

# Exponential Smoothing of Postponement Rates of Gynecological Surgeries in a Tertiary Care Hospital-Time Series Forecasting with Regression Analysis

Momia Yashpal<sup>1</sup>, Koushal Vipin<sup>2</sup>, Talati Shweta<sup>3</sup>, Hemant Bhagat<sup>4</sup>

<sup>1,2,3</sup>Department of Hospital Administration, Post Graduate Institute of Medical Research and Education Chandigarh, Chandigarh, India

<sup>4</sup>Department of Anesthesia and Intensive Care, Post Graduate Institute of Medical Research and Education Chandigarh, Chandigarh, India

**Abstract:** ***Background:** Hospital contributes significant Tangible and Intangible resources on a concurred plan by the scheduling of surgery in OT List. Cancellation is a major problem in most hospitals. It is an inconvenience to doctors, patients and Management, which has a significant ripple effect. Postponement decreases efficiency by declining throughput leads to wastage of resources hence burden to the nation. **Methodology:** 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 and postponement rates were evaluated for Time series analysis and exponential smoothing and 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 Gynecology operation theaters the 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 with the postponed surgeries and on regression analysis they are in a perfect linear relationship. Hence throughput is responsible for the postponements.*

**Keywords:** Moving Average, Exponential Smoothing, Regression Analysis, ARIMA, DES, Operation Research, Forecasting, Optimization, Operation Theater

## 1. Background

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. A 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. A late postponement is a waste of, material, money, time and Human resources hence is the burden to 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 preoperative 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 decreased productivity in their work places.<sup>4</sup> There is a need for the health care 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<sup>10</sup>

## 2. 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 Advance cardiac center (ACC), Pediatric Operation

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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, Advance Pediatric Centre is 243 and Advance Cardiac Centre is 208, and advance eye center is 101 respectively. Main Operation theatre complex situated on 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.

### Research Design

This study was conducted between 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 a previous day. Data for scheduled, performed and postponed surgeries were collected for seven months. The observation was not made on 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 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 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 plus application.

### Exclusion Criteria

All the cases posted as unlisted cases or emergency cases.

### 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** 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 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

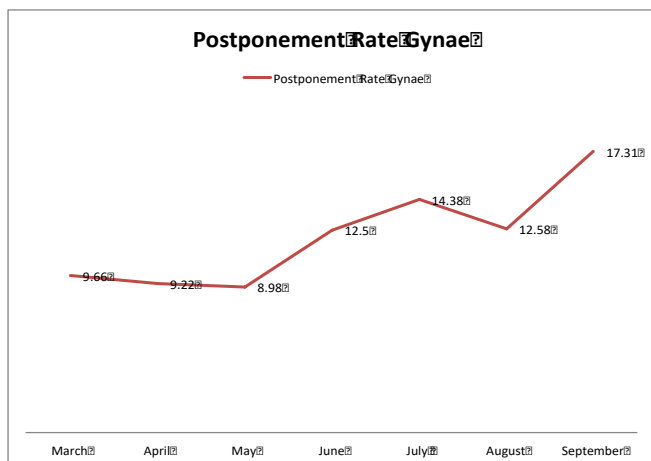
## 3. Observation and Results

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. 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 1,103 surgeries were scheduled and 971 surgeries were postponed and 132 surgeries were performed with postponement rate of 11.97 % in the Gynecology surgery department.

Postponed Surgeries

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

Month-wise postponement rate of scheduled surgeries in Pediatric surgeries Department is graphically represented on time trend in Fig 1. Postponment rate decreases from 9.66% to 9.22 % from the month of March to April 2017 then further decreases to 8.98 % in the month of May. Increase of 12.5 % postponement rate was observed in the month of June. Postponement rate increases to 14.38% in the month of July and then decreased to 12.58% in the month of August and increased to 17.31 % in the month of September as shown in Figure 1.



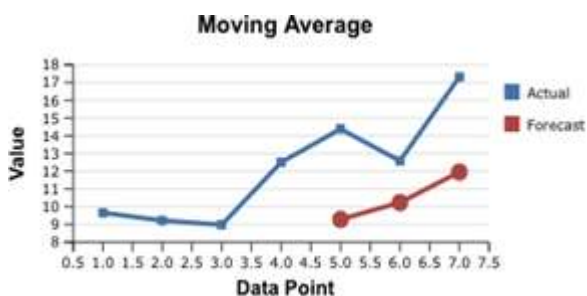
**Figure 1:** Postponement Rates Trend

### Moving Average Forecasting for Postponment rates of Gynecology Surgeries

On the ground of data for the month of March, April May and June the forecasted value for the postponement rate for the month of July was 9.286 %, for the August it was 10.233%, and for the September 11.953%. Forecasted postponement Rate increased from July to August and then decreased from August to September however in actual it decreased from 14.38% in July to 12.58% in August and increased to 17.31% in September 2017 as shown in FIG 1.

### Exponential Smoothing forecast of Postponement Rates (Gynecology Surgery Operation Theater).

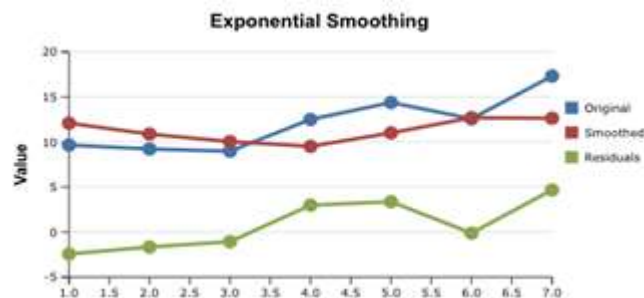
On the application of exponential smoothing with Alfa value, 0.5 shows operation theater remained well optimized and smoothed in the month of May and August by generating Residual less the One. During the month of July due to the rainy season patients requests for postponement Residual are 3.37 % and 4.6 % in the month of September due to overload after the rainy season which 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 as illustrated in Table 2 and Fig 3.



**Figure 2:** Postponement Rates Moving Average Forecasting

**Table 1:** Postponement Rate Moving Average Forecasting

Month	PPR	Forecasts	Std. Error
March	9.66		
April	9.22		
May	8.98	NAN	NAN
June	12.5	NAN	NAN
July	14.38	9.28667	9.28667
August	12.58	10.23333	10.23333
Sept.	17.31	11.95333	11.95333



**Figure 3:** Exponential smoothing of Postponement Rates

**Table 2:** Exponential smoothing of Postponement Rates

Month	Original	Smoothed	Residuals
March	9.66	12.09	-2.43
April	9.22	10.875	-1.655
May	8.98	10.0475	-1.0675
June	12.5	9.51375	2.98625
July	14.38	11.00688	3.37313
Aug.	12.58	12.69344	-0.11344
Sept.	17.31	12.63672	4.67328

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

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

Postponed Surgeries= Scheduled Surgeries – Performed Surgeries

### Input Indicator

- Scheduled Surgeries

### Throughput Indicators

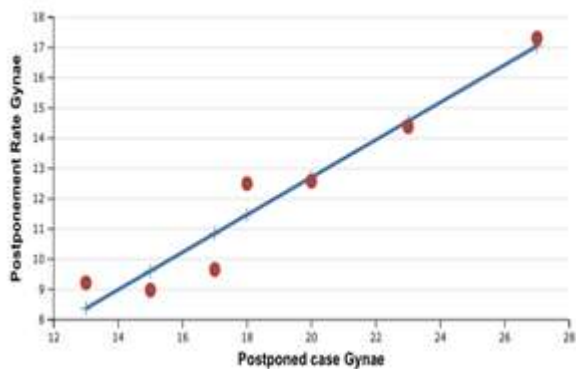
- Postponed surgeries (Independent Variable)
- Postponement Rate (Dependable Variable)

**Hypothesis:** Postponement Rates has perfect Linear Relationship with the postponed surgeries.

**Null Hypothesis (H0):** Postponement Rates does not have a perfect linear relationship with the postponed Surgeries

On the perusal of the p-Value 0.00038 Table 3 which is less than 0.005, we successfully rejected the null hypothesis that is Postponement Rates does not have a perfect linear relationship with the postponed Surgeries. 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 are responsible for the high postponement rate during the post-rainy seasons like in the month of August as suggested by the participating stakeholders.

Scatter Diagram (Predicted Y, Postponement Rate Gynae vs. Postponed case Gynae)



**Figure 4:** Regression line plot between postponed surgeries and postponement rates

**Table 3:** ANOVA for Regression between postponed surgeries and postponement rates

	d.f.	SS	MS	F	p-level
Regress.	1.00	53.0	53.0	71.3	0.00038
Residual	5.00	3.72	0.74		H0 (5%)
Total	6.00	56.7			Reject
	Coef	S.E.	LCL	UCL	t Stat
PP Cases	0.62	0.07	0.43	0.81	8.44

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 % 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.

#### 4. 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.

#### 5. Recommendation

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

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