Direct Cost	Computer	Billing Exe	0.1477	0.002797

		: 4			cutive		
	Registration	Minutes Used: 3	Direct Cost	Computer	Billing Executive	0.11	0.002093
	Consent & Explanatio	Minutes Used: 4	Direct Cost		Technician		0

	n						
	Cannulation	Minutes Used: 10	Direct Cost		Staff Nurse		0
	IV set	Unit Cost	Direct Cost			753	14.325557
	Contrast	Unit Cost	Direct Cost			2516	47.866005
Proc	Lab	Minute	Dire		Tech	20.	0.38

essing	our	s Used: 10	ct Cost		nician	032	11102
	Labour	Minutes Used: 15	Direct Cost		Staff Nurse	18.028	0.342977
	Labour	Minutes Used: 10	Direct Cost		House-Keeping	9.615	0.1829222

	Labour	Minutes Used: 15	Direct Cost		Typist	18.028	0.342977
	Labour	Minutes Used: 7	Direct Cost		Billing Executive	8.413	0.160054
	Labour	Minutes U	Direct C		Radiolog	360.57	6.859723

		s e d : 3 0	o s t		i s t		

Procedure	CT Scan	Minutes Used: 5	Direct Cost	CT Machine		73.25	1.393557
Post-Procedure	Film Printing	Minute sUsed: 3	Direct Cost	Film Printer		0.721	0.013717
	Film	Unit Cost	Direct Cost			144	2.739551
	Film	1/M	Ind			1.	0.

	processing chemical	onth	irect Cost			23	0234
	CD burrning	Minute sUsed: 5	Direct Cost			0.178	0.003386
	CD	UnitCost	DirectCost	Computer		30	0.570074

	Report Printing	Minutes Used: 2	Direct Cost	Computer		4.013	0.076346
	Paper	Unit Cost	Direct Cost			1	0.019025
Other	Tissue Paper	Unit Cost	Direct Cost			8	0.1521977
	Contrast	Unit Cos	Direct C			995	18.929544

	syringe	t	ost				
	Connector	Unit Cost	Direct Cost			290	5.517152
	Envelop	Unit Cost	Direct Cost			5	0.095123
Total Cost						5256.3355	1000
Total Variable Cost						4783.14	

					2	
Total Fixed Cost					473.193	

The above activity mapping and related costing show the cost incurred by the hospital for a plain and contrast CT scan is Rs. 684.307 and Rs.5256.335

Cost Drivers for MRI

a. Plain MRI

Table no:9a, Cost drivers and associated cost for plain MRI

Process	**Sub-Process**	**Cost Drivers**	**Category**	**Equipment**	**Human Resource**	**Total Cost**	**%**
Pre-Procedure							
	Billing	Minutes Use	Direct Cost	Computer	Billing Exe	0.147	0.008774

		d: 4			cutive		
	Registration	Minute sUsed: 3	Direct Cost	Computer	Billing Executive	0.11	0.006565
	Consent& Explanation	Minute s Used: 4	Direct Cost		Technician		0

Processing	Labour	Minutes Used: 10	Direct Cost		Technician	20.032	1.195628
	Labour	Minutes Used: 10	Direct Cost		Housee-Keeping	9.615	0.57388
	Labour	Minutes Used: 10	Direct Cost		Typist	18.028	1.076018

		d: 15					
	Labour	Minutes Used: 7	Direct Cost		Billing Executive	8.413	0.502138
	Labour	Minute sUsed: 30	Direct Cost		Radiologist	360.57	21.520955
Proced	MRImac	Minute	Direct	MRIMac		1064.1	63.51

ure	hine	sUsed:40	Cost	hine			179
Post-Procedure	Film Printing	Minute sUsed:3	Direct Cost	Film Printer		0.721	0.043034
	Film	Unit Cost	Direct Cost			144	8.594773

	Film processing chemical	1/Month	Indirect Cost			1.51	0.090126
	CD burning	Minutes Used: 5	Direct Cost	Computer		0.178	0.010624
	CD	Unit Cos	Direct C	Unit Cos		30	1.790578

		t	ost	t			
	Report Printing	Minutes Used: 2	Direct Cost	Computer		4.013	0.239522
	Paper	Unit Cost	Direct Cost			1	0.0596866
Other	Tissue Paper	Unit Cost	Direct Cost			8	0.477487
	Envelope	Unit	Direc			5	0.29

	l o p	C o s t	t C o s t				8 4 3
Total Cost						1 6 7 5 . 4 3 7	1 0 0
Total Variable Cost						2 6 1 . 0 2 2	
Total Fixed Cost						1 4 1 4 . 4 1 5	

b. Contrast MRI

Table no:9b, Cost drivers and associated cost for Contrast MRI

Process	**Sub-Process**	**Cost Drivers**	**Category**	**Equipment**	**Human Resource**	**Total Cost**	**%**
Pre-Proceduree							
	Billing	Minutes Use	Direct Cost	Computer	Billing Exe	0.147	0.00235 3

		d: 4			cutive		
	Registration	Minute sUsed: 3	Direct Cost	Computer	Billing Executive	0.11	0.001761
	Consent& Explanation	Minutes Used: 4	Direct Cost		Technician		0

	Cannulation	Minute sUsed: 10	Direct Cost	Staff Nurse		0
	IV set	Unit Cost	Direct Cost		753	12.052889
	Contrast	Unit Cost	Direct Cost		2516	40.272333
Processin	Labour	Minute s Us	Direct Cos	Technicia	20.032	0.3206422

g		ed: 10	t		n		
	Labour	Minutes Used: 15	Direct Cost		Staff Nurse	18.028	0.288565
	Labour	Minutes Used: 10	Direct Cost		House-Keeping	9.615	0.153902
	Labour	Minute	Direct		Typist	18.028	0.288

		s Used: 15	Cost				565
	Labour	Minutes Used: 7	Direct Cost		Billing Executive	8.413	0.134663
	Labour	Minute sUsed: 3	Direct Cost		Radiologist	360.57	5.771461

		0					
Procedure	MRI Machine	Minute sUsed: 40	Direct Cost	MRI Machine		1064.1	17.03251
Post-Procedure	Film Printing	Minutes Used: 3	Direct Cost	Film Printer		0.721	0.011541
	Film	Unit Cost	Direct Cost			144	2.304935

	Film processing chemical	1/Month	Indirect Cost			1.51	0.02417
	CD burning	Minute sUsed: 5	Direct Cost			0.178	0.002849
	CD	Unit C	Direct	Comput		30	0.48001

		ost	Cost	er			95
	Report Printing	Minute sUsed: 2	Direct Cost	Computer		4.013	0.064234
	Paper	Unit Cost	Direct Cost			1	0.016006
Other	Tissue Paper	Unit Cost	Direct Cost			8	0.128052
	Con	Uni	Direct Cost			99	15.

	trasts yringe	t Cost			5	92646
	Connector	Unit Cost	Direct Cost		290	4.641883
	Envelop	Unit Cost	Direct Cost		5	0.0800032
Total Cost					6247.465	100
Total Variable					481	

Cost					5.022	
Total Fixed Cost					1432.443	

The cost incurred by the hospital for a plain and contrast MRI scan is Rs. 1675.437 and Rs.6247.465, respectively.

The annual fixed costs of the CT and MRI machines is used from the retrospective data of February – January‟20.

Table no: 10, Annual fixed costs for Plain & Contrast CT & MRI scans

Cost Head	CT	MRI
Electricity cost when on standby	2190000	19710000
Man power	27840000	27840000
Insurance	16639999	27518400

+ maintenance		
Machine Cost	2154789.429	6475714
Depreciation Cost	1508352.6	4533000
Other Machine Cost	3540	3540
Other machine depprec	1770	1770

iation		
Lighting Cost	1314000	1314000
Cleaning Cost	3600000	3600000
Total Fixed Cost	85506401.029	18736054

To calculate the contribution margin the formula is :

Selling Price - Variable cost / Selling price x 100

Table no: 11, contribution margins for Plain & Contrast CT & MRI scans

	Plain CT scan	Contrast CT Scan	Plain MRI scan	Contrast MRI Scan
Selling Price	4330	5139	7712	11087
Variable Price	229.14	4783.148	261.022	4815.02
Contribution Margin	4100.86	355.852	7450.98	6271.98
%	94.7	6.92	96.6	56.5

	1 %	%	8 %	7 %

The sum of the contribution margins is used to calculate the break-even for the respective machines.

Breakeven Analysis:

$$\text{Breakeven point of a machine} = \frac{\text{Total annual fixed cost}}{\text{Contribution Margin}}$$

Table no: 11, break-even point of CT & MRI machines

Breakeven Point		
Fixed cost	8550641.029	18736054
Contribution margin	4456.712	13722.96
Units	1918.598516	1365.307

Hence the CT and MRI machines should perform annually 1919 and 1366 scans respectively to reach the break-even. Scans beyond this number of units are profit for the hospital.

Discussion

The studies on Cost Analysis of CT and MRI have been generalized to one procedure cost that is generally taken as a 'scan'. This study tried to fragment the scans based on two wide variations, the plain and contrast scans. The variable cost of the contrast MRI scan was 94% more than the plain scan, whereas the variable cost of contrast CT scan was 95% more than the plain scan. This emphasizes the need to perform costing separately for plain and contrast scans, and that the generalization of these costs would overestimate or underestimate the break-even point.

The study estimated the cost price of the MRI scan as Rs. 1675.437, Rs. 6247.465 whereas of the CT scan as Rs.684.30, Rs. 5256.33 for plain and contrast respectively, which is lesser than a study by Ibrahim, R et al, which estimated the cost price as Rs. 16974.75, Rs. 19464.38 for MRI and Rs.6834, Rs.3672 for CT, contrast, and plain scans, respectively.[13] The difference is mainly due to the method of calculation, while the current study performed mapping of procedures, the study mentioned above used 3 months data and divided all the costs incurred by the number of scans

performed.

In a similar study by P.Naveen Kumar et al [16], the cost-benefit analysis of CT scan was studied and the estimated cost per scan is Rs. 1756.5.

Another study that compared costs of biopsies guided by CT and MRI machines by ABC found that the cost of MRI-guided biopsy was 2.55-fold higher than the CT-guided biopsy due to the pricey MRI instruments and the longer procedure time. [1] This is true for this study as well where the costs of MRI plain procedures are 2.7 folds higher than the CT, whereas contrast MRI is 1.1 fold higher than CT.

Two studies by Roberts et al[27] and Lave & Lave[19] highlighted the fixed costs and variable costs: 84% and 16 %, respectively, with the latter ranging from 25% -42%. In this context, the current study estimated the variable costs for CT & MRI in the range of 9.5%- 33.5%, 15.5%-77.07%, and fixed costs in the range of 66.5%-90.5%, and 22.9%-84.4% respectively. A study by Routio et al. in 2003 in interventional radiology, revealed its variable cost to be 67%.[28], which is true in the current study w.r.t. contrast MRI. (66.5%). The same study estimated the material costs and high-cost equipment having a major share and minor share of the total cost, respectively. This is true in this study where due to the higher usage of materials in contrast-CT(89.9%) and MRI (75.8%), the machine costs are meagre, ie 1.3% and 17.03% respectively while the equipment has a high cost. [28]

Moreover, the results of this study match a study by Yoshimi Anzai et al that concluded the cost break up like 40% for the personnel, 39.6% for materials,6.4% for equipment, against which this study estimated the personnel cost as 60.1%, material-cost was 27.45% and 11.35% equipment cost.[2]

Conclusion

It is found that the percentage distribution of the cost heads differs depending on the total estimate of the cost price.

Even when CT and MRI equipment perform one type of procedure, which is a scan, these equipment have variety w.r.t the consumables used and the cost incurred by the hospital, hence cannot be generalized while performing cost analysis.

This study estimated the cost prices for plain and contrast CT and MRI services followed by estimating a Breakeven for both the machines based on earned contribution margins.

This study tried to estimate resource utilization on the filed through process mapping and captured its timeframe and calculated the cost by multiplying against its unit value, which reduced the possibility of generalized addition of any costs beyond the scope of usage. Further, the margins calculated are used to estimate the break-even. The study estimated the cost prices for plain and contrast scans as Rs. 1675.437, and Rs. 6247.465 for MRI and Rs. 684.30 and Rs, 5256.33 for Ct scans, respectively.

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