

# Time Series Forecasting of Postponement Rates in Operation Theaters of Advanced Eye Centre -A Robust Optimization Strategy

Momia Yashpal<sup>1</sup> (*corresponding Author*), Gupta Anil<sup>2</sup> (*Co-Author*) Koushal Vipin<sup>3</sup> (*Co-Author*) Kumar Ashok<sup>4</sup> (*Co-Author*) Talati Shweta<sup>5</sup> (*Co-Author*), Bhagat Hemant<sup>5</sup> (*Co-Author*), Singh Ranjana<sup>6</sup> (*Co-Author*)

**Abstract Background** Hospital contributes significant Tangible and Intangible resources on a concurred plan by scheduling of surgery in OT List. Postponement decreases efficiency by declining throughput leads to wastage of resources hence burden to the nation. Patients and their family face economic and emotional implication due to postponement. Postponement Rate being a quality indicator, control check mechanism could be developed from the results. Postponement of elective scheduled operations results in inefficient use of operating room (OR) time on the day of surgery. Inconvenience to patients and families also caused by postponements. Moreover, day of surgery (DOS) postponement creates logistic and financial burden associated with extended hospital stay and repetitions of pre-operative preparations to an extend of repetition of investigations in some cases causing escalated costs, wastage of time and reduced income. **Methodology** A cross sectional study was done in the operation theaters of a tertiary care hospital in which total ten operation theaters of General Surgery Data of scheduled, performed and postponed surgeries was collected from all the operation theater with effect from march 1<sup>st</sup> to September 30<sup>th</sup> 2018. A questionnaire was developed to find out the reasons for the postponement for all hospital's stakeholders (Surgeons, Anesthetist, Nursing officer) and they were further evaluated Time series analysis of scheduling of Operation Theater for Moving average Technique. **Results** Total 12,139 surgeries were scheduled and 10,660 surgeries were postponed and 1,479 surgeries were performed with postponement rate of 12.18 % in Eye surgery OTs during study period. Month wise postponement Rate exponential smoothing of time series data shows the dynamic of operating suits. To test the throughput Postponement Rate was plotted the postponed surgeries and on regression analysis to test perfect linear relationship relation.

**Index Terms—** Moving Average, Exponential Smoothing, Regression Analysis, ARIMA, Opera, Optimization, Operation Theater Postponement Rate

## 1 INTRODUCTION

Hospital contributes significant Tangible and Intangible resources on a concurred plan by the scheduling of surgery in OT List. Postponement decreases efficiency by declining throughput leads to wastage of resources hence burden to the nation. Patients and their family face economic and emotional implication due to the postponement. Postponement Rate being a quality indicator, control check mechanism could be developed from the results. Postponement of elective scheduled operations results in inefficient use of operating room (OR) time on the day of surgery. The efficiency of Operation Theater depends on the constant flow of the patients to fulfill its capacity. The throughput of the theater is declined due to the delay in the postponement of surgery resulting in wastage of resources. Level and reason of postponement can be established through a study. Implementation strategy (action plan) to minimize the postponement of surgery may be formulated through this information. The late postponement is a waste of,

material, money, time and Human resources hence is a burden to the Nation. Postponement of scheduled surgeries Increases costs Diminishes Efficiency Duplicates workload

Squanders Operating Room Time Increases patient's out of pocket expenditure due to Overstay Redundancy in peri-operative course of action and Management Numerous Deliberates have proposed many ways of making strides of proficiency by guarantying Maximum Utilization, Minimizing Over-running, Minimizing Postponement. Patients and their families face economic and emotional implications for a postponement if the case is canceled. When the cases are postponed more than half of family members of patients miss at least 1 day at work. Operating room utilization is defined as the measure of the use of an operating room that is properly staffed with people needed to successfully deliver a surgical procedure to a patient. Many postponements are often due to non-medical problems such as a full ICU, surgeon unavailability, or bad weather and postponement rates can be monitored statistically. Elective surgery cancellations always lead to insufficient utilization of manpower and hospital resources and can also lead to an increase in patients treatment expenses due to a prolonged hospital stay and in many cases, repetitions of pre-operative preparations and management<sup>1</sup>. The delays and postponements specifically lower the morale among the staff, patients, and relatives and may reflect as a

- *Corresponding Author Dr. Yashpal Chander Momia is currently pursuing Master in Hospital Administration (MHA) degree from Post Graduate institute of Medical Education and Research, Chandigarh [India], PH+91-989-963-52005. E-mail: dryashpalmomia@gmail.com*
- *Co-Author Dr. Shweta Talati is assistant professor Hospital Administration PGIMER Chandigarh [India], E-mail: talatishweta@gmail.com*

decreased productivity in their workplaces.<sup>4</sup> There is a need for the healthcare teams to encourage cost-effectiveness in every aspect of patient care. Therefore, avoidance of unnecessary cancellation of elective surgery should lead to a reduction in the overall cost of the treatment.<sup>7</sup> Cancellation is a major problem in most hospitals.<sup>8</sup> It is an inconvenience, which has a significant ripple effect.<sup>15</sup> Cancellation of cases on the scheduled day of surgery leads to inefficient utilization of manpower and scarce resources.<sup>21</sup> Cancellation of elective operations is a parameter to assess the quality of patient care and quality of management system.<sup>18</sup> Hence, this is one criterion for evaluating the efficiency of surgical service which has the low rate of cancellation of operations, which compels the hospital management to demonstrate the good performance.

**RESEARCH METHODOLOGY**

**RESEARCH SETTING:** The study of postponement of scheduled surgeries was done in Main OT located at Nehru Hospital, Cardiac OT located in the Advanced cardiac center (ACC), Pediatric Operation Theater complex located in Advanced Pediatric center (APC), and an Eye Operation theater located in Advanced Eye Center (AEC). Bed compliment of Nehru hospital is 949, Advance Pediatric Centre is 243 and Advance

**Table 1 Abbreviations**  
Cardiac Centre is 208, and advance eye center is 101 respec-

| <i>NAN</i>  | <i>Not Actual Number</i>       |
|-------------|--------------------------------|
| <i>MAPE</i> | Mean Absolute Percentage Error |
| <i>MAD</i>  | Mean Absolute Deviation        |
| <i>MSD</i>  | Mean Squared Deviation         |
| <i>d.f.</i> | Degree of Freedom              |
| <i>SS</i>   | Sum of Square                  |
| <i>MS</i>   | Mean Square                    |

tively. Main Operation theatre complex situated on 4th and 5th floor of Nehru Hospital, Pediatric, Cardiac operation theatre complex and Eye OT.

**RESEARCH DESIGN:**

This study was conducted from March 1<sup>st</sup> to September 30<sup>th</sup>, 2017. It was a cross-sectional study. Study tools: Questionnaire/opinion sheet was used. It included a semi-structured Performa by which information and data were obtained through the communication with the Doctors and Nursing officer.

**SAMPLING TECHNIQUE DATA COLLECTION:**

Observation was done only for the scheduled cases enlisted for a specific day. The List of surgeries was generated before 8 pm on the previous day. Data for scheduled, performed and postponed surgeries were collected for seven months. The observation was not made during holidays, as routine cases were not scheduled on those days. A universal sampling technique was adopted to select the one surgical specialty for each day since there are ten surgical specialties (twelve working days for each department thus data from the various stakeholder was taken for total 120 days). The opinion regarding the postponement was taken from various stakeholders (anesthetist, surgeon and staff nurse) was done by using a ques-

tionnaire/ opinion sheet, after obtaining the informed consent In case of different opinion regarding the postponement of the same case, consensus was arrived by the discussion among surgeon, anesthetist, staff nurse and Hospital administrator and final opinion was entered in Annexure B. Postponement rate was calculated by dividing total number of surgeries postponed on day of surgery by the total no. of scheduled surgeries on that day multiplied by hundred. Data were compiled into two major groups that are Hospital related and patient-related causes of postponement and they were further classified into avoidable and non-avoidable causes of postponement. Statistical analysis was done with the help of SPSS version 22, and stat pus application.

**EXCLUSION CRITERIA:** All the cases posted as unlisted cases or emergency cases.

**DATA ANALYSIS TECHNIQUE:** The data collected was analyzed by using, a descriptive statistical method to describe sample characteristics in terms of frequency, mode, and percentage, moving average, exponential smoothing, Regression analysis, and modeling techniques were used to interpret the data. Following abbreviations were used to interoperate the data.

**ETHICAL JUSTIFICATION**

This was a cross-sectional study to study the causes of postponement of scheduled surgeries. The confidentiality of any patient or the institution was not be breached evolving any ethical issue. Treatment did not be altered delayed deprived when the study was undertaken. The study did not affect the procedure, process, and outcome of the ongoing treatment of the patient. A study in no way involves and experimentation on human no intervention procedure was carried out as apart of study. The ethical issues in the study had been paid due attention to and the study did not delay any patient of required investigation or treatment. Freedom of expression and un-indentured use of information generated victimization of participants and threats were taken care with special attention and due regards as per recommendation during the approval from Institutional Ethics committee.

**OBSERVATION AND RESULTS**

Postponement cause study for the scheduled surgeries was conducted in the operation theaters of PGIMER Chandigarh. Data from the operation theaters was collected w.e.f 1st March to 30 September 2017. During this period there were total 174 working days and total ten surgical departments hence 1740 observations were recorded for scheduled performed and postponed surgeries. During this period 26,662 surgeries were scheduled 21,805 surgeries were performed and 4837 surgeries were postponed and postponement Rate was 18.22% all over the institute. Total 12,139 surgeries were scheduled and 10,660 surgeries were postponed and 1,479 surgeries were performed with postponement rate of 12.18 % in Eye surgery OTs. Postponement rate was calculated by using the formula as under.

Postponed Surgeries

$$\text{Postponement Rate} = \frac{\text{Postponed Surgeries}}{\text{Scheduled Surgeries}} * 100$$

Month-wise postponement rate of scheduled surgeries in Advance Eye Center Surgeries is graphically represented on time trend in Fig 1. Postponement rate increases from 9.99 % to 11.62 % from the month of March to April 2017 then increases to 12.37 % in the month of May and 12.36 % in the month of June. Postponement rate decreases to was 12.35% in the month of July and then increases to 14.65% and 12.49% in the month of August and September respectively. All Advance centers showed the synchronicity between increase and decrease in the postponement Rates of the surgeries on monthly trend.

On the ground of data for the month of March, April May and June the forecasted value for the postponement rate during the month of **July was 11.33 %**, for the **August it was 12.12%**, and for the **September 12.36%**. Forecasted postponement Rate increased from July to August and then also from August to September as seen in actual that is increased from **12.35% in July to 14.65% in August** but in contrast to increasing in forecasted it actually decreased to **12.49% in September 2017**. August.



FIG 1 MOVING AVERAGE MONTH WISE FORECASTING OF POSTPONEMENT RATE

| Month     | Actual Value | Forecast | Standard Error |
|-----------|--------------|----------|----------------|
| March     | 9.99         |          |                |
| April     | 11.63        |          |                |
| May       | 12.37        | NaN      | NaN            |
| June      | 12.36        | NaN      | NaN            |
| July      | 12.35        | 11.33    | NaN            |
| August    | 14.65        | 12.12    | NaN            |
| September | 12.49        | 12.36    | 0.61625        |
| October   |              | 13.12    | 0.89417        |
| November  | -            | 13.16333 | 0.96512        |

Table 2 Table Moving Average Forecasting of Postponement Rates

On the application of exponential smoothing forecasting technique of time series analysis with Alfa value 0.5 shows operation theater remained well optimized and smoothed in the month of April ,May, June, July and September by generating Residual less the One and further be smoothed by appropriate planning with reallocation of Human Resources and List of operation theater can be formulated with respect to availability of surgeons and time in the months of March and August as shown in fig 2.

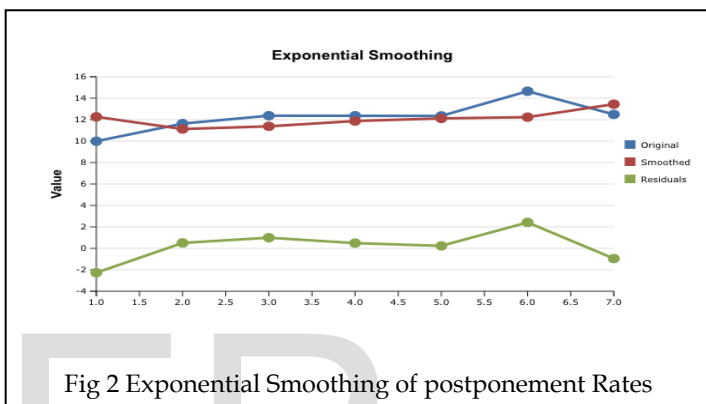


Fig 2 Exponential Smoothing of postponement Rates

Table 3 Exponential Smoothing of Postponement Rates

| Month     | Original | Smoothed | Residuals |
|-----------|----------|----------|-----------|
| March     | 9.99     | 12.26286 | -2.27286  |
| April     | 11.63    | 11.12643 | 0.50357   |
| May       | 12.37    | 11.37821 | 0.99179   |
| June      | 12.36    | 11.87411 | 0.48589   |
| July      | 12.35    | 12.11705 | 0.23295   |
| August    | 14.65    | 12.23353 | 2.41647   |
| September | 12.49    | 13.44176 | -0.95176  |

On the perusal of the formula for calculating the Postponement Rate.

$$\text{Postponement Rate} = \frac{\text{Postponed surgeries}}{\text{Scheduled surgery}} * 100 \dots (1)$$

$$\text{Postponement Rate} = \frac{\text{Scheduled} - \text{Performed}}{\text{Scheduled surgery}} * 100$$

The postponement rate is directly proportion to the

postponed surgeries in equation (1) and inversely proportional to the scheduled surgeries in standard performance. Scheduling is an input indicator, Performed surgeries is an output indicator then throughput is tested through postponed surgeries plotted against Postponement rate in a scatter diagram by Regression methods.

**• Throughput Indicators**

- Postponed surgeries (Independent Variable)
- Postponement Rate (Dependable Variable)
- **Hypothesis:** Postponement Rates has perfect Linear Relationship with the postponed surgeries.
- **Null Hypothesis (H0):** Postponement Rates does not have the perfect linear relationship with the postponed Surgeries

**Linear Regression Advanced Eye Centre**

On the perusal of the p-Value 0.29718 the intercept and 0.22623 for postponed surgery, which is more than 0.05 IN table 4 we

**Table 4 ANOVA for Postponed surgeries with postponed rates**

|                        | <i>d.f.</i>        | <i>SS</i>             | <i>MS</i>  | <i>F</i>   | <i>p-level</i> |                |                |
|------------------------|--------------------|-----------------------|------------|------------|----------------|----------------|----------------|
| <i>Regression</i>      | 1                  | 3.12771               | 3.12771    | 1.90314    | 0.22623        |                |                |
| <i>Residual</i>        | 5                  | 8.21723               | 1.64345    |            |                |                |                |
| <i>Total</i>           | 6                  | 11.34494              |            |            |                |                |                |
|                        | <i>Coefficient</i> | <i>Standard Error</i> | <i>LCL</i> | <i>UCL</i> | <i>t Stat</i>  | <i>p-level</i> | <i>H0 (5%)</i> |
| <i>Intercept</i>       | 5.62554            | 4.83558               | -6.80472   | 18.0558    | 1.16336        | 0.29718        | Accepted       |
| <i>Postponed cases</i> | 0.03141            | 0.02277               | -0.02712   | 0.08995    | 1.37954        | 0.22623        | Accepted       |
| <i>T (5%)</i>          | 2.57058            |                       |            |            |                |                |                |

**Table 5 Comparison of regression results with other Advanced Center**

| <i>Advanced center</i> | <i>P Value</i> | <i>H0</i>        | <i>Contribution to PPR</i> |
|------------------------|----------------|------------------|----------------------------|
| <i>APC OT</i>          | 0.00032        | Rejected         | Throughput                 |
| <i>ACC OT</i>          | 0.01938        | Rejected         | Throughput                 |
| <i>AEC OT</i>          | 0.22623        | Failed to Reject | Input (Scheduling)         |

Rates, does not have the perfect linear relationship with the postponed Surgeries.

Postponement rate also depends on the input factor that is scheduled surgeries. As seen in the formula for calculating the Postponement Rate.

**Discussion**

Postponement of scheduled surgeries results in increased consumption of various tangible resources like Financial Resources, Organizational Resources, Physical Resources, Technological Resources, The organization's borrowing capacity, ability to generate internal funds, formal reporting structure and its formal planning, controlling, and coordinating systems. In addition to this Sophistication and location of a hospital's plant and equipment, Access to raw materials; Stock of technology; such as patents; trademarks; copyrights, and trade secrets; take a toll. The postponement not only impact tangible resources but also to intangible resources like Human resources, Innovation, Knowledge, Trust, Managerial capabilities, Organizational routines, Ideas, Scientific capabilities; Capacity to innovate; Reputation with beneficiaries; Brand name, Perceptions of quality; durability and reliability; Reputation with stakeholder for efficient; effective; supportive; and mutually beneficial interactions which causes depreciation of institute. These factors seem unnecessary in public sector hospital however corporate hospitals have deemed necessary for formulating different strategies to minimize postponement in constrained recourse in developing nations. During analysis of postponement causes it appears that in 80% postponements of scheduled surgeries were due to delay in previous surgery, changing patient health state, not contactable, failure to arrive, scheduling Emergency operation, were responsible. It was also observed that among the postponed surgeries 63.67 % of

cases were due to avoidable reasons as also suggested by Hanna et al that elective procedure were potentially avoidable and may be prevented using quality improvement techniques. Maximum postponements rates are observed during the month of May that may be due to the vacation of the faculty.

failed to reject the null hypothesis that is Postponement



## CONCLUSION

It was evident from our study that surgical postponement rate is relatively lower than other studies conducted in India and abroad. Our study also concluded that only five reasons that are Delay in Previous Surgery, Scheduling Emergency Operation, Changing patient health status, Incomplete preoperative Diagnosis and Patient absent are responsible for the 80% postponement of scheduled surgeries. Among all postponement of scheduled surgical cases, sixty-three percent was avoidable.

The tasks, of all of the information necessary for defining the pathway, the human resources involved, the timing and duration of each elementary task, and the specific expected occupation time of the OR, were assessed. The model that was created for this study is original in that, on the one hand, it integrates a standardized pathway that is simple, but it also contains all of the elements of variability. On the other hand, it feeds from a "waiting list database", with the objective of ending in an optimized allocation of OR resources for registered patients (taking into account their urgency code, in a real-time manner). Lastly, the process between the waiting list and the OR scheduling is inter- active, bi-directional, and dynamic, and is a new approach to two major challenges in modern hospitals.

Further research and studies are necessary. They must address, for example, the precise execution and implementation of the business process. Furthermore, the same modeling could be used for other operative sectors and then extended, in our case, to the entire facilities in the Institute.

## RECOMMENDATION

- Advanced surgical center Operation Theaters who has predictable postponement rates and can be further well optimized by taking appropriate operation research techniques like Linear Programming, Discrete Event Simulation Modeling with Network Analysis.
- **Auto Regression Integrated With Moving Average (ARIMA)** models are also very useful to eliminate the residue by streamlining internal processes after the process flow analysis of department. Residuals in exponential smoothing can be eliminated by the algebraic equations through the linear programming on the result of Data Envelopment Analysis of suggestions from various stakeholders.
- **Value Stream Mapping** (flow chart) of the processes of the surgical department in integration with diagnostic and support services.

- **Value Time analysis** will further help to identify the bottlenecks and waste can be eliminated accordingly.

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