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Original Article

Life cycle costing as a decision making tool for technology acquisition in radio-diagnosis

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ABSTRACT

Background: Life cycle costing analysis is an emerging conceptual tool to validate capital investment in healthcare.

Methods: A preliminary study was done to analyze the long-term cost impact of acquiring a new 3 T MRI system when compared to technological upgradation of the existing 1.5 T MRI system with a view to evolve a decision matrix for correct investment planning and technology management. Operating costing method was utilized to estimate cost per unit MRI scan, costing inputs were considered for the existing 1.5 T and the proposed 3 T machine. Cost for each expected year in the life span of both 1.5 T and 3 T MRI scan options were then discounted to its Net Present Value. Net Present Value thus calculated for both the alternative options of 1.5 T and 3 T MRI machine was charted along with various intangible but critical Figures of Merit (FOM) to create a decision matrix for capital investment planning.

Result: Considering all fixed and variable costs contributing towards assumed operation, unit cost per MRI procedure was found to be Rs. 4244.58 for the 1.5 T upgrade and Rs. 6059.37 for the new 3 T MRI machine. Life Cycle Cost Analysis of the proposed 1.5 T upgrade and new 3 T machine showed a Net Present Value of Rs. 42,148,587.80 and Rs. 27,587,842.38 respectively.

Conclusion: The utility of life cycle costing as a strategic decision making tool towards evaluating alternative options for capital investment planning in health care environment is reiterated.

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Introduction

Twentieth Century has witnessed exceptional advances in technology which has brought scientific marvels into hospitals with unprecedented demand on medical services, particularly in areas such as surgery, clinical laboratory and

radiological services.¹ These advances are continuing at an accelerated pace in the twenty-first century too.

Health has remained priceless since time immemorial and technological advances have made modern medicine more desirable. In an era of limited resources and unlimited demand for health care, health economists tend to weigh benefit against cost when making informed choices. Those

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responsible for allocating resources will need to prioritize between competing claims so that maximum benefit can be obtained from a given budget.²

Most clinicians remain profoundly uninterested in medical economics as the perspective of the economist regarding medical necessity and other societal concerns is frequently at odds with the traditional role of the physicians. While the physicians have in recent years acknowledged the desirability of providing more cost-effective medical care, this theoretical goal is infrequently attained in practice due to absence of adequate financial data in respect of alternative diagnostic and therapeutic strategies.³ Economics does not provide answers or make it easier to take better medicine, but it does clarify how to ask the questions to make decisions more rational and more consistent.

Capital investment decisions will always be difficult to make and medical decision rules for allocation of resource will remain a challenge in the face of competing claims for the “latest and greatest technology” at a time of dwindling resources and increasing competition. A need exists to analyze the down-stream cost impact of a system due to its utilization, maintenance and support across its planned life-cycle while deciding on acquisition of high-end technology. Unfortunately, not much work seems to have been done on the utilization of life cycle costing methodology for capital investment decisions in acquiring high-end healthcare technology, as manifested by a singular lack of publications on the subject.

The present study was conducted in a tertiary care and teaching institution to analyze the long-term cost impact of acquiring a new 3 T MRI scan system when compared to technological upgradation of the existing 1.5 T MRI scan with a view to evolve a decision matrix for correct investment planning and technology management.

Materials and methods

An observational study was carried out for a period of 1 month at the MRI Scan center of a tertiary care and teaching institution, the center at present housing one 1.5 T MRI Scanner. The center is in the process of finalizing a procurement plan for one new 3 T MRI scanner to replace the existing 1.5 T machine. As an alternative plan, the original manufacturer of the equipment has agreed for a complete up-gradation plan of the existing 1.5 T machine, changing its entire software for an improved version and extending its operational life by eight more years.

Operating costing method was utilized to estimate cost per unit MRI scan, the method being found to be particularly suitable for costing studies in service organizations.⁴ While calculating the unit scanning cost, the costing inputs were considered for the existing 1.5 T and the proposed 3 T machine, necessary inputs being obtained by direct observation, perusal of documents, quotations received from the manufacturer and interview with staff. Cost inputs were initially divided into two broad categories, namely fixed and variable cost based on the variability of the cost factor with variation in the level of activity of the center. Total cost for functioning of the MRI scan center for both the options (1.5 T and 3 T) was

calculated and then divided by the total number of expected procedures to be performed to arrive at the cost per unit procedure in respect of 1.5 T and 3 T MRI scan machines.

Volume of MRI scan to be performed by the 1.5 T machine was assumed to be the volume performed by the existing machine, whereas the number of procedures to be performed by the 3 T machine was assumed to be 10% more than the existing machine due to faster throughput of the machine.⁵

All the cost categories that have been identified during cost estimation of MRI procedures were included in the cost breakdown structure of the life cycle of both the options. For ease of calculation, 60% of all scans to be performed were assumed to be without contrast and 40% of all scans with contrast. Cost for each year of the life span of both the equipment options (8 years for 1.5 T upgrade and 10 years for the proposed 3 T machine) was then estimated by multiplying the expected number of procedures in each year with the cost of performing unit procedure for both options. All procedures per year were also multiplied by the expected revenue per scan to derive the expected benefit to be gained by the centre for both options, revenue being calculated by applying the standard rates laid down by the Regulations for the Medical Services-2010 for MRI scans with or without contrast.

Cost for each expected year in the life span of both 1.5 T and 3 T MRI scan options were then discounted to its Net Present Value (NPV), so as to be able to compare the costs associated with alternative options on an equivalent basis. A discounting value of 10% was assumed for annual compounding (10% being the assumed target rate of return) and the expected cash flow in respect of cost and benefit stream for each year of the life cycle of both options multiplied by the discounting factor (worked out from a standardized table of interest factor for annual compounding) to arrive at the present value of the cost streams concerned. Yearly inflation was not incorporated in calculating NPV as demand for healthcare has been traditionally price-inelastic.

Net Present Value thus calculated for both the alternative options of 1.5 T and 3 T MRI machine was charted along with various intangible but critical Figures of Merit (FOM) to create a decision matrix for capital investment planning.

Results

Capital Investment cost apportioned to unit MRI scans was calculated to be Rs. 1032.68 for the 1.5 T upgrade and Rs. 3310.94 for the new 3 T machine (Table 1). When all the fixed and variable costs contributing towards assumed operation of the MRI Scan centre is considered, unit cost per MRI procedure was found to be Rs. 4244.58 for the 1.5 T upgrade and Rs. 6059.37 for the new 3 T MRI machine (Table 2). Revenue for unit MRI scan by 1.5 T machine was calculated as Rs. 6200, whereas the same for the 3 T worked out to be Rs. 7077 due to higher throughput.

Life Cycle Cost Analysis (LCC) of the proposed 1.5 T upgrade showed a Net Present Value of Rs. 42148587.80 (Table 3) while similar analysis performed in respect of the 3 T new MRI scan machine showed an NPV of Rs. 27,587,842.38 (Table 4).

S.no	Cost element	Equipments	
		1.5 T MRI (Life – 8 yrs)	3.0 T MRI (Life – 10 yrs)
1.	Initial installation cost	Nil	159,500,000
2.	Buy-back value of present machine being offered	Nil	(–) 6,700,000
3.	Accessories for new machine	6,599,000	Nil
4.	Cost of upgradation including software	28,156,980	Nil
5.	Building modification	Nil	Nil
	Total Cost	34,656,980	152,800,000
	Cost of machine per year	4,332,122.5	15,280,000
	Cost of equipment per scan	4,332,122.5/4195 = 1032.68	15,280,000/4615 = 3310.94

S.no	Cost element	Cost/Scan (Rs)	
		1.5 T upgrade	New 3 T machine
Fixed cost			
(a)	Labor cost	931	931
(b)	Building depreciation cost	15.6	15.6
(c)	Building maintenance cost	7	7
(d)	Capital investment cost	1032.68	3310.94
(e)	Equipment maintenance cost	1554.80	1006.33
Variable Cost			
(f)	Cost of films and contrast	189	189
(g)	Cost of consumables	19.5	19.5
(h)	Cost of electricity	436	509
(j)	Cost of diesel	59	71
Unit cost per scan		4244.58	6059.37

Discussion

Society consumes resources to satisfy its wants and is obliged to choose from among potential alternative uses of its finite resources. By accepting the need for cost-effective medical decision making, healthcare practitioners are looking for newer strategic tools to control cost without affecting the quality of patient care.

Life Cycle Costing Analysis (LCCA) has been widely recognized as a valid tool for capital assets evaluation model in healthcare. Such analysis is performed to ensure total cost visibility for the entire life span of medical technology being proposed for procurement.

In our study the cost of performing unit MRI scan by 1.5 T upgrade was Rs. 4244, whereas the same for the proposed 3 T machine was found to be Rs. 6059. However, medical care has been found to be largely price inelastic, pain, critical needs and fear of uncertainty reducing the role of price in patient decision making.

While cost for acquiring a technology remains an important factor for decision making on technology acquisition, total cost visibility over the entire life cycle of a system has become a vital input towards decision-making during the early stages of system planning. It is not only acquisition cost, but costs of operating and maintaining the system that gives real cost visibility of the technology proposed to be acquired and thus, a life cycle approach is required while planning for any new system.⁶

Transactions that accrue in the future cannot be compared directly with investments being made at the present because of time-value of money. Every alternative configuration with different cost profile needs to be related to an equivalent basis by discounting the cost of each year in the life cycle of competing alternatives to its Net Present Value.⁷ Discounting

[illegible]

Table 4 – Life cycle costing analysis of 3 T new machine.

3 Tesla year	No of scans	Cash inflow (Rs)	Dis-counting factor (10%)	Present value (Benefits) (Y)	Cash outflow (Rs)	Present value (Cost) (B)
1	4615	32,660,355	0.9091	29,691,528.73	27,963,992	25,422,065.62
2	4615	32,660,355	0.8265	26,993,783.41	27,963,992	23,112,239.84
3	4615	32,660,355	0.7513	24,537,724.71	27,963,992	21,009,347.60
4	4615	32,660,355	0.683	22,307,022.47	27,963,992	19,099,406.53
5	4615	32,660,355	0.5645	18,436,770.4	27,963,992	15,785,673.79
6	4615	32,660,355	0.5132	16,761,294.19	27,963,992	14,351,120.97
7	4615	32,660,355	0.4665	15,236,055.61	27,963,992	13,045,202.52
8	4615	32,660,355	0.4241	13,851,256.56	27,963,992	11,859,529.24
9	4615	32,660,355	0.3856	12,593,832.89	27,963,992	10,782,915.52
10	4615	32,660,355	0.3505	11,447,454.43	27,963,992	9,801,379.38
		326,603,550		191,856,723.4	279,639,920	164,268,881.9
NPV (Y-B) 27,587,842.38.						

Table 5 – Decision matrix for capital investment.

S.No	Figures of merit	1.5 T upgrade	New 3 T machine
(a)	NPV	Rs. 42,148,587.80	Rs. 27,587,842.38
(b)	Image resolution	Moderate	High, subject to specific situations
(c)	Anatomic detail	Moderate	High, subject to specific situations
(d)	Susceptibility & chemical shift artifacts	Moderate	High, as of now
(e)	Acoustic noise	Moderate	High, as of now
(f)	Homogeneity of radiofrequency field	Moderate	Reduced
(g)	Quality of special applications and functional MRI	Moderate	Exceptional
(h)	Energy deposition in patient's body tissues (SAR)	Moderate	High
(i)	Patient experience	Good	Superior
(j)	Knowledge of safety issues as regards pregnancy, implants and medical devices	Already known	Yet to be fully established and certified
(k)	Throughput	Unchanged	Increased
(l)	Research capability	Moderate	Exceptional
(m)	Expected staff moral	Good	High
(n)	Image of the hospital	Enhanced	Much improved

allows for the evaluation of time-phased profile of cost streams for various alternative configurations at its present value by application of a selected rate of interest to measure difference in preference between money at its present value and its anticipated value in future.⁸

In the present study, the Net Present Value of the “1.5 T upgrade configuration” looks more reasonable than that of the “Proposed 3 T MRI scan system configuration”. However, strategic cost management relates to measures of a system in terms of mission fulfillment as well as total life cycle cost expressed in various Figures of Merit (FOM), depending on the system parameters decided upon. In the present study, the decision matrix across fourteen FsOM shows the “3 T configuration” to be having a higher potential for acceptance by the organization, coming out better on parameters like film resolution, machine throughput, research capability and its impact on image of the hospital. However, in a developing country with limited health care resources, the life cycle cost parameter may dominate an informed choice for acquisition of high-end medical technology. Another important issue that needs to be kept in mind is that doubling the magnetic field strength does not automatically translate into increasing advantages, though requiring much higher inputs in financial

terms.^{9,10} There are strengths and weaknesses of alternate decision models that need to be looked into before a decision is made for capital investment besides the life cycle costing, which has been highlighted in this study (Table 5).

To conclude, our study firmly directs towards the need for evaluating decision options for procurement of MRI Scan and similar high-end technology with total cost visibility approach over the entire life cycle of the technology and conclusively proves the utility of life cycle costing as a strategic decision making tool towards evaluating alternative options for capital investment planning in health care environment.

Conflicts of interest

All authors have none to declare.

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Book Review

Miloro Michael, Editor. *Trigeminal Nerve Injuries*. 1st ed by Springer Publishers, Hardbound, 2013, VII, 366 p. 231 illus., 163 illus. In color ISBN: 978-3-642-35538-7 (Print) 978-3-642-35539-4 (Online). Price: 149, 99 € (Print) 124, 94 (eBook), p. 366.

This is the first textbook on diagnosis and management of trigeminal nerve injuries. The author Dr. Michael Miloro has addressed the key concepts in diagnosing trigeminal nerve injury and all the indications for surgical and nonsurgical treatment in the form of algorithms. The emphasized fact in the book is that trigeminal nerve injuries present complex clinical challenges and can be very distressing for patients, resulting in abnormal sensations of the orofacial region with episodes of unpleasant paraesthesia and interference with daily activities. Trigeminal injuries are frequently caused by surgical or dental procedures and patients may seek legal counsel as a result of their injury. In day to day practice, most dentists and surgeons do not evaluate and manage patients with trigeminal nerve injuries because of lack of knowledge and skills required for optimal patient management for specific nerve injury. The authors have covered a wide range of topics written by experts in the field of microneurosurgery, including historical perspectives, demographics, aetiology,

anatomy and physiology, pathophysiology and mechanisms of injury. Clinical neurosensory testing, nonsurgical management, surgical management and principles of microneurosurgery, specifically involving the inferior alveolar and lingual nerves are well explained. Algorithms and a glossary are provided that will assist in the clinical management of these complex scenarios. The authors include surgeons with considerable experience in the field. This book will serve as an ideal clinical reference for surgeons especially dentists, oral and maxillofacial surgeons in managing patients who sustain trigeminal nerve injuries.

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