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Impact of Life Cycle Costing in Procurement of Robotic Track-Based Central Laboratory at Apex Medical Institute in India

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Abstract

Introduction Life cycle costing is an important management tool that takes into account the implications of planning, acquiring, operating, maintaining, and disposing of an asset during its complete life cycle. A major hindrance to the procurement of expensive equipment in developing countries is the lack of a reliable framework combining and integrating all the equipment life cycle aspects into procurement process.

Methods The study was conducted from the data collected from the bids that were received for procurement of two robotic track-based central laboratories which were installed at All India Institute of Medical Sciences (AIIMS), New Delhi. The procurement was done as per the guidelines laid down under General Finance Rules (GFR) 2017 following the two bid systems: technical bid and price/commercial bid.

Results A complete financial analysis of the robotic laboratory was done that involved gathering of all the pertinent financial information into one place and then using that data to analyze the feasibility of the bid. The life cycle costs of both the labs were calculated by assuming the life of equipment as 10 years and by factoring in cost of equipment including 5-year warranty, comprehensive maintenance from years 6 to 10, indicative cost of all reagents for 10 years, and indicative cost of all other consumables for 10 years.

Conclusion Results showed that the cost of equipment alone should not be the sole predictor of making purchase decisions of equipment. Further research may additionally explore differences between processes being followed in government versus private organizations, as well as national guidelines and subnational practices.

Keywords
- life cycle costing
- equipment procurement

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Introduction

The purchase decision of procuring new equipment in laboratory services at a hospital is often based on the patient load, analytical performance, ease of operation, and cost of equipment.[1] Still, very often, it is observed that the total life cycle cost (LCC) of equipment is seldom taken into consideration, but is largely driven by manufacturer reputation and past precedents. There is also little attention paid during the process of procurement towards the cost of consumables, maintenance, and other expenditures. Life cycle costing is an important management tool that takes into account the implications of planning, acquiring, operating, maintaining, and disposing of an asset during its complete life cycle.

Life Cycle Cost of equipment= Cost of equipment + Cost of warranty + Cost of Annual Maintenance + Cost of Comprehensive maintenance + Cost of Reagents + Cost of Consumables + Miscellaneous Costs

Purchase of medical device in hospitals is not just a basic contract between the vendor and healthcare institution but also takes into consideration the needs of user department, technical maintenance, training needs, adequate consumables, and how they can be disposed.[2] A study comparing medical device purchasing across five countries found the need to have more focus on cost-containment.[3] Empirical studies of purchasers in UK hospitals have shown that there are a wide range of stakeholders potentially involved in purchasing decisions (from clinicians, nurses, technicians, finance staff, and/or managers), but their responsibilities and protocols are ill-defined, their skills, and expertise differ.[4] They often work in silos and make decisions under high-pressure conditions.[5] The lack of stakeholder analysis as part of purchasing planning processes resulted in conflicts and delays in decisions.[6] A more recent scoping literature review of the logistics function in hospitals demonstrated that logistics functions can be highly inefficient and fragmented.[7]

A major hindrance to the procurement of expensive equipment especially in hospitals of developing countries is the lack of a reliable framework combining and integrating all the equipment life cycle aspects into procurement process. A study conducted by Mohammad et al at All India Institute of Medical Sciences (AIIMS), New Delhi,[8] highlighted the positive impact of organizational competitive procurement environment on total purchase costs. The study suggested that life cycle costing methodology is a better option for uniform comparison of Comprehensive Maintenance Contract (CMC) costs, as it has been used for tenders of newly commissioned cancer hospital. Thus, LCC analysis that is a widely used decision-support technique can be particularly helpful for decision makers in hospitals to identify the most cost-efficient alternatives from arrays of feasible alternatives that would meet specific functional requirements.[9]

Advanced expensive medical equipment often denotes the overall strength of modern hospitals and is the reflection of its technological and scientific rigor. With the surge in management requirements, expected quality of medical care, and scientific research ability of hospitals, expensive medical equipment are frequently purchased and utilized in the daily operation systems of hospitals to greatly promote the improvement of administration, delivery of healthcare, and scientific research levels of hospitals.[10] Besides, the in-depth use of large medical equipment in daily hospital diagnosis and treatment and the benefits it creates are the main sources of income of hospitals.

However, equipment management in a lot of hospitals in India is still in nascent stage using traditional equipment management methods. The after sales maintenance is done by contacting the manufacturer/vendor for any malfunctioning that occurs during use. Vendors provide the maintenance cost for equipment, and insurance is purchased for the life of large medical equipment. Further, it is also expected that there is a long running life of the medical equipment. The focus of management mainly remains at the procurement of equipment. The purchase cost of equipment is valued, while the cost of consumables and miscellaneous during use is ignored. This hidden cost that is seldom taken into consideration that leads to increase in operational cost of hospitals and also indirectly leads to rising costs of medical diagnosis and care.[10]

The total life of medical equipment includes procurement, usage, maintenance, and depreciation of the equipment, which are closely interrelated. From the perspective of hospital procurement system, the above-mentioned links belong to different departments. Making purchase decisions in silos, where procurement is not linked to its usage, might lead to reduction in the cost-effectiveness ratio of equipment. Further, there is a fundamental difference between public procurement purchase and any other purchase in India. As generally seen, private organizations have a wider range of strategic options available for purchase, while the public procurement in India is conducted through tendering as advertised, limited, or single inquiries using single or two bid system as laid down under government guidelines/rules/regulations such as General Financial Rules (GFR) 2017 of Ministry of Finance, Government of India, Central Vigilance Commission guidelines, manuals on procurement issued by Public Sector Enterprises among others.[11]

Full LCC is determined by calculating the cost of procurement cost and the cost of maintenance.[12–14] Procurement costs can be understood as the small part of an iceberg that can be seen directly above water surface.[10] In contrast, the several components of the LCC of maintenance are like the undetectable and unrecognizable parts hidden like an iceberg.[15] Gao et al[16] reported that while making the purchase decisions of expensive medical equipment, considering only the unit price while ignoring the associated long-term costs as well the reliability, maintainability, safety, and environmental protection of medical equipment might result in frequent downtime and even lead to potential cases of medical negligence. The robustness or quality of analytical process like calibration stability, on-board reagent stability, and chances of contamination, accompanied with equipment, is often ignored in the comparison criteria. It is also seen that the total cost of investment, which is needed to tackle the issues arising due to faults and medical negligence, is often very high and hampers the overall financial well-

being of the organization.[17] The quantitative assessment and analysis of utilization of expensive medical equipment are made based on the data generated from the hospital's inventory including the data of usage of the equipment of patients, its downtime, maintenance data and other auxiliary data, such as hospital human capital and energy consumption, space and water requirements.[18] Among large medical equipment, the maintenance cost of imaging equipment during use and the consumables cost in laboratory diagnostics equipment consist of a large proportion in lifetime expenditure.

Aim and Objectives

In order to obtain economic and reasonable LCC, this study aimed to establish an economic analysis done during the procurement of two robotic track-based central laboratories at AIIMS, New Delhi and various parameters that were used during the procurement process. As it is seen that in many purchase assessments made in hospitals, the maintenance or consumables cost is higher than the procurement cost.[10] Our study aimed at evaluating the economic decision of procuring expensive medical equipment when it is guided through LCC. The rationale of this process was to comprehensively and systematically understand the costs involved in life cycle of expensive equipment and to ascertain that whether the hospital is able to purchase equipment at lower costs and provide better social and economic returns to the institution and patients alike. Further, it is also important that decisions regarding the size of equipment, its parameters and functions, operational costs, and performance metrics are taken into consideration at the planning stage of procurement as it will help in determining the technical feasibility, energy consumption, safety and overall utility of the expensive equipment in given healthcare setting. Our study aimed to provide a reasonable basis for the procurement of expensive medical equipment by considering the life cycle costing of medical equipment in the planning stage, so as to ensure that comprehensive consideration of the requirements is made aimed at reducing maintenance costs and reducing obstacles and costs in the process of equipment management.

Methods

The study was conducted from the data collected from the bids that were received for procurement of two robotic track-based central laboratories which were installed at AIIMS, New Delhi. The procurement was done as per the guidelines laid down under GFR 2017 following the two bid systems, that is, technical bid and price/commercial bid. The GFR rules are a compilation of rules and orders that are to be followed by all departments and organizations under the government (as executive instructions) in matters involving public finances.[19] Five vendors participated in the tender of the robotic laboratory during both the procurement cycles. One vendor was disqualified on technical grounds. The data from remaining four vendors was anonymized for the purpose of the study.

The study focused on life cycle costing based on data-based approach that was undertaken during the finalization of bids and its impact on total cost of procurement of both the robotic track-based central laboratories.

The study parameters included the cost of equipment, cost of comprehensive maintenance, indicative cost of all reagents, and indicative cost for ranking of bids, along with the functional capacity of the equipment. Further, total

Table 1 Data-based approach to finalization of specifications

Modules	Firm A	Firm B	Firm C	Firm D	AIIMS-ND
Preanalytical					
Input/output module	1,400 tubes/h	1,200 tubes/h	600 tubes/h	800 tubes/h	600 tubes/h
Decapper	1,400 tubes/h	1,200 tubes/h	600 tubes/h	800 tubes/h	600 tubes/h
Centrifuge	1 centrifuge 400 tubes/h 2 centrifuge 720 tubes/h	300 tubes/h	400 tubes/h at 10 min	300 tubes/h	300 tubes/h (2-centrifuge)
Aliquoting module	1–28 tubes 400 tubes/h	1–17 secondary tubes	1–9 tubes 150 tubes/h	1–4 tubes 200 tubes/h	1–4 tubes 150 tubes/h
Analytical					
Biochemistry	2,000 tests/h	1,200 tests/h	800 tests/h	1800 tests/h or 650 tests/h	800 tests/h
Immunology	170 tests/h	400 tests/h	180 tests/h	240 tests/h	170 tests/h
Hematology	900 tests/h	100 tests/h	Information not available	120 tests/h	100 tests/h
Coagulation	Information not available	560 tests/h	Information not available	150 tests/h	150 tests/h
Postanalytical					
Refrigeration	13,599 tubes	5,000 tubes +5,000 tubes	13,900 tubes	15,000 tubes	10,000 tubes

Table 2 Life cycle cost of Lab 1

Life cycle costing impact—core Lab 1 case study						
	Bidder →	A	B	C	D	Lab 1
1.	Cost of goods including turnkey works with 5 years warranty	219423804	199435025	149860000	166852000	C
2.	CAMC for 5 years	11548868	15490148	5004380	305526	D
3.	Indicative cost of all reagents for 10 years	791832122	1262823094	1162111322	850748618	A
4.	Indicative cost of all other consumables for 10 years	285666802	149310209	136881170	94324922	D
Life cycle cost for ranking of bids (i.e., 1 + 2 + 3 + 4)		1308471595	1627058476	1453856872	1112231065	D

Table 3 Life cycle cost of Lab 2

Life cycle costing impact—core Lab 2 case study						
	Bidder →	A	B	C	D	Lab 1
1.	Cost of goods including turnkey works with 5 years warranty	154751100	195631696	190499562	181786081	A
2.	CAMC for 5 years	1000000	447314	1927716	12077447	B
3.	Indicative Cost of all reagents for 10 years	882220293.9	858455730	1305189078	1172377702	B
4.	Indicative cost of all other consumables for 10 years	50462430	100745324.7	49991506	154324309	C
5.	Pre-bar coded tube and flash back needle costs	67356800	150245200	64944600	97188007	C
Life cycle cost for ranking of bids (i.e., 1 + 2 + 3 + 4 + 5)		1155790624	1305525265	1612552462	1617753546	A

LCC of the bid was considered for the final evaluation of the bid.

Results

Life cycle costing was conducted based on the bids submitted by the vendors during the procurement cycle. The vendors were anonymized as A, B, C, D and these vendors participated in both the bids of procurement of robotic laboratory (titled Lab 1and Lab 2) that was done separated over a period of 1 year.

Financial Evaluation

A complete financial analysis of the robotic laboratory was done that involved gathering of all the pertinent financial information into one place and then using that data to analyze the feasibility of the bid. During the purchase cycle of Lab 1, detailed analysis of costs of individual tests, reagents, consumables, and miscellaneous expenditure was done. The same process was followed during the purchase cycle of Lab 2 and an individual item comparison was conducted between the prices quoted by vendors during first lab bid versus the second bid.

The data of the technical specifications of the vendors and the requirement of the institute is shown in ►**Table 1**.

The LCCs of both the labs, namely Lab 1 and Lab 2, were calculated by assuming the life of equipment as 10 years[20] and by factoring in cost of equipment including 5 years warranty, comprehensive maintenance from year 6 to 10, indicative cost of all reagents for 10 years, and indicative cost of all other consumables (including calibrators, quality controls, additives, and cleaners) for 10 years, as shown in ►**Tables 2** and **3**.

As evident from ►**Table 2**, even though the cost of goods quoted by vendor C (Rs. 14.98 crore) was the lowest for bid of Lab 1, Vendor D had an effectively lower price over the 10 years life cycle costing after factoring in comprehensive maintenance, cost of reagents, and indicative cost of all consumables (Rs 112.22 crores of Vendor D vs Rs 130.84 crores of Vendor A). Hence, by procuring the said system after doing tender evaluation by life cycle costing, the institute is saving Rs. 18.62 crores over a period of 10 years as per the assumed workload vis-à-vis had the procurement been done just on equipment or equipment + Comprehensive Annual Maintenance Contract (CAMC) cost basis.

Conclusion

Efficient budget management of expensive medical equipment includes selection of better alternative with low

maintenance and operation costs, which will lead in consequence to low LCC during the device life span. LCC data base provides basic information essential for decision making when a group of alternatives is available.[21] Lack of LCC implementation might lead to selection of less economic medical device model that has difficulties in acquiring their spares parts and/or those devices with high maintenance cost and consequently high LCC during the device life span. The traditional methods of procurement of expensive equipment in hospitals in India have primarily relied on past purchase experiences and focused on cost of equipment in determining the Lab 1 bidder with separate tenders made for consumables later. Most good quality equipment nowadays are used as closed systems where the reagents and other consumables to be used on the equipment are manufactured by the same manufacturer. This often results in higher quality standards of results obtained on those analyzers and robustness of calibration and maintenance. However, purchase of consumables and reagents separately often needs to be done on a proprietary basis that leads to escalated costs and difficulties in rate justification.

The findings from the data analyzed in this study revealed that LCC could be implemented efficiently to maintain the hospital medical devices assets in a cost-effective manner which is aimed at long-term preservation of the asset value. It also shows the importance of having data-driven decisions in procurement, where the best financial outcome is achieved after longitudinal assessment of costs involved in life cycle of equipment.

As per the latest guidelines by the Govt. of India, which is aimed at ensuring good quality of work and to keep check on time and cost overruns, they have stated that Lab 1 or Least Cost Selection Method will not be the only tendering format for selecting bidders for executing projects. So far, Lab 1 was the method preferred by ministries, govt. institutes, public agencies and public sector undertakings to ensure that the lowest bidders are selected to carry out standard or routine works/nonconsultancy services like audit and engineering design of noncomplex works. The selection of bidders for works and nonconsultancy services through alternative procurement methods like the Quality-cum-Cost Based Selection has been allowed as per the guidelines issued by the Department of Expenditure's Public Procurement division. This further strengthens the case to have a more comprehensive assessment of the bids by factoring in the LCCs of expensive equipment rather than the cost of equipment alone to ensure data-based decision making.

The major outcomes of the current study include:

- Results showed that the cost of equipment alone should not be the sole predictor of making purchase decisions of equipment as up to 30% reduction in the equipment cost was offered by the same vendor as seen in ►**Tables 2** and **3**.
- Results showed that best financial cost was achieved by vendors offering comprehensive lower costs of equipment, reagents, and consumables.
- The high initial cost is not necessarily indicating the best or the worst alternative for making purchase decisions. In the Lab 2 case, the best alternative was the one with lower initial cost. However, in the Lab 1 case the best alternative was with the higher initial cost. Therefore, the availability of LCC information for particular devices is vital for decision-making to justify devices and process selection based on total costs rather than the initial purchase price as the cost of operation, maintenance, and disposal costs might exceed the initial cost of the equipment.
- Most commonly, equipment cost and the maintenance cost are the main cost factor in LCC of the robotic laboratory. Therefore, when comparing the annual LCC values for both cases, the key effective cost categories affecting LCC were the consumables cost and the maintenance cost. By adding these factors, it can improve the life time performance of the equipment due to low maintenance and will substantially reduce the LCC.
- Market competition in hospitals involves one or more elements (e.g., price, quality, convenience, and superior products or services); however, as our study shows that competition can also help in reducing the cost of procurement (►**Tables 2** and **3**). A key role of competition in hospitals is the potential to provide a mechanism for reducing healthcare costs. Competition generally eliminates inefficiencies that would otherwise yield high procurement costs, which can help in making better financial decisions for hospitals.
- There is a need to move beyond traditional procurement processes based on historical events and should be more data driven utilizing the multidisciplinary decision-making process of health technology management and provide the best value of money.
- We recommend further research be undertaken to support the development and validation of a unified set of criteria able to guide high-cost equipment procurement in low- and middle-income countries. Further research may additionally explore differences between processes being followed in government versus private organizations, as well as national guidelines and subnational practices.

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Conflict of Interest
None declared.

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