Does a single specialty intensive care unit make better business sense than a multi-specialty intensive care unit? A costing study in a trauma center in India

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ABSTRACT

Context: Though intensive care units (ICUs) only account for 10% of hospital beds, they consume nearly 22% of hospital resources. Few definitive costing studies have been conducted in Indian settings that would help determine appropriate resource allocation. **Aim:** To evaluate and compare the cost of intensive care delivery between multi-specialty and neurosurgery ICU in an apex trauma care facility in India. **Materials and Methods:** The study was conducted in a polytrauma and neurosurgery ICU at a 203 bedded level IV trauma care facility in New Delhi, India from May, 2012 to June 2012. The study was cross-sectional, retrospective, and record-based. Traditional costing was used to arrive at the cost for both direct and indirect cost estimates. The cost centers included in study were building cost, equipment cost, human resources, materials and supplies, clinical and nonclinical support services, engineering maintenance cost, and biomedical waste management. **Statistical Analysis:** Fisher's two-tailed *t*-test. **Results:** Total cost/bed/day for the multi-specialty ICU was Rs. 14,976.9/- and for the neurosurgery ICU was Rs. 14,306.7/-, manpower constituting nearly half of the expenditure in both ICUs. The cost center wise and overall difference in the cost among the ICUs were statistically significant. **Conclusions:** Quantification of expenditure in running an ICU in a trauma center would assist healthcare decision makers in better allocation of resources. Although multi-specialty ICUs are more expensive, other factors will also play a role in defining the kind of ICU that need to be designed.

Key words: *Intensive care unit, traditional costing method, trauma*

INTRODUCTION

Though intensive care units (ICUs), only account for 10% of hospital beds, they consume nearly 22% of hospital resources.[1] A diversity of costing methods has resulted in poor external validity and inability to compare findings between such evaluations'.[2] There is also considerable heterogeneity between countries and even within the country in allocation of resources and distribution of the services.[3] In the United States, guidelines from the Public Health Service Panel on Cost-effectiveness in Health and Medicine have been made applicable to critical care.[4] Not only have very few costing studies in ICU settings been conducted in India to enable formulation of guidelines, intensive care services is also provided free of cost in government hospitals with no budgetary allocation or control. Trauma services are especially vulnerable to cost pressures because their payer mix is often marginal and the care provided is extremely resource-intensive.[5] Few studies have been conducted in developing countries to assess the cost of ICU. The authors are not aware of any that compare a polytrauma and single specialty ICU within the same setting. The study was undertaken to determine, from a costing perspective if a multi-specialty ICU was more cost-effective than a unispecialty ICU, all other factors being same.

Thus, the exercise was undertaken to estimate the per bed/day cost delivery of these two disparate ICUs in an apex trauma care facility in India.

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MATERIALS AND METHODS

The study was conducted at a 203 bedded level IV trauma care facility in New Delhi, India from May 1, 2012 to June 30, 2012. The study setting was a polytrauma ICU comprising 12 beds and a neurosurgery ICU of 20 beds. The study was cross-sectional, retrospective, and record-based. Data were collected from executive finance committee, accounts section, engineering section, stores department, and computer facility. The traditional (syn-average or gross) costing was used to arrive at the cost for cost estimates. The following cost centers were included in study:

1. Capital assets cost
    a. Building cost* (ICU, Central Sterile Supply Department [CSSD], laundry, manifold)
    b. Equipment (ICU, laundry, CSSD, manifold)
2. Operating cost
    a. Human resources (faculty, residents, nursing staff, technician, physiotherapists, hospital attendants, sanitary attendants, security staff)
    b. Materials and supplies
    c. Support services
        1. Clinical: (Laboratory, radiology, physiotherapy, blood bank, manifold, pneumatic chute system)
        2. Nonclinical: (Laundry, manifold, CSSD, dietetics, housekeeping, security)
    d. Engineering maintenance cost
    e. Biomedical waste (BMW) management

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

Capital assets annual 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 year 2011-2012/Cost Inflation Index of procurement year). Thereafter, annualized method of depreciation (Recommended by World Health Organization) was applied to arrive at an annual cost by dividing replacement cost of the asset in year 2011 by annualization factor. The formula for calculating annualization factor is $= (1/r) \times (1 - 1/[1 + r]^n)$ where,

r is real interest rate, formula = ([1 + nominal interest rate]/[1 + annual inflation]−1)

Nominal interest rate is the prevailing national bank savings rate for year 2011.

n = number of years of life (100 years for building, 10 years for machinery and 15 years for equipment [fixed], respectively).

On the basis of above-mentioned methodology per square meter building, the annual cost of the trauma center and equipment annual cost were calculated. Thereafter, building cost of ICU and support services was calculated. Building cost was taken from records of the expenditure finance committee.

Similarly, annual cost of equipment was calculated for ICUs. Supply order of equipment was 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 ICU. Annual building cost and equipment cost of support services were apportioned to ICU on the basis of workload.

Operating cost

Unstructured interviews were held with ICU staff and records of ICU studied to gain an insight into the functioning of ICU and support services. To calculate various floor areas of ICU and support services, records of engineering department were studied. Engineering maintenance cost was calculated by calculating the per square meter engineering maintenance cost for a period of 1 year. The same was apportioned to ICU on the basis of workload. Building maintenance cost was taken from the accounts department.

Interviews were also carried out to calculate the time devoted by various categories of hospital staff in ICU, in order to apportion their salaries. Salary of employees was taken from the accounts section, and mid-point salaries based on the number of hours spent by the healthcare worker in the ICU were apportioned. Direct costing was taken for healthcare workers who were exclusively dedicated for the ICU.

The tests sent from ICUs to the laboratory for 2 months were averaged out from the records and the cost of the consumables apportioned to per day basis. Similarly, the cost consumables for testing of blood for transfusion were calculated from the cross tabulation of ICU and blood bank records. Since the trauma center was integrated through a picture archival and retrieval system, the cost of total radiological procedures of the entire study duration was taken, and the per day cost calculated. Cost of consumables was taken for a period of 1 year to account for the fluctuation in consumption to seasonal variation. Actual quantity as per indent book was considered, and cost of the same was taken from rate contracts of the trauma facility.

Average monthly CSSD and ICU load for CSSD was calculated by taking average of 2 months. Average number of drums, sets, and linen processed in one cycle was calculated from CSSD records and then the total number

of cycles run in CSSD for steam sterilization and ethylene oxide for ICU was assessed. Manifold cost was apportioned based on the number of points at each of the ICU. The cost of manifold includes the capital cost, cost of equipment, cost of operations cost of liquid oxygen, and the cost of the cylinders.

Average monthly laundry and ICU (kilograms) for laundry were calculated by taking average of 3 months. The per bed cost of dietetics was extracted from a costing study conducted the same year on dietetics. The BMW management cost to the trauma care facility was calculated on per bed basis from the total cost paid by the institution. Per square meter cost of BMW management was calculated, and then ICU BMW management cost was arrived.

All cost were calculated with conversation from Indian Rupees (Rs) to US (USD) Dollar 1 USD = Rs 50/-. Operating cost for different support services was taken as per actual from the contract agreement executed between the institution and outsourced agency.

RESULTS

The trauma centers is part of a large tertiary care facility and is itself spread over an area of 20,600 sq. meters and has 204 beds. The 32 ICU beds are spread over two floors. The second floor polytrauma ward has 12 beds, and the third floor ward has 20 beds dedicated to neurosurgery cases.

All the cost estimates were calculated for financial year 2011-2012. Annualization factor for capital assets was calculated to be Rs. 38.5/- and Rs. 8.82/- (12.53) for building, machinery, and equipment (fixed), respectively. Annualized building cost of trauma center was calculated to be INR 1761/- per square meter and engineering maintenance cost was calculated to be INR 3784.94/- square meter.

Intensive care units estate and maintenance cost

The cost of estates including the building cost (civil, landscaping, sanitary, tubewell), electrical work, heating, ventilation and air conditioning, sewage treatment plant, and the sub-station apportioned per bed/day is Rs. 218/-for the multi-specialty ICU and Rs. 130.7/-for the neurosurgery ICU. The total maintenance cost for the year 2011-2012 was Rs. 102,412,489/-/bed/day cost for the multi-specialty ICU was Rs. 498.61/-and for the neurosurgery ICU was Rs. 299.17/-[Table 1].

Manpower cost

The annual manpower cost for the multi-specialty ICU and neurosurgery ICUs was Rs. 29,770,860/-and Rs. 44,987,820/-, respectively. The daily cost per bed for multi-specialty ICU is Rs. 6797/-and for neurosurgery ICU was Rs. 6231/-[Table 1].

Consumables

The daily cost per bed for consumables including equipment, instruments, general store items, linen stationary, drugs etc., was Rs. 3819.3/-and Rs. 4118.2/- for multi-specialty and neurosurgery ICUs, respectively. The equipment alone accounted for 46% and 43% of

Table 1: Cost comparison of multi-specialty and neurosurgery ICU of trauma facility

Cost centers	Multi-specialty ICU: Cost/per/day in Indian rupees	Neurosurgery ICU: Cost/per/day in Indian rupees
Building	107.5	64.5
HVAC	41.0	24.6
Cost of electrical work	52.7	31.6
Sewage treatment plant	6.0	3.6
Electrical substation	10.7	6.4
Engineering maintenance	498.6	299.2
Manpower	6797.5	6231.2
Equipment	1753.3	1805.5
Instruments	8.5	8.0
Linen	47.5	41.5
Stationary	38.9	24.6
Drugs	999.4	1024.0
General stores	971.7	1214.7
Laboratory	453.8	453.8
Blood bank	723.9	328.6
Manifold	97.4	162.3
Pneumatic chute	6.6	4.0
CSSD	215.8	215.8
Laundry	176.8	353.6
Dietetics	178.8	178.8
BMW	11.3	6.8
Computer facility	26.0	18.3
Total cost/bed/day	Rs. 14,976.9/-	Rs. 14,306.7/-

ICU: Intensive care unit; CSSD: Central Sterile Supply Department; BMW: Biomedical waste; HVAC: Heating, ventilation and air conditioning

Table 2: Cost centers wise statistical significance between the ICUs

Cost centers	Multi-specialty ICU: Cost/per/day±SD	Neurosurgery ICU: Cost/per/day ± SD	*P*
Support services: Nonclinical	609±87	773±122	<0.0001*
Support services: Clinical	1228±122	949±125	<0.0001*
Consumables	3815±220	4118±215	<0.0001*
Equipment	1753±168	1805±170	<0.0001*
Estate	716±92	430±57	<0.0001*
Manpower	6797±212	6231±188	<0.0001*
Total cost/bed/day	14,976.9±1021.5	14,306.7±989.7	<0.0001*

ICU: Intensive care unit; SD: Standard deviation; **P* value <0.0001; Statistically significant difference

consumables cost in multi-specialty and neurosurgery ICUs, respectively.

Support services cost

The daily cost of clinical support services was Rs. 1281.7/- and Rs. 948.7/-per bed for the two ICUs; the difference primarily because the blood bank cost was Rs. 723.88/-per bed for the multi-specialty ICU and only Rs. 328.56/-.Total annualized cost of manifold building and equipment for year 2011-2012 was calculated to be INR 100,544/-and INR 4,528,671.65/-, respectively. ICU manifold terminal units formed only 5.1% of the total manifold terminal units installed at the trauma facility and the daily expenses incurred on manifold were Rs. 97.39/-for multi-specialty and Rs. 162.31/-for the neurosurgery ICU.

The total cost due to nonclinical support services was calculated to be Rs. 608.7/- for the multi-specialty ICU and Rs. 773/- /bed/day for the neurosurgery ICU. The cost of CSSD and dietetics apportioned to both the ICUs was the same, Rs. 215.8/- and Rs. 178.8/- /bed/day, respectively whereas cost of laundry was Rs. 176.8/- for the multi-specialty ICU and Rs. 353.6/- /bed/day for the neurosurgery ICU [Table 1].

Monthly cost incurred by the Institute on BMW management was INR 1,041,666/- and cost apportioned to the center was INR 95,942. 92/-. The cost of the BMW management which was apportioned to the ICUs per month was Rs. 350.3/- and Rs. 210.8/- respectively [Table 1].

The per annum cost of multi-specialty ICU Rs. 5,366,605/-.

The overall cost was higher in the multi-specialty with cost being Rs. 14,977/- /bed/day (-per annum) as against the neurosurgery ICU with Rs. 14,307/- /bed/day (Rs. 5,222,055/- per annum)

DISCUSSION

Economic evaluations can provide health-care decision makers with valuable information on the relative efficiency of alternative health-care services. This is even more important since ICUs are resource intensive and expensive to build and operate. In developing nations, the needs to focus on prudent resource allocation cannot be over emphasized. Majority of private hospitals ensure fairly accurate cost evaluation measures in ICUs since the patient is directly billed against it. However, in public sector hospitals little stress is given on cost containment which can only be assessed after cost evaluation. An institutional study assessed that trauma and acute care surgery patients represent a significant (65%) and increasing institutional cost. Per patient ICU costs were the largest single category, suggesting that cost control efforts should focus heavily on critically ill patients.[6]

This study was conducted at an Apex Trauma Centre, primarily with objective of understanding the various cost centers and cost proportions in an intensive care facility. Secondarily, the study setting also provided an opportunity to compare the cost in running a polytrauma and as against a neurosurgery ICU. The intention was to ascertain whether, from a purely hospital expenditure perspective, a multi-specialty or a single specialty ICU is more effective.

The proportion of expenditure on cost centers between the two ICUs remained the same [Figures 1 and 2], the majority of the expenditure being attributable to manpower (45% and 44%) followed by consumables (25% and 29%) clinical support services, nonclinical support services, and estates, in that order. Therefore, the proportion on expenditure among the various heads remained fairly constant between the two ICUs. A Direct Cost Analysis study of ICU Stay in Four European Countries using a Standardized Costing

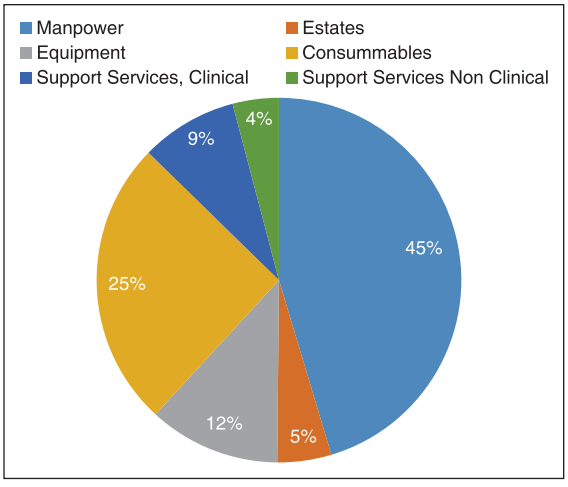

Figure 1: Cost proportion among various cost centers in multi-specialty intensive care unit

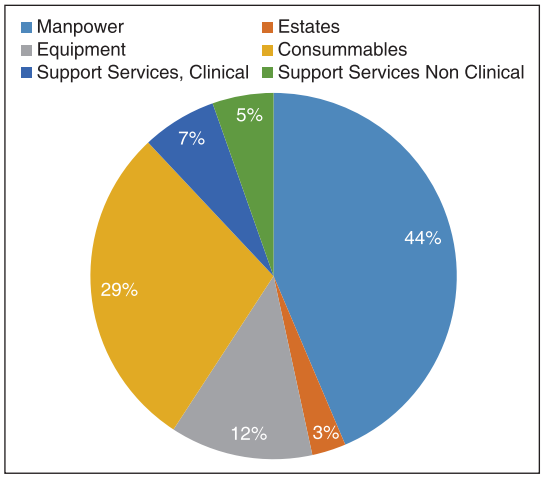

Figure 2: Cost proportion among various cost centers in neurosurgery intensive care unit

Methodology revealed a wide variation, between the countries assessed from €1168 to €2025/day.[7] While this reflects a commonly known fact that far higher expenditure is incurred in western world on healthcare, the same study also suggested that manpower constituted the largest chunk in terms of costs, ranging from 60% to 64% of the expenditure incurred. Costing studies in ICUs in the Indian scenario have been few and far in between.

The overall cost was higher in multi-specialty ICU. Perhaps, more tellingly, the difference between the two ICUs is not only statistically significant with regards to the overall cost but also when independently analyzed for manpower, equipment, estates, consumables, clinical services, and non clinical services.[Table 2] Data from both foreign and domestic ICUs indicate that 50% to 80% of direct costs are variable personnel costs, primarily for nursing. On average, ICUs use almost 3 times as many nursing hours per patient day as do general floors.

Viewed from an entirely financial perspective, neurosurgery ICU outweighs the benefits of a multi-specialty trauma ICU [Figure 3]. This maybe because the manpower, forming the largest chunk of expenditure, being from the same specialty can probably be utilized more effectively. Second, although the consumable cost is higher considering it is a neurosurgery ICU,this is offset by the fact the similar structural and engineering cost drives down the capital and maintenance cost. Further, the clinical profile of the patients being similar, may have brought down the cost of the clinical support services in neurosurgery ICU as against the multi-specialty ICU. However, outcomes need to be viewed from the clinical prism as well, since multi-specialty ICUs would provide the opportunity to treat the patient more holistically and permit inter unit transfers, cross consultation and promote pooling of resources.

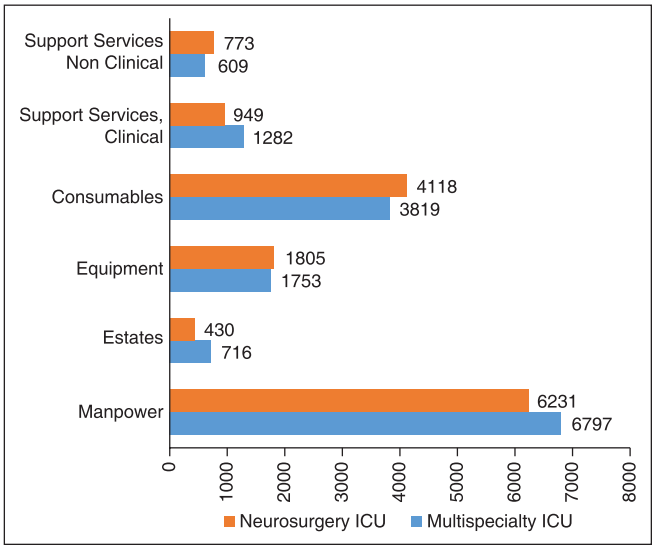

Figure 3: The cost center center wise differences between neurosurgery and multi-specialty intensive care units (ICUs) of trauma center are depicted in the figure. Though the consumable, nonclinical support services cost and equipment cost is higher in the neurosurgery ICU, with the overall cost is lower than multi-specialty ICU primarily because of the manpower and estates costs

The primary drawback can be attributed to poor data availability and financial record keeping inherent in a government hospital. Though the activity-based costing would have been more accurate, it would have been much more tedious and time-consuming. Thus, despite its disadvantages, the research was conducted using the traditional or average costing methodology. Another disadvantage of the study was the multi-specialty ICU was 12 bedded whereas the neurosurgery ICU was 20 bedded, and it is likely that total operational cost per bed in neurosurgery ICU may have been brought down about by this factor as well. It can be safely extrapolated that the findings will be applicable internationally and certainly within the Asian continent.

CONCLUSION

It is essential for clinicians and administrators to comprehend the enormous resources and the consequent expenses that are involved in commissioning and running an intensive care facility. This study attempts to quantify in financial terms, the expenditure involved in running an ICU in a trauma center to assist doctors and healthcare decision makers in allocation of resource not only in a developing country but the western world as well. Though the study does provide evidence that operating a unispecialty ICU like neurosurgery is more economical than a multi-specialty ICU, before sweeping policy decision making is undertaken, clinical and other factors must be taken into careful consideration. Further comparative studies in terms of clinical outcomes may aid in choosing between the alternatives.

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