

EXPONENTIAL SMOOTHING OF POSTPONEMENT RATES IN OPERATION THEATRES OF ADVANCED PEDIATRIC CENTRE - TIME SERIES FORECASTING WITH REGRESSION ANALYSIS

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Abstract— Background Hospital contributes significantly tangible and intangible resources on a concurred plan by the scheduling of surgery on the 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 controls check mechanism could be developed from the results. Postponement of elective scheduled operations results in inefficient use of the operating room (OR) time on the day of surgery. Inconvenience to patients and families are also caused by postponements. Moreover, the day of surgery (DOS) postponement creates logistic and financial burden associated with extended hospital stay and repetitions of pre-operative preparations to an extent 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 1st to September 30th, 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 958 surgeries were scheduled and 772 surgeries performed were and 186 surgeries were postponed with a postponement rate of 19.42% in the cardiac surgery department during the study period. Month-wise postponement Rate exponential smoothing of time series data shows the dynamic of operating suits. To test throughput Postponement rate was plotted the postponed surgeries and on regression analysis is in a perfect linear relationship.

Index Terms— Moving Average, Exponential Smoothing, Regression Analysis, ARIMA, DES, Operation Research, Forecasting, Optimization, Scheduled surgeries Forecasting.

I. BACKGROUND

Hospital contributes significantly tangible and intangible resources on a concurred plan by the scheduling of surgery on the 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 controls check mechanism could be developed from the results. Postponement of elective scheduled operations results in inefficient use of the 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 cause of postponement can be established through a study. Implementation strategy (action plan) to minimize the postponement of surgery may be formulated through this information. A late postponement is a waste of, material, money, time and human resources hence are the burden of the Nation.

Postponement of scheduled surgeries Increments costs Diminishes Efficiency Duplicates workload Squanders Operating Room time. Increases patient's out of pocket expenditure due to Overstay Redundancy in a preoperative course of action and management. Numerous Deliberates have proposed many ways of making strides of proficiency by guaranteeing 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 of 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. Delays and postponements specifically lower the morale among the staff, patients, and relatives and may reflect a decreased productivity in their workplaces. There is a need for 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. Cancellation is a major problem in most hospitals. It is an inconvenience, which has a significant ripple effect. Cancellation of cases on the scheduled day of surgery leads to inefficient utilization of manpower and scarce resources. Cancellation of elective operations is a parameter to assess the quality of patient care and quality of the management system. Hence, this is one criterion for evaluating the efficiency of surgical service which has a low rate of cancellation of operations, which compel the hospital management to demonstrate the good performance.

II. RESEARCH METHODOLOGY

A. RESEARCH SETTING:

The study of postponement of scheduled surgeries was done in Main OT located at Nehru Hospital, Cardiac OT located in the Advance cardiac center (ACC), Pediatric Operation Theater complex located in Advance Pediatric center (APC), and an Eye Operation theater located in Advance Eye Center (AEC). Bed compliment of Nehru hospital is 949. Advanced Pediatric Centre is 243 and Advance Cardiac Centre is 208, and advance eye center is 101 respectively. Main Operation theatre complex is situated on the 4th and 5th floor of Nehru Hospital, Pediatric, Cardiac operation theater complex and eye OT. General Surgery Department has 25 Senior Resident doctors and 9 consultant surgeons.

B. RESEARCH DESIGN:

This study was conducted from March 1st to September 30th, 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.

C. 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 a 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 stakeholders were 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 questionnaire/ 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 a hundred.

NAN	Not Actual Number
MAPE	Mean Absolute Percentage Error
MAD	Mean Absolute Deviation
MSD	Mean Squared Deviation
d.f.	Degree of Freedom
SS	Sum of Square
MS	Mean Square

Table 1 Abbreviation

Data were compiled into two major groups that are hospital related and patient-related causes of the 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 plus application.

D. EXCLUSION CRITERIA:

All the cases posted as unlisted cases or emergency cases.

E. DATA ANALYSIS TECHNIQUE:

The data collected was analyzed by using, the 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 interpolate the data

III. 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 to be breached evolving an 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 any experimentation on human no intervention procedure was carried out as part of

study. The ethical issues in the study had been paid due attention to and the study did not delay any patient required investigation or treatment. Freedom of expression and unindented 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 the Institutional Ethics Committee.

IV. OBSERVATION AND RESULTS

Postponement case study for the scheduled surgeries was conducted in the operation theaters of PGIMER Chandigarh. Data from operation theaters were 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 institution. However, Total 958 surgeries were scheduled and 772 surgeries performed were and 186 surgeries were postponed with a postponement rate of 19.42% in the cardiac surgery department during the study period. Total 1,825 surgeries were scheduled and 1,609 surgeries were postponed and 216 surgeries were performed with postponement rate of 11.84% in the pediatric surgery department. 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 asunder.

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

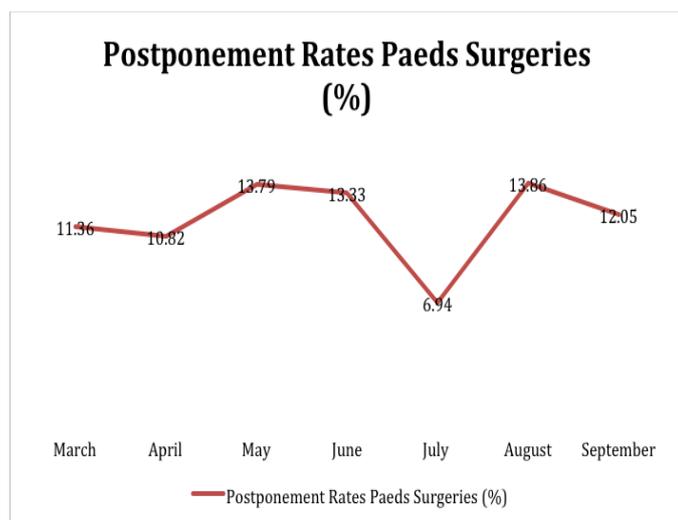


Fig.1 Postponement Rates Trend

Month-wise postponement rate of scheduled surgeries in Pediatric surgeries Department is graphically represented on the time trend in Fig 1. Postponement rate decreases from 11.36 % to 10.82% from the month of March to April 2017 then increases to 13.79% in the month of May and 13.33% in the month of June. Postponement rate decreases to be 6.94% in the month of July and then increases to 13.86% and 12.05% in the month of August and September respectively and increases to 12.37% in the month of May and 12.36% in the month of June. Postponement rate decreases to 12.35% in the month of July and then increases to 14.65% and 12.49% in the month of August and September respectively.

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 11.99%, for the August it was 12.64%, and the September 11.35%. Forecasted for postponement rate increased from July to August and then decreased from August to September as saw in actual that is increased from 6.94% in July to 13.86% in August and then decreased to 12.05% in September 2017

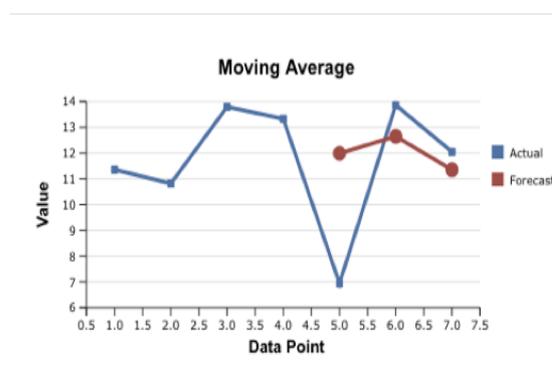


Fig 2 Moving Average Forecasting

Month	Actual Value	Forecast	Standard Error
March	11.36		
April	10.82		
May	13.79	NaN	NaN
June	13.33	NaN	NaN
July	6.94	11.99	NaN
August	13.86	12.64667	NaN
September	12.05	11.35333	2.77996
October	-	11.37667	2.95022
November	-	10.95	2.9919

Table 2 Moving Average results of Forecasting

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 the September 12.36%. Forecasted for postponement rate increased from July to August and then also from August to September as saw 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.

On the application of exponential smoothing with Alfa value, 0.5 shows operation theater remained well optimized and smoothed in the month of March, April, June, and September by generating Residual less the One. During the month of May due to the Summer Vacation of Consultants Residual is 2.6 and further be smoothed by appropriate planning with reallocation of Human Resources and List of operation theater can be formulated with respect to the availability of surgeons and time.

Month	Original	Smoothed	Residuals
March	Original	Smoothed	Residuals
April	11.36	11.73571	-0.37571
May	10.82	11.54786	-0.72786
June	13.79	11.18393	2.60607
July	13.33	12.48696	0.84304
August	6.94	12.90848	-5.96848
September	13.86	9.92424	3.93576

Table 3 Exponential Smoothing of Postponement Rates

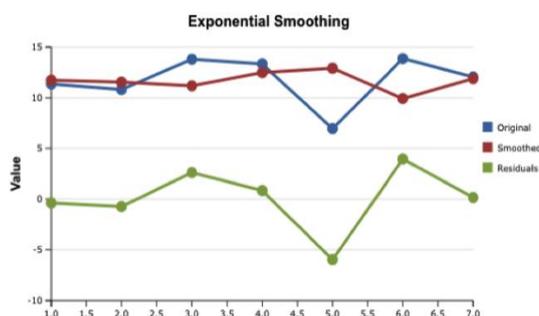


Fig 3 Exponential Smoothing of Postponement Rates

On the perusal of the formula for calculating the postponement rate.

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

$$\text{Postponed Surgeries} = \text{Scheduled Surgeries} - \text{Performed Surgeries}$$

- I. Input Indicator
 - Scheduled Surgeries
- II. Throughput Indicators
 - Postponed surgeries (Independent Variable)
 - Postponement Rate (Dependable Variable)
- III. Hypothesis: Postponement Rates has a perfect linear relationship with the postponed surgeries.
- IV. Null Hypothesis (H0): Postponement Rates does not have a perfect linear relationship with the postponed Surgeries

scatter Diagram (Predicted Y, Pediatric Surgery PPR vs. Postponed Surgeries

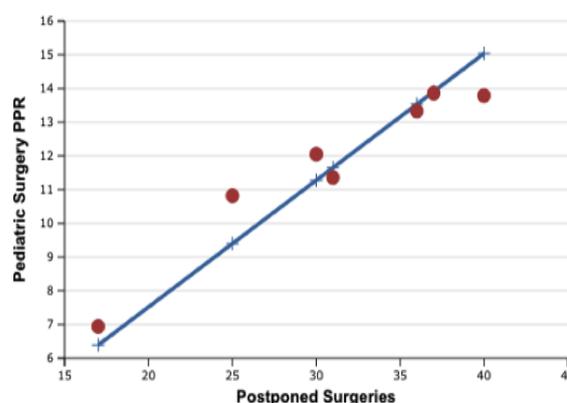


Fig 4 Regression Line Plot Between Postponed surgeries and postponement Rate

V. LINEAR REGRESSION MODEL

$$\text{Pediatric Surgery PPR} = 0.37591 * \text{Postponed Surgeries}$$

R ²	0.99769
R-square	0.99539
Adjusted R-square	0.99539
S ²	0.87605
N	7

Table 4 Regression Statistics

On the perusal of the p-Value 0.00032 which is less than 0.005, we successfully rejected the null hypothesis that is Postponement rates do not have a perfect linear relationship with the postponed surgeries.

	d.f.	SS	MS	F	p-level		
Regression	1	33.1806	33.1806	76.41175	0.00032		
Residual	5	2.17117	0.43423				
Total	6	35.35177					
	Coefficient	Standard Error	LCL	UCL	t-Stat	p-level	H0(5%)
Postponed Surgeries	0.29752	0.03404	0.21002	0.38501	8.74138	0.00032	Rejected
T(5%)	2.57058						

Table 5 ANOVA Test for Postponed surgeries with Postponement Rate

Meaning thereby Postponement Rates has perfect Linear Relationship with the postponed surgeries hence throughput factors are responsible for the postponement rate efficiency of surgeons to access the time of surgery and delay in previous surgeries contribute the major factor for the increased postponement rates and non availability of surgeon during the leave period (Summer Vacations) or occupancy of available surgeons in scheduling emergency operation is contributed another throughput factor for the increasing postponement rates during vacation period of other consultants. Incomplete preoperative workup and changing health status was another throughput factors responsible for the high postponement rate during the post-rainy seasons like in the month of August as suggested by the multiple stakeholders.

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; copyright, 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 a 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 cases, 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 an 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.

VI. CONCLUSION

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

VII. RECOMMENDATION

1. Pediatric surgery Operation Theater has predictable postponement rates and can be further well optimized by taking appropriate operational research techniques like linear programming, Discrete Event Simulation Modeling, and Network Analysis.
2. Auto Regression Integrated with Moving Average (ARIMA) models is 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 algebraic equations through the linear programming on the result of Data Envelopment Analysis of

suggestions from various stakeholders.

3. Value Stream Mapping (flow chart) of the processes of the surgical department in integration with diagnostic and support services.
4. Time value analysis will further help to identify the bottlenecks and waste can be eliminated accordingly.

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