



Comparative study on operation theatre facility utilization in government hospitals and semi-government hospitals

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ABSTRACT

The operation theatre (OT) complex is a costly component of a hospital budget expenditure. This area of hospital activity requires maximum utilization to ensure optimum cost-benefit ratio. Two tertiary care centers in the Colombo district, Sri Jaywardenepura General Hospital (SJGH), the only semi-government tertiary care center in Sri Lanka, and Colombo South Teaching Hospital (CSTH) providing similar service delivery to government hospitals were studied to compare utilization patterns. The results showed no significant statistical difference in average per-bed utilization of SJGH and CSTH ($P=0.499$). The average per-bed utilization rate at CSTH was 23.26%, and SJGH was 25.66%. There was a significant statistical difference in the average per-bed capacity utilization of operating theaters at CSTH and SJGH. The average per bed capacity utilization time per day was significantly higher at SJGH ($P=0.040$). The average per-bed capacity utilization rate at CSTH was 11.63% and 15.2% at SJGH. According to the Consultants' perception of the importance of factors affecting utilization, less significance is given to time management and related administrative functions even though they have the highest correlation to utilization factors. Utilization observed at both hospitals was lower than the global benchmark between 70% and 80%. The study identified the importance of factors affecting utilization towards human resource availability, motivation, training needs and equipment, and resource availability. Surgeons have given less priority to time management and related administrative functions though the literature suggests time management and relative administratively modifiable factors as the most critical factors. (Gupta, 2011). Therefore, it is recommended to address the factors such as "cancellation of planned surgeries", "accurate prediction of procedure times in scheduling theatre lists", "convenient theater time schedules with other clinical work", "patient turn over time", and "patient transport time from wards" as they can result in overall improvement in operating facility utilization.

KEYWORDS: *Utilisation, Operation Theater, Government hospital, Semi-Government Hospital*

1 INTRODUCTION

Along with the rapid globalization and digitalization of health in the 4th industrial revolution, administrative aspects in healthcare have become increasingly important. Management of the hospitals now requires reducing costs to improve the utilization and the efficient use of their financial assets. Furthermore, hospitals must provide the highest level of patient satisfaction while reducing expenditure on resources. One of the most critical units in a hospital in this regard is the operating theatre. Since operating theatres are the hospital's highest cost and revenue center, a study done in South Africa shows that operating theatres are the single most significant expense to hospitals, regarding capitalization and fixed and variable operating expenses. It is, therefore, desirable to optimize the efficient utilization of these assets (Haartmann, 2013).

In healthcare, utilization is considered a means of achieving breakeven in capital investment (Gray, 1986). The heavy usage of routine surgical theatres and expensive equipment in the Sri Lankan hospital theaters is identified to be on weekdays from 8 am to 4 pm considering two 4 hours sessions. The utilization of equipment primarily happens in the daytime, hence, these high-cost machineries are left to idle for the remainder of the day. Suboptimal utilization of these has led to many adverse effects such as increasing running and maintenance costs and prolonged waiting times for routine surgeries. National Health Service - UK recommends utilizing surgical theaters at a minimum of 50% while the gold standard is 70 to 80% (Faiz,

2008), which is not the case when looking at the Sri Lankan context.

According to a study carried out in an Indian tertiary care institute, main concerns for underutilization of the equipment were identified to be factors such as low accessibility, obsolescence, break-down, unaffordability, unavailability of trained manpower, unavailability of consumables and spares, maintenance delays, limited working hours, and restricted availability (Chaudhary, 2015). In Teaching Hospitals in Sri Lanka, senior registrars, registrars, and medical officers carry out surgeries to fulfill the training needs of the system. Their inability to utilize highly sophisticated facilities such as laparoscopes, robotic arms, etc., can eventually lead to underutilization of such equipment and human resources, as trainees carry out most intermediate surgeries in teaching hospitals.

With a bed-strength of 1093 beds and a workforce of 2320, the Colombo South Teaching Hospital (CSTH) is the second-largest government hospital in the Colombo district situated in Kalubowila. CSTH is equipped with robust equipment and contains all the primary specialties, including various surgical subspecialties. On the other hand, Sri Jayewardenepura General Hospital (SJGH) has a bed strength of 1076 and a staff count of 1926, a board-managed government hospital implemented with a profit-making initiative. For this study, patterns that affect the utilization of equipment and the factors which influence their utilization and the capacities of public hospitals and

board-managed institutes were compared and contrasted.

2 RESEARCH METHODOLOGY

A descriptive cross-sectional study was carried out to compare the utilization of surgical facilities in Colombo South Teaching Hospital (CSTH) and Sri J Jayewardenepura General Hospital (SJGH). Ethical approval was taken from the University of Colombo Ethics Review Committee in this regard.

Data collection was done using the following three collection tools.;

2.1 Checklist for theatre facility identification

A theatre facility identification checklist was used to identify the equipment gaps and prevent confounders in analyzing utilization data. The same checklist was also used to collect data regarding the available technical staff of the said hospitals and their training needs. Data was collected from their logbooks and registers and theater- in-charge nursing records as well. All the six routine theaters in Colombo South Teaching Hospital and the eight in Sri Jayewardenepura General Hospital were included in the study.

2.2 Utilisation check list

Assessing utilization rates of routine theaters was carried out using utilization data extracted from nurses' records on operation start time and finish times. A validated checklist was used as a data extraction tool (Hartmann, 2013). A prospective calculation of theater cleaning times and change over times for both

hospitals was done. Theatre changeovers were computed and added to utilization figures assuming that such actions, though not adding value, were essential. The combined average of both hospitals was identified as 4 minutes 55 seconds per surgery and thus, was adjusted to 5 minutes to maintain the convenience of data collection. The mean theater cleaning time was added to each procedure as 5 minutes in utilization rate calculations.

The study was carried out, focusing on all the routine theaters prospectively in both hospitals, measuring the time used for each procedure starting from 2nd May 2019 to 13th June 2019, excluding Saturdays and Sundays, to prevent bias from theater schedules. Theater nurses were educated on the importance of maintaining the accuracy of timings and accuracy of records to use a reverse Hawthorne effect despite the usual recording of procedure start times and finish times. The sample size for utilization data must be calculated using the following formula (Martínez-Mesa, 2014).

$$n = \left(\frac{z_c \sigma}{E} \right)^2$$

Z = 1.95 (Critical value at 95% confidence interval).

σ = Standard deviation of mean theater utilisation time (from existing literature)

E = Designed margin of error.

In order to use the above formula, the sampling unit should be equal to number of procedures, and for comparison, the number of procedures must be equivalent

in both hospitals, which was identified to be a limitation to the study. In this study, the set number of procedures was not equivalent between hospitals. Thus, to overcome this limitation, the measure of a selected period of utilization was used in the study.

Utilization is defined as a proportion of available time that a theatre/ facility is used, as shown in the equation (Hartmann, 2013):

$$Utilization = \frac{Time\ used}{Time\ Available}$$

The “time used” in the above formula was the mean utilization minutes of each piece of equipment for a single day. The data set was statistically analyzed to determine the mean and the standard deviation (\pm SD). The mean was given as the average utilization for each theatre, using the daily utilization values, and the SD was calculated per theatre and per each facility or equipment, giving a sense of the dispersion of data – the greater the SD, the less tightly the utilization rates were clustered around the mean. The “time available” in the formula was considered as 12 hours, as suggested by the literature review conducted.

Capacity utilization was assessed considering the “time available” as 24 hours (Pandit, 2017). The formula used to measure Capacity Utilization Rate was:

$$Capacity\ Utilization\ Rate = \frac{Actual\ Output}{Potential\ Output} \times 100$$

Capacity utilization is a measure of taking the maximum output from the existing investment.

The study data were analyzed using the IBM – SPSS application version 24, where the data of both the hospitals were compared to identify any visible gaps in utilization for each of the individual facilities or pieces of equipment. For comparing the two hospitals, significance testing was conducted, and comparing the mean utilization over the thirty days between the hospitals was done using a t-test.

2.3 Self-administered questionnaire for service providers

Identification of relative importance of factors affecting utilization was made using a self-administered questionnaire, which was given to the consultant surgeons in each hospital who actively utilized operation theater facilities.

The self-administered questionnaire included a continuum of 0 to 10 radial point scale with extreme point descriptors using 11 scale points to assess service providers' perception of factors affecting the capacity to utilize all available facilities optimally. A ten-point Likert scale was used to improve the reliability of data and prevent bias. (Iacobucci, 2018) Factors listed in the questionnaire were already identified factors in the existing literature (Chaudhary, 2015) (Stavrou, 2014). Consultant surgeons being the ultimate decision-makers in day-to-day practiced operations and methods of operation, all were taken as resource personnel for a qualitative assessment of perception on the relative importance of factors affecting utilization. The questionnaire was limited to the English language considering the language of preference of consultants. The

above contained the following major domains:

- Availability of human resources
- Training and development
- Motivation
- Availability of physical resources
- Time management and planning

The questionnaire was pre-tested among a group of consultant surgeons attached to Neville Fernando Teaching Hospital (public hospital with profit-making capacity) regarding clarity, sequence of questions, average time required to complete the questionnaire, willingness to participate, and overall feasibility of conducting the study. Data entry and statistical analysis were done using the principal investigator's software package SPSS version 24.

3 RESULTS & DISCUSSION

CSTH has three floors of routine theater complexes in a newly constructed building which carries two theaters in each complex with one fully equipped theater bed in each theater. Therefore, CSTH has six routine theater beds shared among all available specialties, including General Surgery, Gynaecology, Obstetrics, Urology, Orthopedic, Plastic Surgery, Ophthalmology, ENT, GI, Neuro and Oro maxillary facial surgery.

On the other hand, SJGH has one large theater complex located on the hospital's first floor containing eight theaters with one bed each. This complex is fully equipped and can share all the available resources among all the theaters. There are 44 nurses currently available, and all of

them have undergone theater training, and the number of nurses is sufficient for maximum utilization at present. Several health assistants are a total of 24, with all of them having undergone theater training programs. There is a shortage of additional two health assistants, which currently affects the utilization.

Both hospitals are equipped with the state-of-the-art latest equipment to carry out surgical procedures. CSTH Theater complexes consist of two laparoscopes, five cystoscopes, four C-Arm machines with required safety equipment, four power drills for orthopedic procedures, two 3D laparoscopes, two ophthalmic machines, two ophthalmic microscopes, two bronchoscopes, two PCNL machines, and one each from Laser machines and ENT Microscopes. Meanwhile, SJGH appears to be more equipped with sophisticated facilities. Comparatively, SJGH has three laparoscopes, three cystoscopes, three C Arm machines with required safety equipment, six power drills for orthopedic procedures, one 3D laparoscope, four ophthalmic machines, one ophthalmic microscope, two bronchoscopes, two PCNL machines, two ENT microscopes, one laser machine, and a Robotic Arm.

Colombo South Teaching Hospital has a higher estimated number of admissions per annum, approximately around 150,000, while Sri Jayewardenepura General Hospital has only 50,000 estimated admissions per annum. During the study period of 30 days, it was identified that only 393 surgeries were carried out at CSTH routine theater complexes, while

898 procedures were carried out at SJGH theaters. Out of 393 at CSTH, 231 cases were major cases, demonstrating that 58% of surgeries carried out at CSTH theaters are significant cases. Considering SJGH, only 321 cases were major surgeries which cumulated to a percentage of 35%, while 459 surgeries were intermediate, which amounted to 51% of the total. In a study carried out in the United Kingdom on the frequency of surgical treatments over five years, they identified that only 19% of cases were major surgeries.

In contrast, 28% of cases are intermediate surgeries in the UK setup (Abbott, 2017). Colombo South Teaching Hospital is a tertiary care center with several super specialties, contributing to the higher percentage of major surgeries over intermediate surgeries. In Sri Jayewardenepura General Hospital, many intermediate surgeries are carried out during the evening hour private theater lists.

Daily theater list start times at Colombo South Teaching Hospital carry an average delay of 23 minutes on Wednesdays, while Monday's list starts with only 10 minutes delay. Theater A has 20 minutes average delay on Tuesdays. Theater B has an average delay of 26 minutes on Wednesdays, while Theater C has an average delay of 23 minutes again on Wednesday.

Concerning early starts, Theater A has average early starts of 10 minutes on Mondays and 18 minutes in Theater B on Thursdays, while Theater C was also starting early with an average of 14 minutes on Mondays. Theater C has an average daily start time earlier than the other two theaters with the figure of 8.15 am. Theater A has an average daily start time of 8.16 am. Theater B's average start time goes up to 8.21 am, which is the highest delay in average start times over the week.

Colombo South Teaching Hospital shows comparatively better daily start times than SJGH. The best average start time of Sri Jayewardenepura General Hospital goes as delayed as 23 minutes from the scheduled start time of 8 am. The average start time of the week at CSTH is 8.17 am, while the average start time at SJGH is 8.25 am. The best average start time at CSTH is recorded on Mondays, while the worst is on Wednesdays. The best average start time at SJGH is recorded on Wednesdays, while the worst is recorded on Thursdays.

Operating theater utilization rates were calculated using the following formula.

(Hartmann, 2013).

$$Utilization = \frac{Time\ used}{Time\ Available}$$

Table 1: Mean per bed utilization rate comparison.

Hospital	No of days studied	Mean utilisation per day (Min)	SD	Sig*
CSTH	30	167.5	104.12	0.499
SJGH	30	184.8	92.93	

The average per bed utilization was 167.5 minutes per day at CSTH, while it is 184.8 minutes at SJGH. CSTH shows a standard deviation of 104.12, while SJGH shows a standard deviation of 92.93. The mean per bed utilization rate at CSTH is 23.26%, while the average per bed utilization rate at SJGH is 25.66%. There was no significant statistical difference in mean per bed utilization of Sri Jayewardenepura General Hospital and Colombo South Teaching hospital (P=0.499). Findings indicate that utilization rates of both hospitals remain

significantly low compared to many empirical studies carried out globally.

To measure capacity utilization, available time was considered 24 hours as the available capacity for maximum utilization in time is 24 hours in both hospitals (Table 16). To prevent confounding, average cleaning and preparation time of 5 minutes was added to the used time of both hospitals. Hartmann's formula was used to assess utilization rates using 24 hours as availability. (Hartmann, 2013)

Table 2: Per bed theater capacity utilization rates over the week

Day	CSTH Per Bed Theater Capacity Utilisation rate %	SJGH Per Bed Theater Capacity Utilisation rate %
Monday	11.53	21.31
Tuesday	17.93	24.34
Wednesday	15.28	21.23
Thursday	22.88	18.02
Friday	18.41	21.91

Sri Jayewardenepura General Hospital had higher capacity utilization rates compared to CSTH throughout the week (Table 14). The highest utilization rate of 24.3% was shown on Tuesdays in SJGH, while 22.8% was the highest recorded utilization rate at

CSTH, which falls on Thursdays. The lowest utilization rates were seen on Mondays at CSTH, while the lowest utilization rate falls on Thursdays at SJGH.

A South African study on surgical theater utilization showed that utilization at private hospitals is better than that observed in public institutions. The range in public hospitals is typically between

30% and 40%, while in the studied private hospitals showed utilization of 48%, which is still well below the benchmarked range of 70 - 80% (Hartmann, 2013)

Table 3: Per-bed capacity utilization analysis.

Hospital	No of days studied	Mean utilisation per day (Min)	SD	Sig*
CSTH	30	167.5	104.12	0.040
SJGH	30	219.9	88.20	

In comparing capacity utilization, Sri Jayewardenepura General Hospital had a higher capacity utilization rate than Colombo South Teaching Hospital throughout the week (Table 14). The highest utilization rate of 24.3% was shown on Tuesdays in SJGH, while 22.8% was the highest recorded utilization rate at CSTH, which falls on Thursdays. The lowest utilization rates were seen on Mondays at CSTH, while the lowest utilization rate falls on Thursdays at SJGH. The mean per bed capacity utilization per day is 167.5 minutes per day at CSTH, while it is 219.9 at SJGH. The mean capacity utilization time difference per day was statistically significant at SJGH compared to CSTH (P=0.040). CSTH shows a standard deviation of 104.12, while SJGH shows a standard deviation of 88.20.

In his study on Operating Room Scheduling and Capacity Planning, Luis Vargas mentions that operating theaters excluding emergency services should maintain an estimated capacity utilization rate of 50-60% in the care of elective surgical patients (Vargas, 2009). In a study

carried out in India, studying standard operating rooms in sizeable public teaching hospitals, an average operating time of 10 hours and 31 minutes is recorded (Vinukondaiah, 2000). The above contributes to a total capacity utilization of 43%, which is higher than the findings of CSTH and SJGH.

Very few of the study findings were consistent with those of other studies done on utilization. Nevertheless, most of the findings differed from other studies due to distinct differences in the Sri Lankan setup from other countries. Most studies on utilization were carried out in a global scenario, while hardly any published research was carried out in the Sri Lankan scenario on utilization rates.

The relative importance of theater utilization factors as perceived by theater staff was assessed using a self-administered questionnaire. Being the overall decision makers, consultant surgeons were considered to assess the perception of theater staff regarding the importance of factors affecting utilization. Twenty-five were assessed, which were categorized into five domains as

mentioned above. Table 17 shows the scores achieved by consultants in the two hospitals concerning the perceived importance of factors affecting utilization. Consultants in the two hospitals under study did not significantly differ in scores obtained for perception in domain study ($p>0.05$). Therefore, all the responses were pooled in for factor-based domain analysis.

From CSTDH, seventeen practicing consultants were recruited for the study. Out of the seventeen consultant surgeons, thirteen were responsive, with a response rate of 76%. In SJGH, out of twelve recruited consultant surgeons, nine were responsive, with a response rate of 75%. It was observed that the 22 consultants who participated in the study reported different scores for the domains under study. Overall scores were high for domains on staff availability, equipment, training, and motivation; however, it was low for the time management domain. Therefore, mean scores reported by consultants for high scoring domains were compared against the low score domain of time management. This was done using a paired sample t-test. Consultants in both hospitals have not shown any significant difference in their scores obtained for Time Management and Equipment and Physical resource availability ($P=0.888$). Consultants in both hospitals have shown a significant difference in their scores obtained for Staff Management and Training needs ($P=0.000$). Consultants in both hospitals show a significant difference in their scores obtained for Time Management and Motivation of Staff ($P=0.000$). Consultants in both hospitals have shown a significant difference in their

scores obtained for Time Management and Equipment and Human Resource Availability ($P=0.000$).

Following these findings, it was understood that consultant surgeons in both hospitals did not recognize the importance of time management for utilization but training needs of the staff, motivation, equipment availability, and human resources.

Availability has higher importance in utilization. Many empirical studies have identified time management and proper administration and planning of theater proceedings as the most important factors for improved utilization. A study to understand scheduling concepts in operating theater functions identified that a clear schedule specifying starting time and ending time framework of surgeries is an effective way to improve the utilization of available theater time. (Saha, 2019). Another similar study on operation theater efficiency in the Netherlands identified the essential aspects of surgeons' perspective: effective scheduling and delay reduction. In this study, all surgeons have given priority to time management and scheduling similarly (Hans, 2012).

4 CONCLUSIONS

Various studies around the globe identified a significant correlation between theater start time and utilization. However, this study concludes that there is no relationship between operation theater start time delays and total utilization in both institutions.

This institution-based descriptive cross-sectional study was carried out to identify and compare the operating theater utilization pattern SJGH and CSTH. Both hospitals have similar utilization rates statistically, but in capacity utilization, which is a measurement of investment return, Sri Jayewardenepura Hospital shows a better statistically significant value in utilization. In addition, both hospitals have significantly low utilization rates compared to international benchmarks of 70% of the available time (Hartmann, 2013).

It was identified that consultants' perception of the importance of factors affecting utilization is more concerned towards human resource availability, motivation, training needs and equipment, and resource availability. They have given less importance to time management and related administrative functions even though the literature suggests the most crucial factor is time management and the related administratively modifiable factors (Gupta, 2011).

The utilization rates of both hospitals remain significantly low compared to international benchmarks. A short-term, medium-term, and long-term planning is required for improving operating theater utilization. Further studies need to be carried out to identify possibilities of improving capacity utilization in public hospitals to reduce the waste of large amounts of public money invested in infrastructure, utilities, and equipment. Therefore, more attention should be given by hospital administration as well as consultant surgeons to improving time management during the operating lists.

Time management had the least mean score and highest correlation to the factors affecting utilization. A thorough interventional study needs to be carried out to streamline the following factors.

- Cancellation of planned surgeries.
- Accurate prediction of procedure times in scheduling theatre lists.
- Convenient theater time schedules with other clinical work.
- Theater list start time.
- Patient turn over time.
- Patient transport time from wards.

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