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ORIGINAL RESEARCH & CONTRIBUTIONS

Costs and Utilization of Operating Rooms in a Public Hospital in Trinidad, West Indies

Seetharaman Hariharan, MBBS, MD, FCCM; Deryk Chen, MBBS, FRCA, MBA

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ABSTRACT

Context: A top-down evaluation of the costs of operating rooms (ORs) is not commonly done because it is relevant mostly in a publicly funded system.

Objective: This study was conducted to determine the costs and utilization of ORs in a public hospital in Trinidad, West Indies, for two one-year periods using a top-down model.

Design: Quantitative observational study.

Main Outcome Measures: A "cost-block" model suggested for evaluation of intensive care unit costs was adapted to suit ORs. Data were obtained from personal interviews, records, and surveys from the appropriate hospital departments. Adjusted OR utilization times also were recorded for both years.

Results: The total annual costs of 4 ORs for the years 2006 and 2009 were approximately US $2.2 and $3.2 million, respectively. Capital expenditure contributed to 70% of the costs, followed by consumables (15%) and medical staff salary (8%). The daily cost of running the ORs was US $6242 in 2006, which rose to $8873 in 2009. The cost of unutilized OR time was approximately US $298,342 in 2006 and was reduced to $198,315 during 2009.

Conclusion: The adapted cost-block model was useful to evaluate the costs of ORs in a public hospital in Trinidad and can be used from the government's expenditure perspective. Because the cost of running the ORs was high, efficiency must be improved to minimize waste.

INTRODUCTION

Operating rooms (ORs) are one of the most resource-intensive areas of a hospital to provide surgical care.[1] A recent release from the US Healthcare Cost and Utilization Project found that the cost of a hospital stay after a surgical procedure in an OR was 2.5 times more expensive than that of a hospitalized patient not requiring a surgical procedure.[2] The infrastructure and equipment capacity may vary between the hospitals in accordance with the surgical procedures, and hence most cost evaluation studies of ORs focus on the cost of individual procedures. However, in a publicly funded health care system, the proportion of expenditure for ORs is more relevant, because contemporary ORs require a major proportion of the hospital's budgetary allocation. Many published studies pertaining to OR management focus on costs, as there is an agreed position that ORs represent one of the most critical areas of a hospital for financial allocation.[3,4]

There are many reasons ORs are resource intensive. The infrastructural aspects of the ORs consist of many engineering issues, such as OR space, controlled temperature and humidity, sterile environment, and electricity backup systems, which require careful attention and continuous maintenance. ORs also extensively use consumables, they hold equipment requiring regular maintenance because their failure results in delays and cancellations of surgery. The human resources component in ORs is always multidisciplinary, including clinical and nonclinical staff members, which is another major contribution to the cost.

Reviewing the cost of ORs and comparing the cost with the efficiency of its utilization is essential in every hospital regardless of whether the hospital is publicly or privately funded.[5] Although there have been published reports applying various management tools and mathematical modeling algorithms to improve the efficiency of ORs,[6-9] few studies, to our knowledge, have looked into the cost aspect of ORs from the perspective of public health expenditures.

A study done in the United Kingdom (UK) highlighted the common problems encountered by OR managers, showing a need to ensure the full utilization of the OR sessions to minimize the substantial financial impact likely to be incurred by the hospital.[10] OR times are precious throughout the world, and it is therefore important that such an expensive facility be utilized efficiently. It has been acknowledged that more data are needed from different parts of the world in this area of hospital-based health care.[11,12]

There are three major public health institutions in Trinidad, West Indies: Port-of-Spain General Hospital, Eric Williams Medical Sciences Complex, and San Fernando General Hospital. All three hospitals are equipped with ORs, offering free surgical care to patients. The availability of operating times in these ORs is currently limited. Presently there is little documentation on the status of the costs of running ORs in Trinidad's public hospitals.

This study seeks to determine from a funding agency's (governmental) perspective the cost of ORs as a whole unit in a public teaching hospital, and to evaluate the utilization of the ORs to quantify the cost-efficiency.

Seetharaman Hariharan, MBBS, MD, FCCM, is a Professor of Anesthesia and Critical Care Medicine in the Department of Clinical Surgical Sciences at the University of West Indies, St Augustine Campus in Trinidad and Tobago. E-mail: uwi.hariharan@gmail.com. **Deryk Chen, MBBS, FRCA, MBA,** is an Associate Lecturer in Clinical Surgical Sciences at the University of the West Indies in Trinidad, Trinidad and Tobago. E-mail: uwideryk@yahoo.com.

METHODS

Approval was obtained before the study from the Ethics Committee of the Faculty of Medical Sciences, The University of the West Indies, St Augustine, Trinidad and Tobago, and from the hospital authorities. Because this was a quantitative observational study that collected data exclusively on costs and utilization of ORs in public hospitals in Trinidad and Tobago and involved no patient clinical data, the committee approved a waiver for informed consent. All data were collected prospectively by personal visits to the various departments of the hospital and by obtaining relevant information from records to minimize the chances of missing data.

The cost of the ORs was determined using a "cost-block" model developed in the UK for estimating costs of intensive care units (ICUs).[13] This is a top-down model and is well applicable to the objective of the study, which was to estimate costs from the governmental perspective. The costs were broken down into six blocks: 1) capital expenditure, 2) estate, 3) nonclinical support services, 4) clinical support services, 5) consumables, and 6) staff. The definitions of each block for ICU in the original model were adapted to suit ORs (see Sidebar: Definitions of Cost Blocks Used for Operating Rooms).

Data were obtained from the Human Resources, Administration, Finance, Pharmacy, Stores, and Biomedical Engineering Departments of each hospital. Study team members collected data concerning the infrastructure of the OR on a scheduled visit. Each team member personally observed and noted all the equipment in the ORs. From the office records, costs of equipment were calculated. Similar data were collected for consumables and drugs.

Data also were collected by interviewing the managers and the staff attached to the related departments regarding the overall staffing pattern. Data regarding human resources were collected by recording the availability of the number of nurses, physicians, and support staff. The salaries of the staff working exclusively in the ORs were recorded, and salaries of staff who also contribute to other parts of the hospital such as general wards and outpatient clinics were apportioned by the time they contributed in the ORs.

The cumulative costs of all the blocks were used to derive the annual costs of the ORs during 2006 and 2009, from which the average daily costs were calculated. The study was actually conducted during 2010; hence, 2009 was chosen as the base period. Because the research team was aware that the OR was poorly utilized in the past, the year 2006 was chosen as a period for comparative evaluation.

Data regarding the amount and types of surgeries performed during the designated time frame was obtained from medical records at the Surgery Department. The total amount of consumables and other equipment used each month in the specified period was averaged by looking at the relevant stock request sheets. Information regarding the cost in 2006 and 2009 of each item used and the total cost of maintenance for each month during the specified timeframe (utility bills, etc) was also obtained from relevant sources such as the Departments of Purchase, Pharmacy, Finance, and Engineering. From all these collected data, the total cost of managing the ORs during the specified period was calculated using Microsoft Excel spreadsheet software (Microsoft, Redmond, WA).

After allowance for turnover time, OR utilization times were calculated for both years, and the time utilized and unutilized during elective surgery hours was calculated.

The total cost of running the ORs vs the utilization times was calculated for each year (2006 and 2009), and comparisons were made.

RESULTS

The OR complex in the public teaching hospital studied consisted of eight rooms, although only four rooms were in use during the study period. The ORs had state-of-the-art equipment, which included modern anesthesia machines with microprocessor-controlled mechanical ventilators, noninvasive and invasive monitoring modalities, laparoscopic equipment, endoscopes for all specialties, a C-arm x-ray machine, infusion pumps, and consumables, including anesthetic and perioperative drugs. Both elective and emergency surgical procedures were performed for all age groups .

The ORs had a full complement of medical and nursing staff, which included consultant surgeons in most surgical

Definitions of Cost Blocks Used for Operating Rooms

Capital expenditures:
Cost price of anesthesia machines, anesthetic equipment including fiberoptic scopes, surgical instruments including orthopedic and neurosurgical drills, C-arm x-ray machines, surgical endoscopes of all specialties, laparoscopic equipment, arthroscopic equipment, operating room beds, intravenous poles, autoclaves, operating room lights, diathermy, intraoperative cell salvage equipment (cell saver), cardiopulmonary bypass machines, arterial blood gas machines, and others, with 10% depreciation per year since the year of purchase

Estate:
Costs of water, electricity, telephone, scrub production and laundry, laminar flow and scavenging, and sterilization services

Clinical support:
Salaries of nursing staff including head nurses, registered nurses, enrolled nursing assistants, patient care assistants, Anesthesia Department assistants, orthopedic technicians, radiographers, perfusionists

Nonclinical support:
Salaries of housekeeping personnel, patient escorts, customer service representatives, clerical staff

Consumables:
Cost price of sutures, gloves, drugs, intravenous fluids, piped gases, syringes and needles, anesthetic equipment (endotracheal tube, laryngeal mask airway, etc), disposable gowns, disposable diathermy equipment, other disposable surgical equipment, suction catheters, and others

Staff:
Salaries of consultants, registrars, house officers in Anesthesia and Surgery, interns in Surgery apportioned to the time spent in operating rooms

specialties, consultant (physician) anesthetists, registrars, house officers, a head nurse, registered nurses, scrub nurses, nursing assistants, patient escorts, and other support staff. Although the recovery room had the physical infrastructural capacity with all facilities to hold 10 patients, only 4 receiving areas were equipped with monitors and staff, making it a 4-bed unit, to provide 1:1 nursing care.

During 2006, the number of elective surgical patients who were operated on in the 4 rooms was 1476, which increased to 1995 during 2009.

Figures 1 and 2 show the cost blocks for 2006 and 2009, respectively. Capital expenditure was the highest cost block and contributed 70.5% of the expenditure during 2006 and 68% during 2009. Consumables were the second most expensive block, which contributed 17% (average for both years) of the total expenditure. Staff salary contributed 7.5% (average for both years), whereas estate, clinical support, and nonclinical support contributed the remainder.

Table 1 shows the cost variables such as total annual costs, costs for the 4 ORs, average cost per OR, cost per patient, and cost per hour for both years studied. The annual total costs of running ORs for 2006 amounted to US $2,278,455, which increased to $3,328,862 during 2009.

The cost of running the whole OR complex was approximately US $6242 per day during 2006 and $8873 during 2009. This amounted to US $1560 and $2218 per OR for the respective years. From these, the cost of 1 hour of OR time was calculated at US $65 in 2006 and $92 during 2009.

Table 2 shows the adjusted utilization of elective surgery time during the study periods. The total number of adjusted utilization time for all ORs during 2006 was 3223 hours, which increased to 4235 hours in 2009 during elective surgery time slots; approximately 4588 hours were unutilized during 2006 and 2145 hours were unutilized during 2009. In terms of fiscal quantification, this unutilized time amounted to US $298,342 during 2006 and $198,315 during 2009.

Table 3 shows the individual costs for each cost block for the two years of study.

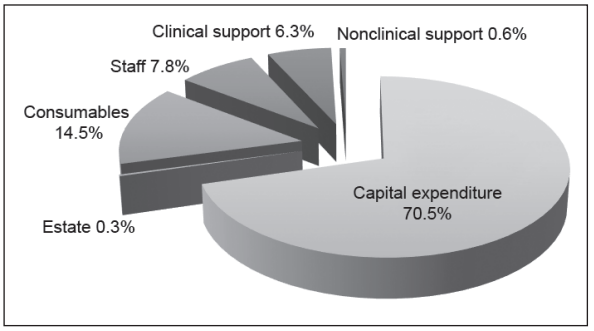

Figure 1. Cost blocks for the year 2006.

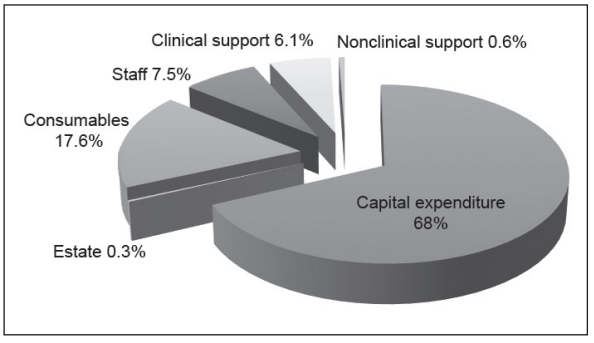

Figure 2. Cost blocks for the year 2009.

DISCUSSION

The present study establishes the potential applicability of the cost-block model to evaluate costs of running ORs in public hospitals using a top-down method. The cost-block model was developed for evaluating costs of ICUs, which was earlier applied in Trinidad.[14] We adapted the model to evaluate the costs of ORs, which to our knowledge has never been reported.

The cost-block method study group for ICUs has suggested that some of the blocks such as estate and nonclinical support services could be excluded,[13] and there have been some reports of ICU costs without using these blocks. However, we adapted all the cost blocks suggested initially for cost evaluation of ICUs for OR cost blocks and included all in our study to get a better result of the adaptation. Additionally, we also collected data by conducting personal interviews and observations and did not use a self-administered questionnaire. We calculated the costs by working with the various relevant sources and departments in the hospital. Because the top-down model is relatively new for computing costs of ORs, we wanted to minimize error as much as possible.

The comparison of costs between the years 2006 and 2009 revealed some interesting facts. Notwithstanding the finding that the overall proportions of the individual cost blocks were similar, the total annual costs increased by almost US $1 million in 3 years, despite only a 35% increase in the number of patients operated on (from 1476 to 1995).

The cost-block for staff was smaller than the capital expenditure and consumables blocks in both study years (Table 3). This may be because, in the model we adopted, the nursing staff in the rooms was grouped under the clinical support block, which would have increased the proportion of this block while decreasing that of the staff block. The proportion for the capital expenditure block was higher, which may possibly be because all equipment in the ORs, including anesthetic machines, monitors, and mechanical ventilators, usually is imported from other countries such as the UK and the US. The high costs involved in this process is understandable; however, the dominance of the capital expenditure over the staff block is a unique finding that is different from the previous applications of the cost-block models for ICU, where the staff proportion of the cost blocks always took the lead.

Table 1. Cost variables for years 2006 and 2009 in a public hospital in Trinidad, West Indies

Variable	2006 (US $)	2009 (US $)
Total annual costs	2,278,455	3,238,862
Cost of running all operating rooms per day	6242	8873
Cost per operating room per day	1560	2218
Cost per operating room per hour	65	92

Table 2. Utilization of operating time for years 2006 and 2009 in a public hospital in Trinidad, West Indies

Variable	2006	2009
No. of operated-on patients (elective)	1476	1995
Total time utilized (hours)	3223	4235
Total time unutilized (hours)	4588	2145
Cost of unutilized time (US $)	298,342	198,315
Cost of unutilized time % of total costs[a]	13	6

[a] Total costs: 2006 = US $2,278,455; 2009 = US $3,238,862.

Additionally, because capital expenditure is the biggest proportion of costs, this infrastructure is available whether there is increased productivity or not. This point is salient for the managers of the hospital system to increase the number of cases by employing more staff, bringing in economies of scale, and increasing the productivity with minimal increase in costs.

The comparison costs per patient showed that there was not much difference between the years studied. This also may be evidence of potential economies of scale in the years studied. The cost of all other blocks formed only a small part of the total expenditure.

It is also interesting to note that there was a 25% increase in the OR utilization time between 2006 and 2009; 41% of the elective surgery time was utilized during 2006, which increased to 66% during 2009. However, the cost of the wasted time for the year 2006 was 13% of the total annual expenditure, which almost halved to 6% of the total annual expenditure during 2009. This is despite the fact that the difference in the total annual expenditure between the 2 study years was almost US $1 million. This is an indication that by increasing the productivity of the ORs even by smaller amounts, a great deal of money can be saved. However, productivity may not always mean that the number of cases must be increased; rather, only the utilization time of ORs must be increased because there can be varying durations for the same type of surgery when performed by different surgeons.[15]

Table 3. Overall costs for each cost block during the study years

Cost block	2006 (US $)[a]	2009 (US $)[a]
Capital expenditure	1,606,330	2,203,471
Consumables	331,553	568,330
Staff[b]	176,851	242,594
Clinical support staff	143,286	196,552
Nonclinical support staff	13,213	18,125
Estate[c]	6907	9475

[a] Discrepancies in the totals are because each cost block was converted from Trinidadian dollars to US dollars, with the exchange rate of 1:6.4.

[b] Salaries of consultants, registrars, house officers, and interns in Anesthesia and Surgery Departments.

[c] Costs of water, electricity, telephone, scrub production and laundry, laminar flow, etc.

Because the cost-block model is a top-down model, this was the most appropriate model for our scenario, where hospitals are government funded. Most cost studies involving ORs use a bottom-up approach, by activity-based costing, including each consumable used. Additionally, most studies involve costing specific surgical procedures, rather than averaging the cost from the total expenditure. We chose to use the top-down model because of the following reasons:

1. In a public health care system such as in Trinidad and Tobago, service is offered free to citizens.
2. From the government's perspective, it may be pertinent to elucidate the appropriateness of the utilization for the investment made in ORs.
3. The overall costs and the costs per hour information will be very helpful in policy decision making, including allocation of OR time to surgeons.
4. The individual cost-block information may also assist in policy decision making, such as staff recruitment and investment in capital equipment.
5. This method has, to our knowledge, never been adopted to evaluate the costs of ORs in a publicly funded setting.

Cost-effectiveness analysis involves the evaluation of the ratio of the cost of an intervention to the patient outcomes measured by quality-of-life indexes.[16] However, the aim of the present study was not to evaluate the cost-effectiveness of a particular surgery or individual surgical intervention where cost of surgery is compared with patient outcomes. The objective of the present study was to evaluate the cost of ORs as a functioning whole system. When a system is evaluated, efficiency is more meaningful than effectiveness because efficiency may mean how well the processes of the system are run, whereas effectiveness may imply whether a treatment or intervention is useful.

Many methods and formulae have been suggested to calculate OR utilization times.[17] The broad application of the term *efficiency* in an OR situation is also disputed because there can be allocative efficiency vs technical efficiency.[18] In our view, the wide individual variations in the many factors such as public vs private hospitals, different methods of scheduling, different surgical durations, and OR slot allocation procedures dictate that there cannot be a one-size-fits-all formula for calculating OR utilization. This may be one of the reasons for the dispute between the applicability of the model developed in the US and that developed in the UK. Even in the UK, there have been reports that the formula suggested for calculating OR utilization may not be exactly applicable in different hospitals.[19,20] Hence, we used a simple adjusted utilization time in our study.

LIMITATIONS

There are several limitations to the present study. The short duration of the study may be a drawback. Data collection for costs is cumbersome and susceptible to errors, especially with varying interpretations of the definitions.[21] To minimize errors, we made sure that the same team member who understood the definition of the cost block collected data for the cost block by interviewing the personnel and reviewing the records in the respective department. Another limitation is that the top-down model averages only the costs of entire ORs, which is not applicable to cost an individual surgical procedure. Using the top-down model was another reason that we could not compare our findings with other published reports from the rest of the world, which predominantly use activity-based costing for individual procedures. We did not obtain cost figures for other public hospitals, which would have provided a better comparison. In addition, OR utilization times are calculated in many different ways throughout the world, and we followed a simple adjusted utilization time.

CONCLUSION

The cost-block method provided a useful framework to evaluate the costs of running ORs in a public hospital in Trinidad and Tobago and the opportunity for government and policy planners to improve cost-efficiency. ❖

Disclosure Statement

The author(s) have no conflicts of interest to disclose.

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