

Performance Evaluation of Outsourced Medical Equipment Maintenance Service in a Tertiary Care Hospital

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Abstract- Outsourcing of non-core activities has become a growing trend in healthcare industry. It provides multiple advantages to the healthcare organizations, like increased operational efficiency, technical expertise & risk sharing. However at the same time is found to be associated with various types of risks. Periodic evaluation of the services provided by the third party service provider & matching them against set standards is primary requisite to mitigate occurrence of such risks. This study evaluated the performance of outsourced medical equipment maintenance service in a tertiary care teaching hospital by retrospective analysis of records. A set of Key Performance Indicators (KPIs) were used for this purpose. Outsourcing ensured high operational efficiency of the department in terms of high completion rates of planned preventive maintenance (PPM) and breakdown maintenance (BM) work orders(WO) as well as maintenance of equipment uptimes above 95%. User satisfaction score of 83.67% and Cost of service ratio(COSR) of 4.20% portrays outsourcing as a cost effective decision for the organization.

Index Terms- Breakdown Maintenance, Cost of Service Ratio, Key Performance Indicators, Planned preventive maintenance, Outsourcing

I. INTRODUCTION

Outsourcing can be defined as “transferring services or operating functions that are traditionally performed internally, to a third-party service provider and controlling the sourcing through contract and partnership management”. [3] Hospitals outsource their peripheral activities to specialized non-hospital organizations in order to ensure better focus of management over the core activities. It also ensures increase in operational efficiency, access to skilled expertise, better risk management, cost-effectiveness, flexible staffing as basic advantages. However if not properly managed, outsourcing decisions may lead to performance and financial risks.

KPI is the tool that enables service users to validate the performance of service providers & ensures that the services have met their contractual obligations. It can be used to ensure Service Delivery; to validate realization of benefits of Outsourcing; to trace the path of performance & to drive continuous improvement as well as innovation in provision of their services. For those KPIs which do not have any standard or benchmark for comparison, performance should be measured over time to identify and investigate significant trends & opportunities for improvement. [1]

Health-care facility regardless of its size should essentially have a maintenance program for medical equipment. Clinical engineering (CE) department or the medical equipment maintenance department in the hospital is responsible for implementation of such programs. The complexity of the maintenance program depends on factors such as the type of facility, its size and the resources required.[2] Basic functions provided by medical equipment maintenance department are preventive & breakdown maintenance, planning and purchase consulting, replacement planning, technical inventory management, acceptance tests, training, safety checks and functional control.

Performance of clinical engineering (CE) department in prior studies has been evaluated in terms of the ratio of total CE expenses and total equipment acquisition costs, full-time employees (FTEs) per beds, service time, equipment uptime etc. [7][8][9]

II. PERFORMANCE METRICS FOR EQUIPMENT MAINTENANCE DEPARTMENT

Performance evaluation was done using a set of Key performance indicators as the research tool. This study was done by defining KPIs, categorizing them according to the benefits of outsourcing, measuring them by retrospective study of departmental records, and finally the monthly performances for one year was evaluated by comparison with the Service Levels (SL) and empirical standards or by time series analysis in the form of control charts.

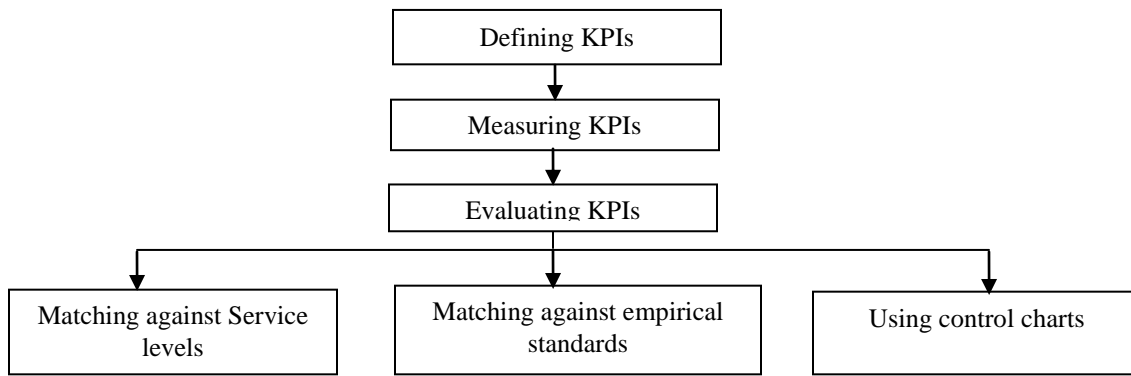


FIGURE1: Flow chart of performance evaluation methodology

A. DEFINING KPIs

Defining of KPIs was done by considering expert opinion captured by conducting nonstructural informal interviews with hospital's top management as well as with the technical manager and engineers in clinical engineering department. Thorough review of previous literature was done & framing of KPI was done using WHO guidelines for medical equipment maintenance program. [2]

B. CATEGORIZING KPIs

Indicators are classified into 4 categories based on core advantages of outsourcing i.e. operational efficiency, technical expertise, risk management, cost effectiveness

OPERATIONAL EFFICIENCY

A) Related to planned preventive maintenance (PPM)

- Completion rates for PPM
- PPM yield

B) Related to breakdown maintenance (BM)

- Mean Time To Repair(MTTR)
- Equipment downtime
- Obtaining time for spare parts
- Completion rates for BM

TECHNICAL EXPERTISE

- Devices supported per technical staff
- Percentage technical staff
- Percentage of clinical engineer
- User training
- Training of technical staff

RISK MANAGEMENT

- No. of incident report per month
- Uptime for life saving equipments
- No. of critical equipment work order

COST EFFECTIVENESS

- Cost of Service Ratio(COSR)

C. EVALUATING KPIS

Performance evaluation is done in following 3 ways:

- i. Matching of KPIS against the normative standards (i.e. service levels as specified in organizations Service level agreements)
- ii. Matching of KPIS against empirical standards [2]
- iii. Evaluation using control charts, in case of KPIS for which SLs & empirical (universal) standards were not defined or unavailable

USER SATISFACTION ANALYSIS

To ensure the validity of repository data, retrospective analysis of 93 user satisfaction forms was done on eight criteria mentioned in the user satisfaction form.

- i. Accessibility of service engineer
- ii. Response of breakdown calls
- iii. Response to emergency calls
- iv. Quality of repair(Repeated failure)
- v. Quality of PPM
- vi. Feedback on Equipment status
- vii. Courteousness of Service Personnel
- viii. Overall satisfaction

III. RESULT ANALYSIS WITH GRAPHS

1) Operational Efficiency

TABLE1: KPIS (Operational Efficiency)

Month	PPM completion rates (%)	PPM Yield (%)	BM completion rates (%)	Equipment uptime	MTTR (in minutes)	Spare part obtaining time(in days)
May13	98.17	1.83	90.03	97.69	38.43	9.12
Jun13	98.96	1.04	91.45	97.7	48.22	6.98
Jul13	97.71	2.29	89.53	97.76	55.6	7.12
Aug13	96.76	3.24	86.93	98.01	37.3	5.97
Sep13	98.38	1.62	90.03	98.52	44.6	6.63
Oct13	98.32	1.68	91.07	98.69	22.64	7.47
Nov13	97.33	2.67	90.38	98.75	52.24	8.92
Dec13	95.52	4.48	94.14	98.68	16.78	7.95
Jan14	97.99	2.01	95.9	98.54	48.26	6.1
Feb14	95.13	4.87	96.45	99.0	28.94	9.53
Mar14	97.19	2.81	95.31	99.09	53.64	3.76
Apr14	96.83	3.17	94.64	99.0	39.58	7.76
Mean ± Standard deviation	97.35±1.15	2.64±1.15	92.15±3.02	98.45±0.52	40.51±12.45	7.27±1.59

PPM Completion Rates

A good completion rate goal is to be above 90% [2]

PPM completion rates for all the months are above 90% indicating good performance

PPM yield

Evaluation of this KPI is done using control charts. Values for all the months are under the control limits indicating stable performance. No violation of control rule is found (Fig2)

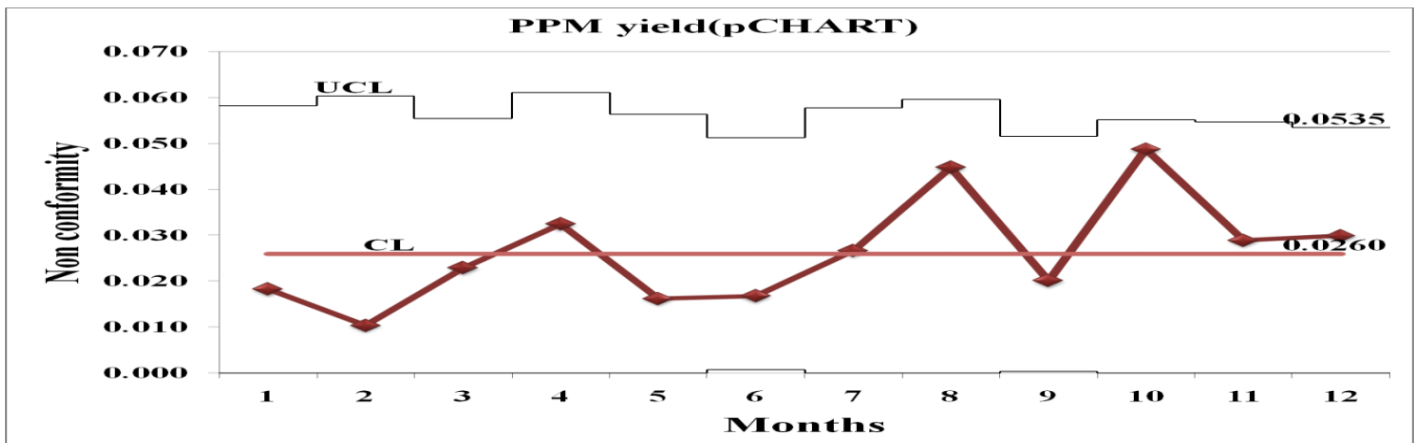


FIGURE2: PPM YIELD (p-CHART)

BM Completion rate

A good completion rate goal is to be above 90% [2]
 All BM rates are above 90%, except for the month of July13 & August13

Equipment Uptime

Equipment uptimes for all the months are above 95% irrespective of the age of equipment Performance not only matches the service levels, but there is progressive increase in the performance over the months.

Service Level (SL)

Outsourced service provider caters to following three service levels pertaining to **equipment uptimes**.

TABLE2: Service Levels for Equipment Uptime

SL no.	Age of Equipment	Equipment Uptime
1	Less than 3 years	95%
2	3-8 years	90%
3	Above 8 years	85%

MTTR (Mean Time To Repair)

Performance is evaluated using individual control charts & values for all months are under control limits, there is no violation of control rules as well (Figure 3)

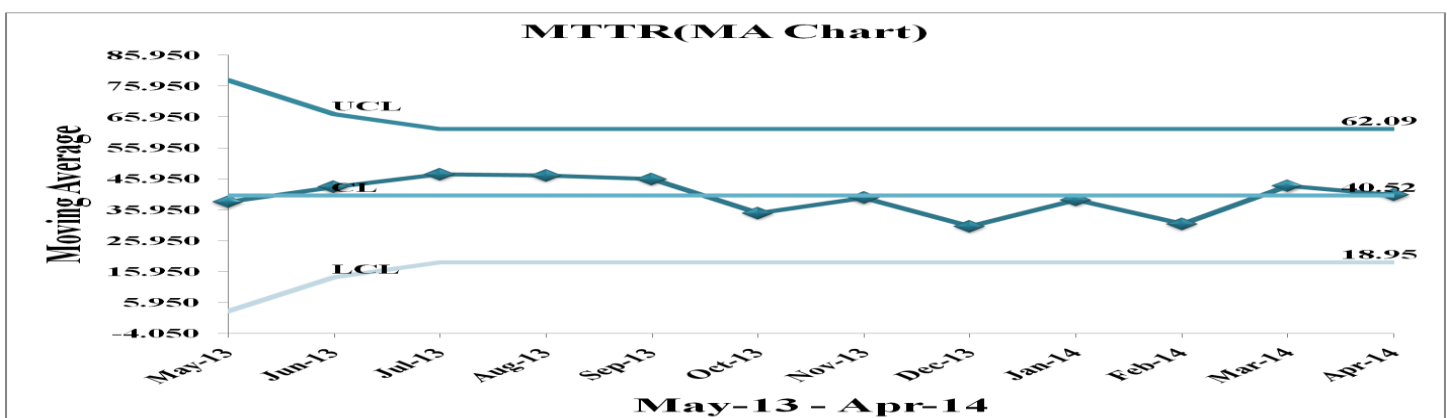


FIGURE3: MTTR (MA-CHART)

Spare Part Obtaining Time

Spare parts obtaining time is applicable to those spares which are unavailable at department stores & are ordered from head quarters. Performance is evaluated using individual control charts & values for all months are under control limits, there is no violation of control rules as well (Figure4)

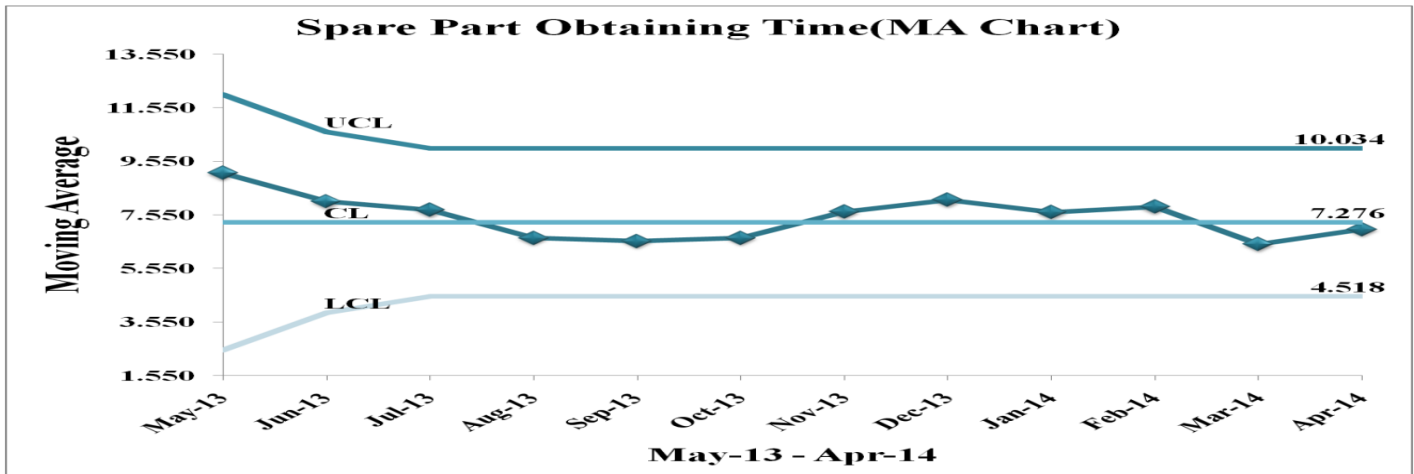


FIGURE4: Spare Parts Obtaining Time (MA-CHART)

2) Risk Management

TABLE3: KPIs (Risk Management)

Month	Equipment uptime (%)	Critical Equipment Work orders (%)	Incident Reports
May13	97.69	9.97%	1
Jun13	97.7	12.09%	2
Jul13	97.76	11.05%	5
Aug13	98.01	9.54%	4
Sep13	98.52	11.84%	5
Oct13	98.69	11.61%	6
Nov13	98.75	16.03%	6
Dec13	98.68	8.98%	3
Jan14	98.54	16.04%	4
Feb14	99.0	9.47%	6
Mar14	99.09	25.00%	5
Apr14	99.0	17.26%	5

Life Saving Equipment Uptime

Equipment uptime for all the months is above 95% irrespective of the age of equipment. Thus the performance matches the service level.

Critical Equipment Work Orders

Performance is evaluated using control charts. All values are within control limits except for the month of March14 where WOs were 80. No other value violates the control rule. Performance can thus be interpreted as fair performance. (Figure5)

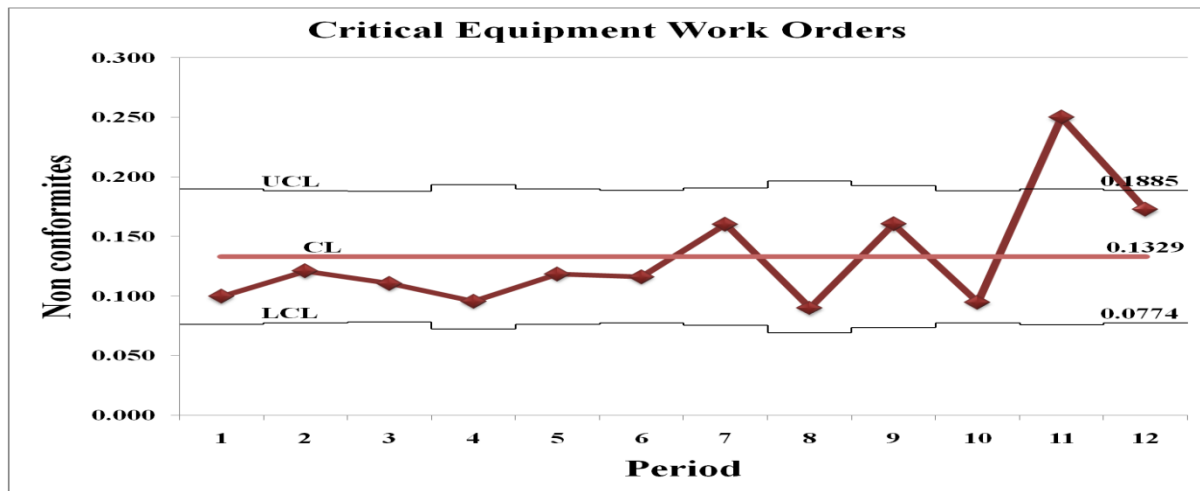


FIGURE5: Critical Equipment Work Orders (p chart)

Incident Reports

Performance is evaluated using control charts. No violation of control rules is indicative of good performance (Figure6)

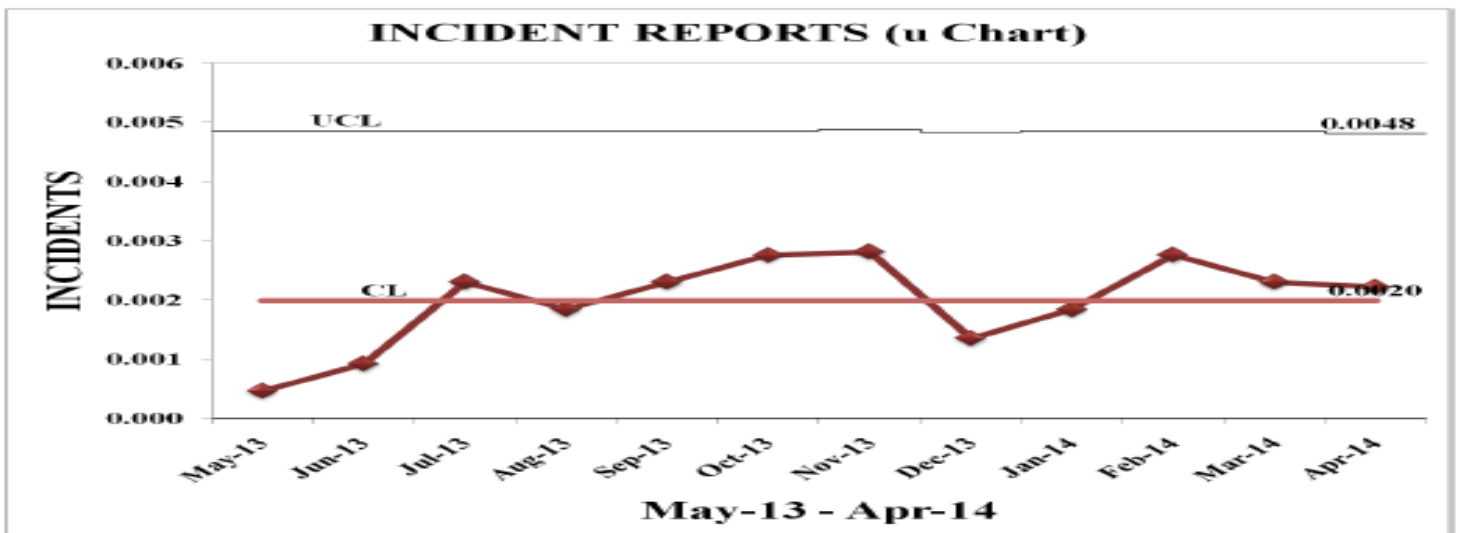


FIGURE6: Incident Reports (u-CHART)

4) Technical Expertise

- i. Percentage Technical staff - 90.0%
- ii. Percentage clinical engineer - 90.0%
- iii. Device supported per technical staff (KH Equipments) – 361.11
- iv. User training programs (in 2013) - 10
- v. Continued Nursing education training – 627
- vi. Staff training programs (in 2013) – 12

Above mentioned indicators shows that outsourcing adds up to the technical expertise not only to the staff involved in the maintenance of equipment but also the hospital staff (i.e. the users of medical equipments), by providing them with adequate training. Training was provided to users on topics such as Care & Maintenance of equipment, Infusion pumps, Cardiac Monitors, Defibrillators, Electrosurgical units, ventilators. Training imparted to staff included induction and orientation at the time of joining the organization , followed by training on various other topics including standards in healthcare engineering, administration aspect of clinical engineering, equipment related training.

5) Cost Effectiveness

$$\begin{aligned} \text{Cost of Service Ratio} &= (\text{Maintenance cost/Equipment Acquisition Cost}) * 100 \\ &= (14884398.1 / 354390431) * 100 \\ &= 4.20 \% \end{aligned}$$

COSR equivalent to 4.20% can be considered as cost effective decision as literature supports COSR of 8% ranging from 6% to 12% .[30]

USER SATISFACTION ANALYSIS

User’s perspective of the service provided by the outsourced department was analyzed by evaluating the user satisfaction forms for that year. Analysis of 93 user forms was done based on 8 criteria. Scoring is as follows

- 100 – very good
- 75 – good
- 50 – average
- 25 – poor
- 0 – very poor

Category wise & overall user satisfaction scores were calculated.

TABLE4: Category Wise User Satisfaction Score

CATEGORIES	Score	Category wise satisfaction score
Accessibility of service engineer	8075	86.83%
Response of breakdown calls	7875	84.68%
Response to emergency calls	7775	83.60%
Quality of repair(Repeated failure)	7375	79.30%
Quality of PPM	7425	79.84%
Feedback on Equipment status	7700	82.80%
Courteousness of Service Personal	8300	89.25%
Overall satisfaction	7725	83.06%
Total score (74400)	62250	83.67%

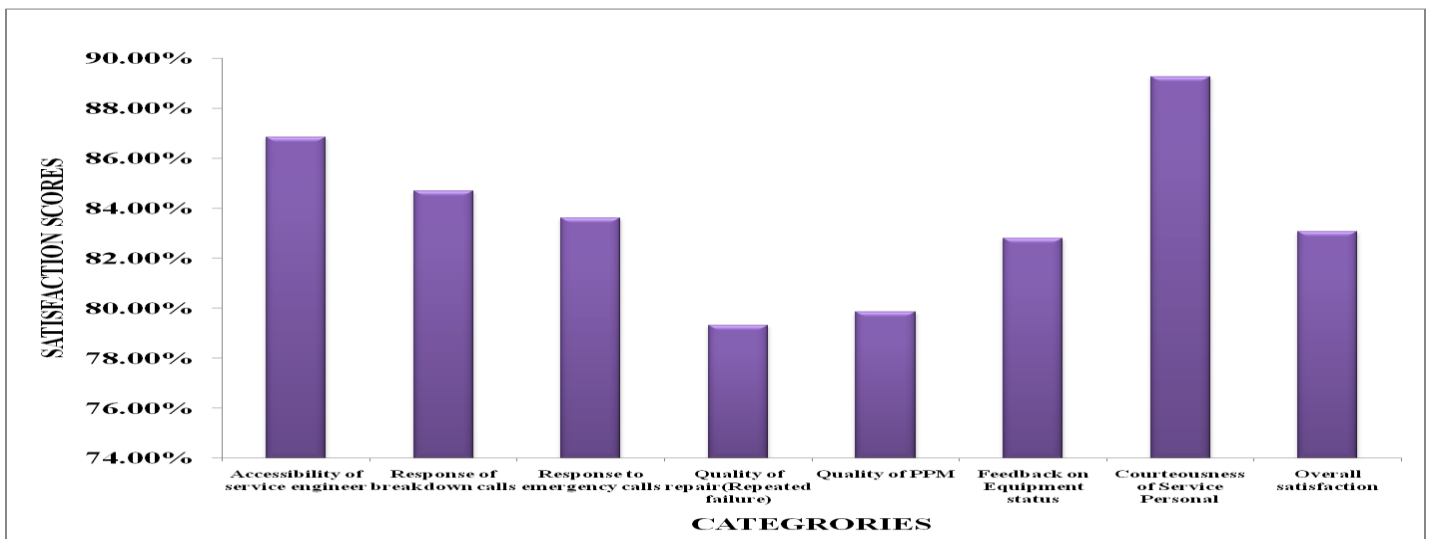


FIGURE7: Bar Graph (User Satisfaction)

IV. CONCLUSION

The key issue in successful management of outsourcing contract is to measure the performance of outsourcing service provider's, to ensure that all the agreed outcomes are achieved. As the very famous business axiom says "If you cannot measure it, you cannot manage it". This study focuses on measuring the performance of outsourced service, aimed basically at quantifying the extent to which benefits of outsourcing viz. operational efficiency, technical expertise, risk sharing are achieved in the organization.

Study results showed good performance indicators in all the categories. Completion rates (both BM & PPM) above 90% with an average of 92.15% and 97.35% respectively. Average monthly equipment uptime for all equipment is 98.45% & 98.05% for lifesaving equipment indicating that the service levels are achieved successfully throughout the year. Good technical expertise can be expected from service providers as 90% of the department staff are clinical engineers. COSR of 4.20% can be stated as cost effective outsourcing decision. Although there minor non-conformities were identified in terms of critical equipment working orders, overall outsourcing performance can be considered satisfactory. Above concluded facts are well supported by a user satisfaction rate of 83.67%. Detailed studies can be done further to find out the user's perspective of the outsourcing service quality, by using tools such as SERVAQAUL to identify gaps. This will lead to development of a proactive management system. Root cause analysis of individual indicator can be done to further device strategies to minimize such occurrences.

APPENDIX

FORMULAE FOR KPIS

I. PPM completion rates

The completion rate is percentage of procedures completed

PPM completion rate = (Number of PPM completed/Number of PPM schedule)*100

II. PPM Yield

PPM yield is the percent of scheduled PPM procedures performed where problems were found that affected equipment operation or safety

PPM yield = (Number of WO in which problems identified/PPM scheduled)*100

III. Mean Time to Repair

Average of all repair time (The time between the start and finish of repair)

IV. Equipment Downtime

The percentage of time that a device is out of service

Equipment downtime = (No. of hours equipment was out of service/total available time)* 100

V. Spare Parts obtaining Time

Time elapsed between making a purchase requisition for spare part and the time when spare part is received.

VI. BM completion rates

The completion rate is percentage of procedures completed

BM completion rate = (Number of BM completed/Number of BM schedule)*100

VII. Cost of Service Ratio (COSR)

The ratio of the total cost of service to total equipment acquisition cost is sometimes called the Cost of Service Ratio (COSR)

Cost of Service Ratio = (total cost of service/total equipment acquisition cost)* 100

REFERENCES

- [1] Joseph F. Dyro, "Clinical Engineering Handbook"^{1st} ed..London: Elsevier Academic Press2004, pp.207-210.
- [2] " Medical equipment maintenance programme overview", WHO Medical device technical series 2011.
http://www.whqlibdoc.who.int/publications/2011/9789241501538_eng.pdf. Retrieved 2013-11-14.
- [3] Velma , "Managing Strategic Outsourcing in the Health care Industry", *Journal of Health care Management*,Vol 46; pp.239-249, 2001.
- [4] S.J.Tabibi,M.J. Kakhani, E.Ehsani-Chime , "Evaluation of outsourcing's strategy in supportive services of Ministry of health and medical education's hospitals", *Journal of Health Administration*, Vol 10 Issue 30,pp.59-66, 2007.
- [5] M.Ferdosi , E.Farahabadi, M.Mofid et al, "Evaluation of Outsourcing in Nursing Services: A Case Study of Kashani Hospital, Isfahan in 2011. *Sociomed*,Vol25 Issue1;pp- 37-39, 2013.
- [6] R. Magnezi, M.Kedem, H.Reuveni, "Outsourcing of primary care: satisfaction level in the Israeli Defense Forces" *Military medicine* ,Vol 169 Issue5;pp-379-84,2004.
- [7] B.Wang , W.Richard ,Eliason, S.Vanderzee, "Global Failure Rate: A Promising Medical Equipment Management Outcome Benchmark" *Journal of clinical engineering* , Vol31issue3;pp-145-151,2006.
- [8] B.Wang, "Clinical engineering benchmarking: An analysis of american acute care hospitals" *J Clin Eng*,Vol33Issue1;pp-24-27,2008.

- [9] A.M.I. Cruz, S.P. Perilla, N.N. Pabón, “ Clustering techniques: measuring the performance of contract service providers” *IEEE Eng Med Biol Magazine*. Vol29 Issue2;pp-119-26,2010.
- [10] M.Musakhani , A.Nayebi , J.Bakhshi, “ Presented a proposed methodology for evaluating the performance of suppliers in the outsourcing process” *J Knowledge Management*. Vol20 Issue77;pp-123–138, 2007.
- [11] S.J. Maschuris, M.N .Kondylis, “ Outsourcing in public hospitals: A Greek perspective”, *Journal of Health Organization and Management*.;Vol20 Issue1:pp-4–14, 2006.
- [12] A.S. Preker,A.Harding, “ Innovations in Health Service Delivery: The Corporatization of Public Hospitals” *World Bank Publications*, 2003.
- [13] S.Witter ,T. Ensor, M.Jowett , R.Thompson , “ Health Economics for developing Countries. Institute For Management and Planning Studies”;pp. 312–315, 2004.
- [14] K. Patrick. A.Lynch “reliable metric for evaluating the financial performance of an HTM department”. *Technation magazine*,
<http://www.1technation.com/expert-advice-measuring-cost-service>.

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