



TO STUDY COMPREHENSIVE MACHINE HOUR RATE ANALYSIS OF MAGNETIC RESONANCE IMAGE IN A TERTIARY CARE TEACHING INSTITUTE

Hospital Administration

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ABSTRACT

Background: In India the health care is the largest sector. The medical equipment like MRI is a cost center. Collecting the data of different costs and analyzing it and calculating the machine hour rate shows the performance and effective utilization of MRI service. It is useful for health care manager as a management control tool.

Materials and Methods: The observational and empirical study was conducted in a tertiary care teaching institute, the primary data was collected through semi structured interviews with staff and secondary data from registers. MRI related cost identified. The CMHR was calculated.

Results: After analysis it was obtained, the total cost for operating the MRI was Rs.19788186 (US\$291184.26). The total number of the man hours operating MRI was 5040 hours in one year. The CMHR of MRI was Rs.3926.23 (US\$57.77).

Conclusion: The CMHR is an appropriate methodology in health care business to verify the effectiveness and efficiency of a diagnostic equipment.

KEYWORDS

Comprehensive machine hour rate, costing method, MRI diagnostic service.

INTRODUCTION

The India Brand Equate Foundation (2016), which was an initiative of the Ministry of Commerce and Industry, Government of India stated, "healthcare has become one of the India's largest sectors- both in terms of revenue and employment." "Health care comprises of hospitals, medical equipments and devices, clinical trials, outsourcing, telemedicine, medical tourism, telemedicine, and health insurance". Chaudhary and Kaul (2014) stated that, the medical equipment almost shares 40-50% of all costs for setting up a tertiary care hospital. According to Ibrahim and Samain et.al. (2012), the cost of equipment was the highest contributing factor, elucidating the manager for financial analysis and proper resource utilization. Kumar (2014) revealed that, Alexander Hamilton Church introduced the notion of machine-hour rate method and developed this idea in his subsequent writings. Tenovici (year not known) described the machine hour rate and defined as "a rate calculated by dividing the budgeted or estimated overhead or labor and overhead cost attributable to a machine or group of similar machines by the appropriate number of machine hours. The hours may be the number of hours for which the machine or group is expected to be operated, the number of hours which would relate to normal working for the factory, or full capacity". This method is the most appropriate method in machine intensive cost centers. It was also identified as "Price method-hour-machine" (THM the abbreviation comes from the original translation in French: Taux- Heure- Machine). The North American economist Spencer A Tucker considered this method as a standalone method for cost centers or productive centers. According to Pal(2015), the MHR (machine hour rate) is a rational method for absorption of overheads in estimating cost. In the computation of MHR, the indirect expenses in connection with the cost center are apportioned. Machine operator's wages or staff salaries are treated as direct wages and charged to the job directly. In comprehensive or composite machine hour rate CMHR the staff salaries can be identified directly with machine or equipment. As described by Bilek (2009), Donald Maxwell Matthews, 1942 published the first of this type methodology "machine rate" to estimate how much to charge for logging equipment. E.M. (Ted) Bilek in 2007 introduced Charge out model.

In health care industry, the diagnostic center is a major cost center, majority of the overheads are incurred by using equipments, such as, depreciation, power, comprehensive annual maintenance, etc. Therefore MHR, provides the most equitable basis for absorption overheads in equipment intensive cost centers. MHR is the cost of operating for one hour and it is the most appropriate method for industries where more machines are used for production. In this method the machine (the diagnostic equipment: MRI) is treated as a cost center and hence this method is also suitable for any health care facility.

Steps for Computation of Machine Hour Rate:

1. Each equipment or a group of equipments or devices should be treated as a separate cost center.

2. Overheads are divided into two types such as standing charges and machine expenses. Standing charges are fixed expenses which do not vary with the utilization of equipment such as rent, rates, insurances, administration cost, etc. Equipment expenses are variable expenses which vary with running of equipment, such as depreciation, repairs, annual maintenance, etc. During computing MHR some of the overheads may require to be apportioned for the equipment cost center.
3. The effective machine hours of the equipment for a given period need to be calculated.
4. The standing charges of the equipment are estimated for a given period and are divided by the total number of effective working hours, to arrive at the simple machine hour rate (SMHR).
5. When the staff salaries (the machine operator's wages) added to the SMHR, it is called as Comprehensive Machine Hour Rate.(Simranjot 2017).

Advantages of Machine Hour Rate Analysis

According to Gómáthivállí (2013) and Assar (2017),

1. It helps to measure the relative efficiency of different machines.
2. It facilitates comparison of cost of operating different machines.
3. It helps to ascertain idle time of machines relating to non-productive time.
4. It is the most desirable scientific method, where the time factor is taken into account.

The study was carried out in 2007 and the results and findings of the study were extracted from post graduation thesis work, cannot be and should not be extrapolated to the present day cost and price. We acknowledge the serious limitation of the article upfront. However the methodology of the article is highly relevant and topical to health and hospital administrators in financial management of public and private hospitals. The primary objective of this study is to share the methodology which will be helpful to research scholars of hospital administration.

Objectives

The objectives of this study were as follows:

1. To describe Comprehensive Machine Hour Rate (CMHR) and its application at MRI unit.
2. To classify costs and overheads relevant to the diagnostic service in healthcare.
3. To estimate the Comprehensive Machine Hour Rate of MRI.

MATERIAL AND METHODS

The study was observational and empirical. It was conducted over a period of one year in a tertiary care teaching institute. The study was approved by the institutional ethics and research committee. The research design used in this study was analytical in nature.

Data Collection

Primary Sources

The data was collected through personal observation and unstructured

interviews with MRI technicians, radiologist, biomedical, electrical and civil engineers, purchase section and stores department personnel and others.

Secondary Sources

The data was collected from the reception registers, MRI log book, purchase and stores department registers. Relevant Journals retrieved from website Google Scholar. Based on the previous studies, (James,2013, Agarwal,2017, and Dallan, year not known), we applied costing method to calculate CMHR of MRI.

Identification of costs related to MRI.

The service cost or expenses in case of MRI scan are classified into:

a. Fixed Machine Expenses: Which remains constant, irrespective of equipment usage (interest, insurance, rent, annual maintenance, supervision, administration).

b. Variable Machine Expenses: Which are variable with usage of equipment (power, depreciation, repairs), the auxiliary equipment depreciation, and energy consumed by air conditioning, computers, printers, fans, lights and fuel.

c. Direct Material Expenses : Which includes films, covers, forms, printer, contrast etc.

d. Direct Labor Expenses: Which includes the salaries of the associate professor, assistant professor, senior resident, MRI technologists, biomedical engineer, two darkroom assistants, two labor assistants, anesthetists.

e. Over Heads: these are a group of expenses, which are indirect and not identifiable with the cost unit but are incurred generally for the delivery of service and can be apportioned to and absorbed by the cost units. Over heads is the aggregate of indirect material, indirect labor and indirect expenses. Indirect labor cost includes the apportioned cost of the head of the unit, personal secretaries, computer operator, secretarial assistant, and department utilities and medical fund for staff. Other indirect expenses includes the costs of building maintenance, indirect consumables, housekeeping, information technology, and the expenses of administration, managerial, and stores functionaries (apportioned).

Equipment cost

The depreciation of MRI scanner estimated by sum of year's digital method, and the depreciation cost for a year, and per hour calculated. The energy consumed by MRI scanner was 80 KWH and the cost calculated per hour. To estimate the machine hour rate, the notional rental cost of MRI unit area was taken from the engineering department and local market rates and the annual maintenance cost of equipment per hour calculated.

Calculate the CMHR of MRI

The data which was collected from the medical stores records was analyzed. The expenditure of all staff obtained from human resource department, the energy consumption rate and cost etc, collected from engineering department. The practical time of MRI was estimated by observation. The time element estimated from the staff records and MRI scanner data base itself. A spreadsheet for data was developed and analyzed. The comprehensive machine hour rate (CMHR) is calculated by computing all expenses together. The results were analyzed using MS Excel 2007. CHMR was calculated by using the following formula:

$$\text{CHMR of MRI} = \frac{\text{Equipment relevant cost} + \text{Material relevant cost} + \text{Labor cost} + \text{Over heads}}{\text{Total man hours operated on MRI}}$$

Table 1. Classification of costs relevant to MRI diagnostic service and their description.

S.No	Description	Year cost	Cost/hour	S.No	Description	Year cost	Cost/hour
	Equipment:Direct;fixed				Labor: Direct; fixed		
1	Rent notional	420,000	83.33	26	Associate Professor	525,662	104.3
2	MRI Interest	1,793,550	355.86	27	Assistant Professor	65,267	12.95
3	Insurance	44,619	8.85	28	Sr. Resident	214,668	42.59
4	AMC MRI	2,425,500	481.25	29	MRI Technician .Chief	302,863	60.09
5	UPS AMC	69,589	13.81	30	MRI Technician two	362,136	71.85
		(4753258)	(943.11)	31	Bio-medical mechanic	161,941	32.13

RESULTS

Eight distinct costs were identified and estimated to calculate CMHR of MRI. The machine cost may be divided into fixed costs, operating costs, labor costs and over heads. According to Horngren et al.(2003), again the costs can be classified into two major types: direct/indirect and variable/fixed. Costs simultaneously maybe classified into: Direct and variable, direct and fixed, indirect and variable and, indirect and fixed.

In our study following types of costs were traced out and distinguished which are identified with MRI unit: 1.Equipment related direct and fixed (EDF cost), 2.Equipment related direct and variable (EDV cost), 3. Material related direct and variable (MDV cost), 4. Material related indirect and variable (MIV cost), 5. Labor related direct and fixed (LDF cost), 6. Labor related indirect and fixed (LIF cost), 7. Over heads related indirect and fixed (OHIF cost) and, 8. Over heads related indirect and variable (OHIV cost). The classification of costs relevant to MRI diagnostic service and their description and expenditure were shown in the Table.1. The different costs of any health care service can be plotted in a matrix model, and shown in the Fig. 1.

Equipment: direct and fixed cost: The total cost of equipment MRI, direct and fixed costs includes, rent of the MRI unit, interest on the capital payment of MRI, insurance, annual maintenance and uninterrupted power supply's annual maintenance. It was Rupees (Rs) 4753258 (US\$ 69944.46; date of conversion 2018 May 19), which was 24.02% of total cost. Fig.2 shows the percentages of different costs. Table.2 shows the different cost heads and the relevant expenditure incurred for the MRI scan facility in one year. Fig. 3. shows the graph showing the different types of costs.

Equipment related direct and variable cost: It includes MRI depreciation (Rs 6059550), air handling unit depreciation (Rs 100375), air-conditioning and other support equipment depreciation (Rs 66000), civil works depreciation (Rs 275000), repairs and civil maintenance (Rs125000), electricity consumed by MRI equipment (Rs 1145700), electricity consumed by air-conditioning (Rs 882000), and generator fuel expenses (Rs 30440). The MRI related direct and variable expenses for the study period was Rs. 8684065 (US\$127786.50), which was 43.88% of total cost.

Material related direct and variable: Which includes the expenses for MRI films (Rs 2378839), customized covers (Rs 80263), report forms (Rs 1374), requisition forms and others (Rs 6934), laser printer (Rs 203190), and contrast agents (Rs 231567). These expenses incurred for that year was Rs. 2902167 (US\$42705.55), which was 14.66 % of total cost.

Material related indirect and variable: Which includes injections (Rs 10594), surgical utilities (Rs 33079), surgical spirit (Rs 861), dettol (Rs 437), injection dextrose normal saline (Rs 2475) and isolate pediatric used (Rs 152). The expense for one year was Rs. 47598 (US\$700.41), which was 0.24% of the total cost.

Labor related direct and fixed: Which includes the doctors salaries of MRI unit, technicians salaries, biomedical mechanics, room assistants, other workers and staff medical fund and utility funds, was Rs.1990345 (US\$29288.04), which was 10.06% of total cost.

Labor related indirect and fixed: Which includes the head of department, and office secretarial staff salaries and it was Rs. 313639 (US\$ 4615.22), these salaries were apportioned (1/6) and allotted to MRI unit, which was 1.58% of total cost.

	Equipment : Direct; variable			32	Dark Room Asst-two		24.19
6	MRI Depreciation	6,059,550	1202.29	33	Unskilled worker x 3	110,160	21.86
7	Air handling unit dep*	100,375	19.92	34	Anesthesia	13,000	2.58
8	A.C & other equipment dep.	66,000	13.1	35	Anesthesia Assistant	5,304	1.05
9	Civil works	275,000	54.56	36	Staff Medical/utility fund	107,418	21.31
10	Repair maintenance	125,000	24.8			(1990345)	(394.41)
11	Electricity MRI	1,145,700	227.32		Labor: Indirect; fixed		
12	Electricity AC	882,000	175	37	Head of Department	102,264	20.29
13	Generator fuel cost	30,440	6.04	38	Sr. Personal Secretary	28,835	5.72
		(8684065)	(1723.03)	39	Secretarial Assistant	24,255	4.81
	Material: Direct; variable			40	Typist	41,975	8.33
14	MRI Films	2,378,839	471.99	41	Receptionist	86,396	17.14
15	Covers	80,263	15.93	42	S.A. of Planning	29,914	5.94
16	Report forms	1,374	0.27			(313639)	(62.23)
17	Requisition forms	6,934	1.38		Over heads: Indirect; fixed		
18	Laser printer	203,190	40.32	43	Administration	370,960	73.60
19	Contrast agents	231,567	45.95		Over heads: Indirect; variable		
		(2902167)	(575.82)	44	Telephone	39,000	7.74
	Material: Indirect; variable			45	Consumables	60,000	11.9
20	Injections. Others	10,594	2.1	46	Printing & Stationary	114,425	22.7
21	Surgical Utilities	33,079	6.56	47	Postage	12,000	2.38
22	Spirit	861	0.17	48	House keeping,water,sewage	430,080	85.33
23	Dettol	437	0.09	49	MRI Books & Journals	70,649	14.02
24	Inj.DNS	2,475	0.49			(726154)	(144.08)
25	Inj. Isolyte P	152	0.03			19788186	3926.23
		(47598)	(9.44)		*Depreciation		

Figure.1 Narendar Matrix Model costs of hospital, representation cost varieties.

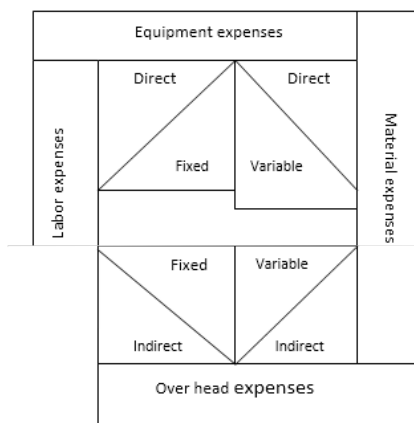


Fig. 2. Different cost percentages of MRI.

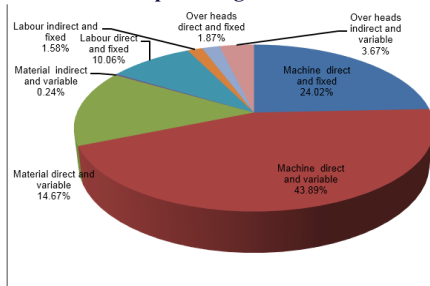
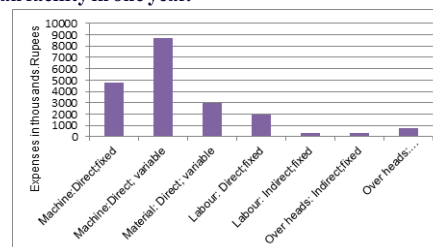


Table 2. Types of costs of MRI: Indian Rupees

S.No	Types of costs	Cost in Rupees
1	Equipment: Direct; fixed	4753258
2	Equipment: Direct; variable	8684065
3	Material: Direct; variable	2902167
4	Material: Indirect; variable	47598
5	Labor: Direct; fixed	1990345
6	Labor: Indirect; fixed	313639

7	Over heads: Indirect; fixed	370960
8	Over heads: Indirect; variable	726154
		19788186

Figure. 3. Graph shows the different types of costs incurred for MRI scan facility in one year.



Over heads related indirect and fixed: which includes expenses of general administration, it was apportioned by (1/12) and allotted to MRI unit, was Rs. 370960 (US\$5458.70), which was 1.88% of total cost.

Over heads related indirect and variable: which includes telephone and IT, consumables, printing and stationary, postage, housekeeping, water, sewage, MRI books and journals, and it was Rs.726154 (US\$10685.40) which was 3.67% of total cost.

Man hours operated the MRI: The MRI diagnostic unit functions for 14 hours in a day i.e., from 8.00 a.m. to 10.00 p.m. The total number of days the MRI unit worked was 360 days, excluding 5 annual maintenance days. The total number of hours was 5040 hours (360days × 14 hours = 5040).

CHMR for MRI is calculated using the following formula:

$$\text{CHMR of MRI} = \frac{\text{Equipment relevant cost} + \text{Material relevant cost} + \text{Labor cost} + \text{Over heads}}{\text{Total man hours operated on MRI equipment}}$$

$$= \frac{19788186}{5040} = 3926.23$$

DISCUSSION

Masmopudi et al., (year not known) that the modern diagnostic equipments have become very complex and sophisticated to render service and operate in stern circumstances. The health care manager

must ensure that their critical medical equipment should be safe, accurate, reliable and also operating at the required level of performance with cost benefit. According to Ma.et. al.,(2011) the appropriate estimation of cost is an important mean and its efficiency and accuracy are the key determining factors to know the profitability, competitiveness and sustainable development of an organization. Overheads are one of the critical factors which determine the profits of any operation in the diagnostic service of health care. Provided that the accounts are estimated/budgeted for the upcoming financial year the hospital can augment the profits with efficient cost control for processing and efficient price fixation of the diagnostic service. The total cost for operating the MRI equipment was Rs.19788186 (US\$291184.26), shown in Table 3. The total number of the man hours operating the MRI was 5040 hours in one year. The CMHR of MRI was Rs.3926.23 (US\$57.77). An average 23 scans were taken in each day. The mean time for a procedure was 30 minutes 58 seconds. The revenue collection through MRI diagnosis was Rs. 31494441 (US\$ 463442.45) in the study year. 7697 scans were performed during the year. Therefore the revenue obtained through a scan MRI was Rs.4091.98 (US\$60.21) which was profitable.

CONCLUSION

The success of any health care lies in the critical analysis and thoroughness of the service operations. The diagnostic equipment like MRI shares the major portion in health care business. It is a cost center, in terms of investment or revenue. This study investigated criticality and effectiveness of MRI service, using the systemically obtained data and analyzed it to obtain the inference. The CMHR is an appropriate methodology in health care business to verify the effectiveness and efficiency of a diagnostic service.

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