Cost Analysis of Operation Theatre Services at an Apex Tertiary Care Trauma Centre of India

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Abstract Operating room services are one of the major cost and revenue-generating centres of a hospital. The cost associated with the provisioning of operating department services depends on the resources consumed and the unit costs of those resources. The objective of this study was to calculate the cost of operation theatre services at Jai Prakash Narayan Apex Trauma Centre, AIIMS, New Delhi. The study was carried out at the operation theatre department of Jai Prakash Narayan Apex Trauma Centre (JPNATC), AIIMS from April 2010 to March 2011 after obtaining approval from concerned authorities. This study was observational and descriptive in nature. Traditional (average or gross) costing methodology was used to arrive at the cost for the provisioning of operation theatre (OT) services. Cost was calculated under two heads; as capital and operating cost. Annualised cost of capital assets was calculated according to the methodology prescribed by the World Health Organization and operating costs were taken on actual basis; thereafter, per day cost of OT services was obtained. The average number of surgeries performed in the trauma centre per day is 13. The annual cost of providing operating room services at JPNATC, New Delhi was calculated to be 197,298,704 Indian rupees (INR) (US\$ 3,653,679), while the per hour cost was calculated to be INR 22,626.92 (US\$ 419). Majority of the expenditures were for human

resource (33.63 %) followed by OT capital cost (31.90 %), consumables (29.97 %), engineering maintenance cost (2.55 %), support services operating cost (1.22 %) and support services capital cost (0.73 %). Of the total cost towards the provisioning of OT services, 32.63 % was capital cost while 67.37 % is operating cost. The results of this costing study will help in the future planning of resource allocation within the financial constraints (US\$ 1=INR 54).

Keywords Trauma · Operating department · Costing · Operation room · Traditional or average costing

Introduction

Injury epidemic is emerging as one of the major cause of morbidity and mortality in developing countries. It is estimated that from its present position as the ninth leading cause of deaths in India, trauma will move up to the third position by 2020 [1]. In some developing countries with middle-income economies where there has not been a reference unit cost and/or standard hospital costing system for medical services, individual hospitals conduct unit cost analysis employing different methods. Different methods result in different calculation outcomes. Information on unit costs of medical services is also needed for performance-based budgeting systems and financing methods of insurance schemes [2]. The public sector has suffered from poor accounting and management systems for a long time. In hospitals, the need for better cost management systems arises from efficiency problems and lack of resources [3].

The cost of OR time depends on the resources consumed and the unit costs of those resources. Ultimately, hospital managers must decide whether the benefits of more accurate and detailed cost information justify the additional costs of

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obtaining that information [4]. Operating room services are one of the major cost and revenue-generating centres of a hospital. According to a study, 40 % of the total cost associated with clinical care was incurred in the operating room [5]. Therefore, it is important to understand the various cost centres and costs involved in the delivery of operating room services, so that limited resources in a developing country like India can be efficiently utilised. There are limited, if any, studies with regard to costing OR department in Indian trauma care setting at the tertiary care level. Unfortunately, determining the actual cost of care in trauma centres has remained difficult. Trauma services are especially vulnerable to cost pressures because their payer mix is often marginal and the care provided is extremely resource intensive [6].

The changing health-care climate has triggered important changes in the management of high-cost components of acute care facilities, which necessitates all the more reason to understand the utilisation of resources in trauma care operating room services. By integrating and better managing various elements of the surgical process, health-care institutions are able to rationally trim costs while maintaining high-quality services [7]. By calculating the cost of operation theatre services at a tertiary care apex trauma centre of AIIMS, this study will give an insight into the amount of resources needed to provide these services.

Methodology

The study was carried out at the operation theatre department of Jai Prakash Narayan Apex Trauma Centre (JPNATC), AIIMS, New Delhi from April 2010 to March 2011 after obtaining approval from concerned authorities. This study was observational and descriptive in nature. The traditional (syn-average or gross) costing methodology was used to arrive at the cost of operation theatre services from the providers' perspective for year 2011. Cost was calculated under two heads as capital and operating cost. Major cost centres were included in the study (Table 1).

Equipment cost which was not traceable (donated), land cost (donated by Delhi Government), administrative cost, computer facility and medical records departments were not included in the study.

Capital Assets-Annualised Cost

To arrive at the annual cost of the capital assets, replacement cost was calculated by multiplying procurement cost with cost inflation multiplication factor (cost inflation index for 2011–2012/cost inflation index of procurement year). Thereafter, the annualised method of depreciation (recommended by the World Health Organization) was applied to arrive at the annual cost by dividing replacement cost of the asset in year

Table 1 Cost centres included in the study

Capital assets cost
Building cost ^a (operating department, CSSD, laundry, manifold)
Equipment (OT, laundry, CSSD, manifold)
Operating cost
Human resources directly involved in the delivery of operation theatre services (faculty, residents, nursing staff, OT technician, sanitary attendants, hospital attendants, security staff)
Materials and supplies
Support services (laundry, manifold, CSSD)
Engineering maintenance cost
Biomedical waste management

^a Building cost included cost incurred towards civil construction; landscaping; sanitary and tube well; electrical work; heating, ventilation and air conditioning; sewage treatment plant; electrical substation cost; and hostel accommodation

2011 by the annualisation factor [8]. The formula for calculating the annualisation factor is $(1/r) \times [1 - 1/(1+r)^n]$ where:

- r is the real interest rate, which is calculated by the following formula:

$$[(1 + \text{nominal interest rate}) / (1 + \text{annual inflation}) - 1]$$

Nominal interest rate is the prevailing national bank savings rate for year 2011.
- n is the number of years of life [100 years and 10 years (15 years) for building, and machinery and equipment (fixed), respectively].

Following the above-mentioned methodology, annualised building (per square metre) and equipment cost of JPNATC was calculated. Thereafter, building cost of operation theatre department and support services was calculated. Building cost was taken from the records of the Expenditure Finance Committee. Similarly, annualised equipment cost was calculated for operation theatre department and support services. Supply order of equipment were taken from the indent books of user department and cost was retrieved from the stores department. Apportioning was not required since all the equipment were dedicated for operation theatre. Annualised building and equipment cost of support services was apportioned to operation theatre department on the basis of workload.

Operating Cost

An unstructured interview was held with operation theatre (OT) staff, and records of operation theatre department were studied to gain an insight into the functioning of operation theatre and support services. To calculate various floor areas of OT and support services, the records of the engineering department were studied. Per square metre engineering maintenance cost was calculated for a period of 1 year and

then calculated for OT by multiplying it with the floor area. Support services engineering maintenance cost was calculated and apportioned to operation theatre department on the basis of workload. Building maintenance cost was taken from the accounts department.

An unstructured interview was carried out to calculate the time devoted by various categories of hospital staff in the operating room, in order to apportion their salaries. The salary of employees was taken from the accounts section. Cost of consumables and implants was taken for a period of 1 year to account for the fluctuation in consumption to seasonal variation. It was assumed that consumables indented by the staff in year of study were consumed in that particular year. Actual quantity as per indent book was considered and cost of the same was taken from rate contracts of AIIMS.

Average monthly Central Sterile Supply Department (CSSD) and OT load (sets, drums and linen processed) for CSSD was calculated by taking the average of the values for the 2-month period. Average number of drums, sets and linen processed in one cycle was calculated from the CSSD records and through an interview with the CSSD manager. Thereafter, total number of steam and ethylene oxide sterilisation cycles run for OT load was calculated. Average monthly laundry and operation theatre load (in kilograms) for laundry was calculated by taking the average for 3-month period. The proportion of OT terminal manifold units to the total terminal units of medical gases, compressed air and vacuum was used as an apportioning criterion for various costs (capital and operating cost). Biomedical waste management cost of JPNATC was calculated on per bed basis from the total cost paid by AIIMS. Per square metre cost of biomedical waste management was calculated and then apportioned to OT. Operating cost for different support services was taken as per actuals, from the contract agreement executed between AIIMS and outsourced agency. Data collected were analysed using Microsoft Office 2010.

Observation

India's first full-fledged trauma centre, JPNATC, became a reality in year 2006. It is spread over an area of 20,600 m² and has more than 200 beds, to provide emergency trauma care. The centre also acts as a referral hospital for Delhi NCR and neighbouring states, where patients were sent by zonal public hospitals for observation and treatment. The operating department/complex is located on the ground floor, adjacent to the emergency and radiodiagnosis department, and has got five operating rooms, with three operating rooms dedicated for the department of General Surgery, Neurosurgery and Orthopaedics while two are dedicated

for trauma cases. Both emergency and routine surgeries (follow-up—trauma cases) are carried out in OT. There were 4,184 surgeries performed in the operation theatre department in year 2011 (Table 2).

On an average, daily 11.46 major and 1.70 minor surgeries were performed in year 2011. All the cost estimates were calculated for the financial year 2011–2012. The annualisation factor for capital assets was calculated to be 38.5 and 8.82 (12.53) for building, and machinery and equipment (fixed), respectively. Annualised building and engineering maintenance cost of JPNATC was calculated to be INR 1,761 and 3,784.94 per square metre, respectively.

Operating Department Cost

Annualised OT building cost and engineering maintenance cost for 2011–2012 was calculated to be INR 1,627,608 and 3,497,281.93, respectively (Table 3). Total annualised cost of OT equipment was calculated to be INR 61,596,227 (Table 3). Equipment maintenance cost was not included, as cost of comprehensive annual maintenance contract/annual maintenance contract was loaded in the cost of the equipment. Human resource cost of the operating department was calculated to be INR 5,478,616. Yearly cost of consumables for 2011–2012 was found to be INR 59,406,042 (Table 3).

Support Services Cost

Total annualised cost of CSSD building and equipment for 2011–2012 was calculated to be INR 216,841 and 431,282, respectively. Total operating cost of CSSD for 2011–2012 was found to be INR 1,879,079. OT load formed 51.79 % of the total CSSD load. Annualised capital and operating cost apportioned to the OT for 2011–2012 was calculated to be INR 325,849 and 1,856,725, respectively (Table 3). CSSD maintenance cost apportioned to the operating department was calculated to be INR 611,352 (Table 3).

Total annualised cost of laundry building and equipment for 2011–2012 was calculated to be INR 480,609 and 1,234,933, respectively. OT load formed 48.98 % of the total laundry load; therefore, 48.98 % of the total laundry cost was apportioned to OT. Annualised capital and operating cost apportioned to the operating department for 2011–2012 was calculated to be INR 840,272.51 and 265,676.40, respectively (Table 3). Laundry engineering maintenance and equipment cost apportioned to the operating department was calculated to be INR 888,990.67 (Table 3).

OT manifold terminal units formed only 5.1 % of the total manifold terminal units installed at JPNATC. Total annualised cost of manifold building and equipment for 2011–2012 was calculated to be INR 100,544 and 4,528,671.65, respectively. Total manifold operating cost was found to be INR 2,461,749. Capital and operating cost apportioned to OT was calculated

Table 2 Surgery census for year 2011 at Jai Prakash Narayan Apex Trauma Centre, New Delhi

	Major surgery				Minor surgery			
	Neurosurgery	Orthopaedics	General surgery	Total	Neurosurgery	Orthopaedics	General surgery	Total
Annually	1,191	1,424	1,569	4,184	79	284	257	620
Monthly	99	119	131	349	7	24	21	52

to be INR 282,803.29 and 18,441, respectively (Table 3). Manifold engineering maintenance and equipment cost apportioned to the operating department was calculated to be INR 59,935.86 (Table 3).

Monthly cost incurred by AIIMS on biomedical waste management was INR 1,041,666 and cost apportioned to JPNATC was INR 95,942.92. The cost of the BMW management which was apportioned to the operating department was

Table 3 Cost summary (in INR) of operation theatre services at JPNATC, AIIMS

	Annually	Monthly	Daily	Per hour
Capital cost				
OT building	1,627,609	135,634	4,459	186
OT machinery and equipment	61,596,228	5,133,019	168,757	7,032
CSSD building	216,841	18,070	594	25
CSSD machinery and equipment	109,008	9,084	299	12
Laundry building	235,402	19,617	645	27
Laundry machinery and equipment	604,870	50,406	1,657	69
Manifold building	5,308	442	15	1
Manifold machinery and equipment	277,496	23,125	760	32
Operating cost				
Manpower	65,743,387	5,478,616	182,621	7,609
Consumables				
Neurosurgery—medicine	1,051,076	87,590	2,880	120
Medicine	3,664,688	305,391	10,040	418
Surgical store	13,118,974	1,093,248	35,942	1,498
Surgical instrument	3,557,550	296,462	9,747	406
Surgical ortho	11,927,440	993,953	32,678	1,362
Surgical NS	7,863,785	655,315	21,545	898
Surgical OT	7,328,306	610,692	20,078	837
Sutures	7,533,222	627,769	20,639	860
Gen. consumables	2,133,207	177,767	5,844	244
Linen	940,482	78,374	2,577	107
Disposable linen	31,438	2,620	86	4
Packing room	226,578	18,881	621	26
Stationery	29,294	2,441	80	3
Support services				
CSSD	1,879,079	156,590	5,148	215
Laundry	265,676	22,140	728	30
Manifold	221,300	18,442	606	25
Biomedical waste management	52,897	4,408	145	6
Engineering maintenance cost (OT and support services)	5,057,561	421,463	13,856	577

INR 4,408. Table 3 gives the detailed information on the capital and operating cost of the operating department.

Annual and monthly cost of providing operating room services at JPNATC, New Delhi was calculated to be INR 197,298,704 and 16,441,559, respectively, while per day cost was calculated to be INR 543,046 (Tables 3 and 4).

Per hour cost of providing operation theatre services was calculated to be INR 22,626.92 (Table 3). Of the total operating room cost, 32.63 % is capital cost while 67.37 % is operating cost. The operating department expenditure mainly comprised of three major components contributing to more than 95 % of the cost, i.e. manpower, capital cost and cost of consumables (Fig. 1).

Discussion

This study at Jai Prakash Narayan Apex Trauma Centre was conducted to gain an insight regarding the amount of resources being dedicated towards the provisioning of operation theatre services at the apex tertiary care trauma centre in the country. The results of this costing will act as rough estimates for planning for operation theatre services in a similar trauma care setting in India.

Majority of the expenditures were for human resource (33.63 %) followed by operation theatre capital cost (31.90 %), cost of consumables (29.97 %), engineering maintenance cost (2.55 %), support services operating cost (1.22 %) and support services capital cost (0.73 %) (Fig. 1). The average number of surgeries performed in the trauma centre with five operating rooms is 13 in 24 h. It is very difficult to comment on the utilisation of operation theatre services because of the paucity of scientific studies with a similar setting in India, and since trauma surgery is not a routine surgical procedure, it will not be wise to compare the average duration of routine surgeries for trauma cases. However, in a study done in a medical college in India, it was found that the cost of general surgery is extremely high and the utilisation pattern is low [9].

The study was carried out at a government institute; hence, data availability was one of the major weaknesses of this study. The study considered the major cost centres

Fig. 1 Cost breakdown of operating room services

towards the provisioning of operation theatre services. It included only the manpower directly associated with the provisioning of trauma care services but it excluded the administrative cost and human resources indirectly contributing towards OT functioning. This was done since no logs of activities were being maintained; therefore, it was very difficult to apportion their salaries. Hospital, being a matrix organisation, may require huge resources and time to arrive at the apportioning of the resources not only in terms of human resources but in other resources as well. Land cost was excluded from the study since the land where the trauma centre is located was donated by the Delhi Government.

The cost contributed by the excluded departments would have had a minimal insignificant impact on the final outcome of this study; however, this costing of operating department is an underestimation of the real cost. The results of this study also suffer from the disadvantages associated with traditional or average costing methodology. However, in a developing country like India, it is difficult to carry out activity-based costing due to lack of awareness and poor record keeping and accounting methods.

Conclusion

Costing of operation theatre services at a tertiary care apex trauma centre of AIIMS has given an insight into the amount of resources needed to provide these services. This study has helped us understand the amount of resources being pumped by the government for the provisioning of OT services in a tertiary care trauma centre and will also bring cost consciousness among the service providers and other stakeholders. This study will help in the future planning of resource allocation within the financial constraints of a developing nation like India. The findings of this study can be taken as baseline

Table 4 Breakdown of daily cost of OT services

OT capital cost	INR 173,216	31.90 %
Support services capital cost	INR 3,970	0.73 %
Manpower	INR 182,621	33.63 %
Consumables	INR 162,756	29.97 %
Support services operating cost	INR 6,627	1.22 %
Engineering maintenance cost	INR 13,856	2.55 %
	INR 543,046	100.00 %

costing data for the planning of trauma care services not only in India but in the SAARC region as well, especially in the light of injury epidemic which is emerging as one of the major causes of morbidity and mortality in developing countries.

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References

1. Joshipura MK, Shah HS, Patel PR, Divatia PA (2004) Trauma care systems in India—an overview. *Indian J Crit Care Med* 7(4):93–97
2. Riewpaiboon A, Malaroje S, Kongsawatt S (2007) Effect of costing methods on unit cost of hospital medical services. *Trop Med Int Health* 12(4):554–563
3. Antikainen K, Roivainen T, Hyvärinen M (2005) Activity-based costing process of a day-surgery unit—from cost accounting to comprehensive management. *Front E-Business Res* 3:775–785
4. Macario A (2010) What does one minute of operating room time cost? *J Clin Anesth* 22:233–236. <http://www.ncbi.nlm.nih.gov/pubmed/20522350>. Accessed 22 Jun 2012
5. Marrin CA, Johnson LC, Beggs VL, Batalden PB (1997) Clinical process cost analysis. *Ann Thorac Surg* 64(3):690–694. <http://www.ncbi.nlm.nih.gov/pubmed/9307458>. Accessed 17 Nov 2012
6. Taheri PA, Wahl WL, Butz DA, Iteld LH, Michaels AJ, Griffes LC, et al (1998) Trauma service cost: the real story. *Ann Surg* 227(5):720–724; discussion 724–725. <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1191353&tool=pmcentrez&rendertype=abstract>. Accessed 17 Nov 2012
7. DeRiso B, Cantees K, Watkins WD (1995) The operating rooms: cost center management in a managed care environment. *Int Anesthesiol Clin*. 33(4):133–150. <http://www.ncbi.nlm.nih.gov/pubmed/8964622>. Accessed 17 Nov 2012
8. Shepard DS, Hodgkin D, Anthony YE (2010) Analysis of hospital costs: a manual for managers. World Health Organization, Geneva, p 100. <http://whqlibdoc.who.int/publications/2000/9241545283.pdf>. Accessed 18 Feb 2011
9. Fahid C (2007) A cost analysis study of the operative services provided at the operation theatre complex. Rajiv Gandhi University of Health Sciences, Bangalore, Karnataka, p 60