# Performance evaluation in operations department

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**ملخص:**

**الأهداف: تلفت هذه المقالة الانتباه إلى جزء من النتائج التي تم الحصول عليها بعد إجراء دراسة شامله تهدف إلى إنشاء نموذج لإدارة أداء المستشفيات والتحقق منه. في هذه المقالة ، يركز الباحث على مؤشرات الأداء الرئيسية للعمليات. لاختبار أهميتها ، استخدم الباحث أربعة (4) مؤشرات الأداء الرئيسية (عدد العمليات الجراحية ، النسبة المئوية للعمليات الجراحية الملغاة والنسبة المئوية لاستخدام المعدات بغرفة العمليات) حيث تعكس هذه المؤشرات الأداء جودة الخدمات المقدمة في العمليات. المنهجية: تم جمع البيانات من أغسطس 2017 إلى أكتوبر 2020 وتم تنفيذها من خلال مشروع تحسين في المستشفى تحت عنوان تخفيض نسبة العمليات الجراحية الملغاة في قسم العمليات باستخدام منهجية التحسين المستمر (PDCA). النتائج: قلت نسبة العمليات الجراحية الملغاة من 14 ٪ في أغسطس 2018 إلى 4 ٪ في مارس 2019 مع تحسن للأداء في وحدة العمليات.**

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**Abstract:**

Objectives: The present article brings to attention part of the results obtained after a thorough research which has aimed to create and validate a model for the hospitals performance management. In this article, the researcher focus operation KPIs. To test its relevance, the researcher used four (4) KPIs (No of surgeries, percent of cancelled surgeries and percent of OR utilization) this KPIs reflects quality of services provided in operation. Methodology: The data were collected from August 2017 to October 2020 and were implemented by an improvement project at the hospital N under the title of reducing the percentage of cancelled surgeries in the operations department using continuous Improvement Methodology (PDCA) and the results: The percentage of cancelled surgeries improved from 14% in August 2018 to 4% in March 2019 with performance improvement in OR department.

**Keywords:**

Hospital performance evaluation, OR, cancelled surgeries, OR utilization and PDCA.

## 1- Introduction:

Measuring performance quality has become a focus in healthcare organizations both at the individual and the national levels as healthcare providers compete intensively with each other (Walker & Dunn, 2006). To compete with other competitors and improve performance quality, it is essential for hospitals to know the strengths and limitations of the organizational performance through performance measurement tools. As Shaw (2003) noted that a key to growing in the healthcare business is adapting the concept of quality improvement by using performance measurement tools. Likewise. Key Performance Indicators are quantifiable performance measurement that reflects the critical success factors of an organization and helps the organization measure its progress towards the goal achievement (Thanyaphut & Wattanapa, 2006). KPIs must be created in accordance with individual organizational mission, vision, or strategy. Mahdi Seifi (2010) claimed that Key Performance Indicator (KPI) is a quantitively form and the measurement of critical success factors (CSFs). Hur Wonchang (2009) suggests that Key Performance Indicator (KPI) is an indicator which represents how goods or services, or finances are allocated to produce certain goods or services, as well as how fast and efficient an organization can deliver goods and services to the customer. The role of performance measurement has reflected the results of management actions or organizational and individual performance, rather than the cause of problems (Stefenson, 2004). Before implementing KPIs, the organizations must establish a template which is presented in a tabulation to record KPIs detailed information and present performance results (Decharin, 2002) and Parmenter (2007), the measurement template should include the items in Table 1.

**Table 1** Key Performance Indicators Template:

| **Components of KPIs template** | **Descriptions/examples** |
|---|---|
| Name of KPIs should be brief and understandable. For example, a KPI name can be (Total Number of Inpatient Admissions). | Name of KPIs |
| The definition is used to describe and clarify the meaning of KPIs to help employees understand what KPIs are measured. | Definition of KPIs |
| Along with the objective of KPIs, the reasons why KPIs are measured should be given. | Rationale of KPIs |
| This part explains how performance measurement is calculated. | Calculation of measure |
| Name of people responsible for controlling and obtaining measurement | Name of responsible person |
| This part shows when KPIs results are measured. For example, KPIs can be measured daily, monthly, quarterly, or annually. | Frequency of measurement |
| The measurement units can be baht, dollar, and percentage. | Unit of KPI measurement |
| KPIs could be (Outcome, Process, and structure KPI) | Type of Measure |

For performance Dashboard: Shadan Malik (2005) used the terminology "enterprise dashboard", which is defined as an interface computer that presents information in the form of tables, reports, visual indicators, and alert mechanism dynamically and with relevance. Donabedian's (2005) three components approach for evaluating the quality of care underpins measurement for improvement. The three components are structure, process, and outcomes. Measurement for improvement has an additional component – balancing measures. Donabedian believed that structure measures influence process measures, which in turn affect outcome measures. Performance dashboards give their users greater visibility and integration of information regarding the performance of the organization,

by collecting relevant data in a timely fashion. Furthermore, because of the ease of access to information this is made more readily available (Koopman et al., 2011; Clark et al., 2013; Tan et al., 2013; Pace and Buttigieg, 2017). The purpose of this research is to monitor the performance of OR by measuring OR volumes, OR cancellations and OR utilization in four different hospitals and using it to apply a project improvement in hospital (N) which considering worst case in OR performance.

## 2- Literature review:

According to (Ioana Bradea and Virginia Mărăcine, 2015). Using the grey systems theory to impact of seven selected KPIs (the beds utilization rate, the average length of hospitalization, the average cost of hospitalization/day, the proportion of physicians in total staff, the nosocomial infection rate, the death rate and the diagnostic concordance) on the hospital's turnover is determined, By analyzing the grey incidence between turnover and several KPIs, for a period of six years, it has been concluded that the greatest impact on performance has the diagnostic concordance and the percent of the physicians in the total staff, followed by the nosocomial infection rate, the average bed utilization rate and the death rate. A Gap in literature was considered case study should be extended by including a greater number of hospitals into the analysis.

According to (OLA Y. HASSAN, 2018) This study assessed the quality of nursing care provided to patients in the operating room at Al-Ahrar Zagazig General Hospital. Design: A descriptive cross-sectional design was utilized. Sample: A sample of 40 nurses working in the operating room in two shifts, for observation of their performance as (scrub and circulating). Setting: The study was conducted from eleven operating rooms Al-Ahrar Zagazig General in the Hospital. Methods: Used two checklists: Inventory checklist for infrastructure, environmental safety and presence of policies and records; and an observation checklist for scrub and circulating nurse performance. A Gap in this research was in considering the nurses were the only factor in the OR improve and neglecting other factors Human like (doctors, nurses, nurse aid, labors and OR admin), Utilities, equipment, and general environment.

According to (Vahid Roshanaei, 2017). Operating rooms (ORs) play a substantial role in hospital profitability, and their optimal utilization is conducive to containing the cost of surgical service delivery, shortening surgical patient wait times, and increasing patient admissions. We extend traditional single-hospital operating room scheduling to a coalition of multiple collaborating hospitals in a strategic network. Using data from the University Health Network (UHN), in Toronto, Ontario, Canada, we propose new centralized approaches to elective and operating room scheduling when multiple collaborating hospitals are involved. We formulate the OR scheduling problem based on location-allocation problems in supply chain management. We ensure caseload balancing among collaborating hospitals in macro and micro levels. A Gap in this research based in theoretically information instead of doing this improve practically.

## 3- Methodology:

Data were collected by using key performance indicators (Operations KPIs) from our hospitals group, Consist of four different hospitals (Hospital C, Hospital L, Hospital A and Hospital N). Data were collected From May 2017 to Oct 2020 (Data collected monthly) and analysis using individual control chart and run chart.

**Table 2** Operations KPIs

| Category | Key Performance Indicator | Target |
|---|---|---|
| **OR** | Total number of surgeries per month | Increasing |
| | percent of cancelled surgeries per month | Less than 5 % |
| | percent of OR utilization | ≥ 80 % |
| Project improvement | | |

**A- Total number of Surgeries:**

It measures the flow in the OR rooms which reflects on hospital revenue and reflects the workload on the staff. It's calculated as the number of all surgeries performed in the OR rooms during the month. In hospital (C) the trend line shows plateau because of a fluctuation (rise and down) but during the pandemic of COVID-19 had degreased and beginning to increase again but not reached to the normal flow yet.

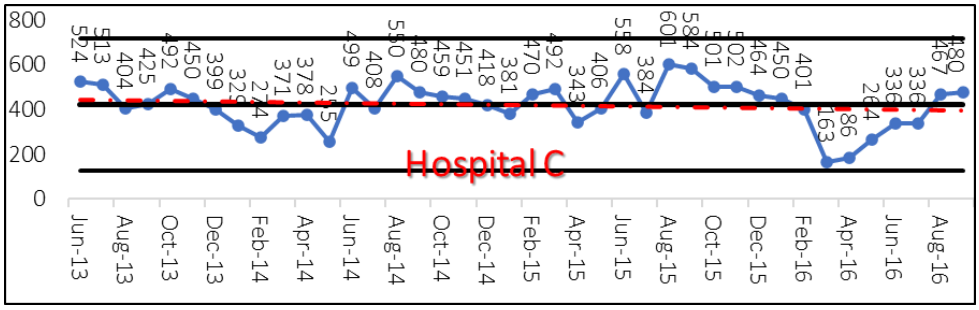



**Figure 1** Total number of surgeries in hospital (C)

Hospital (L) shows the same situation in hospital (C) but the trend line shows degreased in the number of surgeries with a fluctuation (rise and down), during the pandemic of COVID-19 number of surgeries degreased and beginning to increase again but not reached to the normal flow yet.

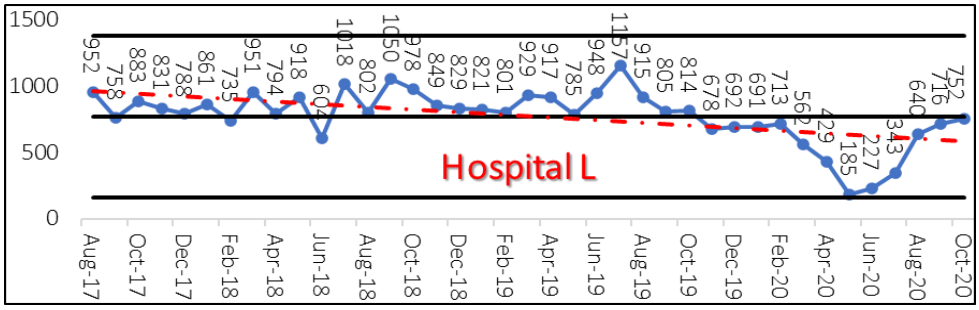



**Figure 2** Total number of surgeries in hospital (L)

Hospital (A) shows the number of surgeries was plateau and sustained till May 2019 that had fluctuation till March 2020 during the pandemic of COVID-19 that the total number of surgeries degrease and beginning to increase again and reached to the normal flow.

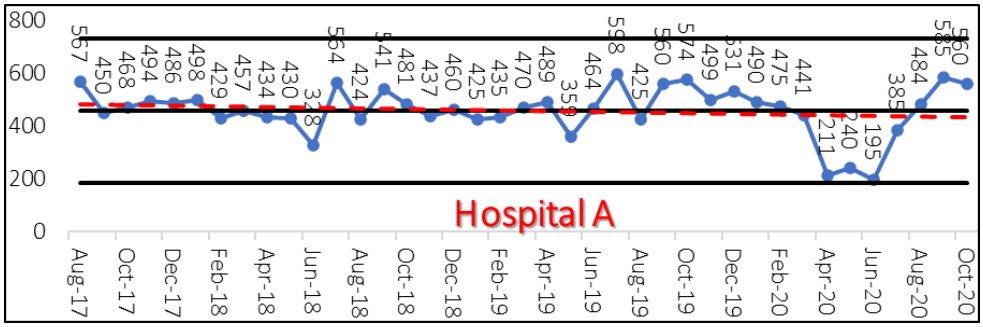



**Figure 3** Total number of surgeries in hospital (A)

Hospital (N) shows the number of surgeries was degreased duo to renovation from Aug 2017 till May 2018 then had fluctuation till March 2020 during the pandemic of COVID-19 that the total number of surgeries degrease till it increase again and reached to the normal flow.

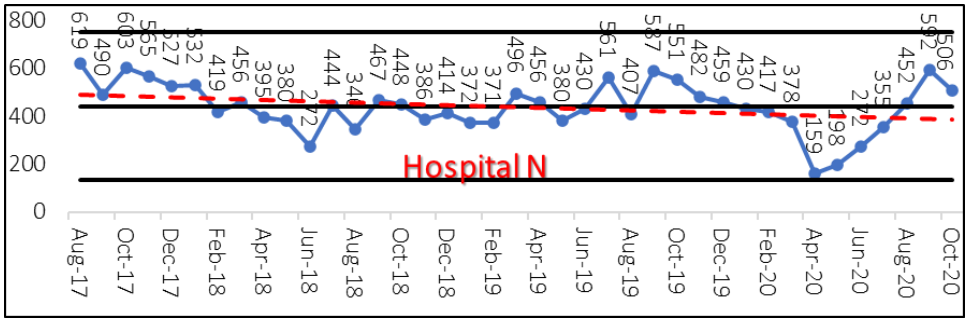



**Figure 4** Total number of surgeries in hospital (N)

**B- Percentage of cancelled surgeries:**

It's percentage of cancelled elective surgeries

Types of cancellations:

- Non-clinical: Ward beds unavailable, Consultant unavailable, Emergencies, Equipment failure / unavailable, Theatre staff unavailable, ICU beds and Administrative error.
- Clinical: Operation not necessary, Pre-operative guidance not followed, Patient arrived with illness and Pre-existing medical condition.
- Patient no-show

It's calculated as number of cancelled elective surgeries divided by total number of scheduled surgeries.

In hospital (C) the trend line shows decreased in cancellation, the period between Oct 2017 till Oct 2018 had a fluctuation (rise and down) while the period Oct 2018 till April 2020 had a desired degreased in the number of cancellation finally the cancellation number increased during the pandemic of COVID-19 and trying to degreased but not reached to the target yet.

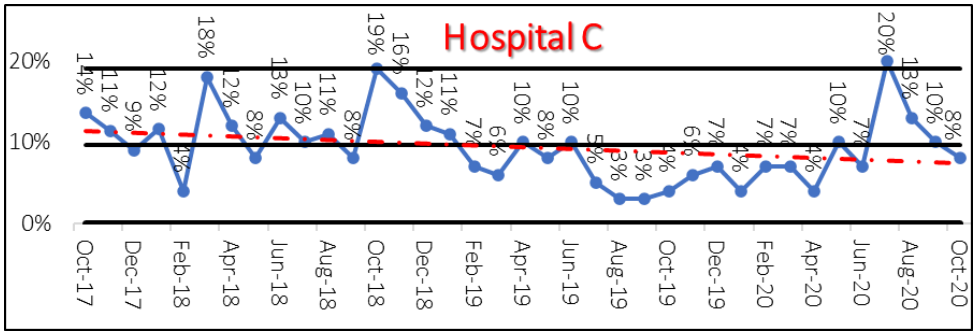



**Figure 5** Percentage of cancelled surgeries in hospital (C)

In hospital (L) the trend line shows increased in cancellation, the period between Oct 2017 till Feb 2020 was plateau with sustained while the period Oct 2018 till April 2020 had a desired degreased in the number of cancellation, finally the cancellation number increased during the pandemic of COVID-19 and trying to degreased till succeed reached to the target in the last 3 months.

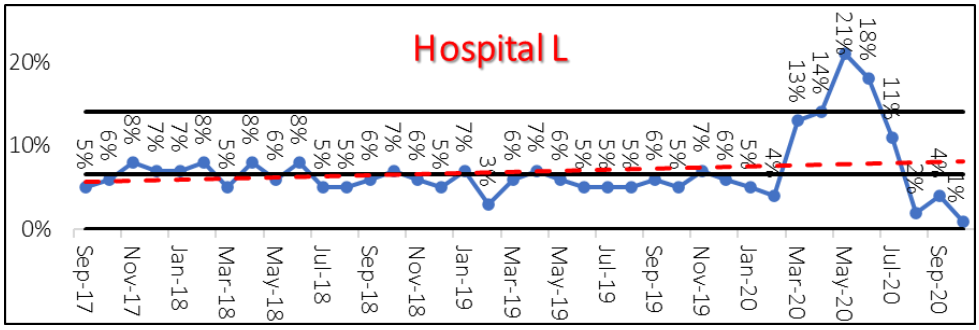



**Figure 6** Percentage of cancelled surgeries in hospital (L)

In hospital (A) the worst situation in all hospitals, started in target with sustained till Dec 2018, in Jan 2019 the number of cancellations increased and still on this increasing because of the limitation of operation rooms, need immediately actions.

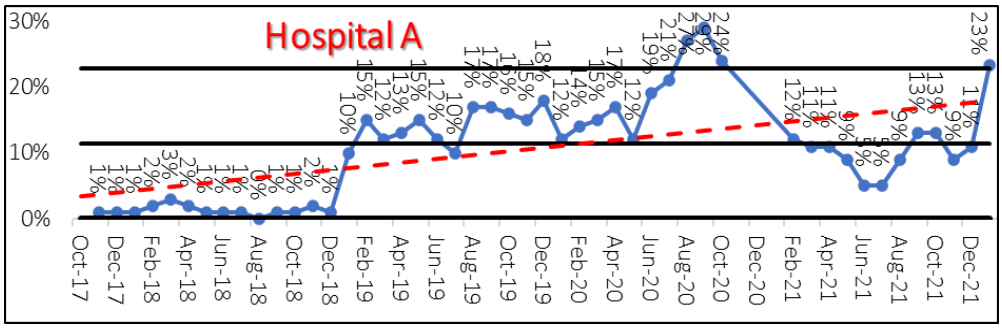



**Figure 7** Percentage of cancelled surgeries in hospital (A)

in Hospital (N) increased during May 2018 till Sep 2018 then an effort occurred, improvements reached the cancellation to the normal rate with target.

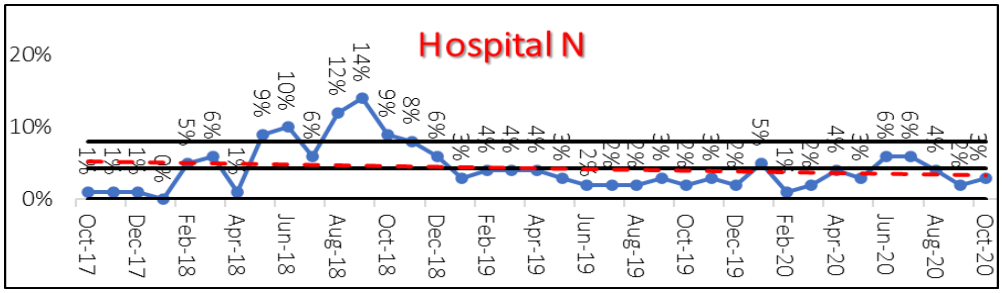



**Figure 8** Percentage of cancelled surgeries in hospital (N)

**Example for Project improvement (Decreasing % of cancelled surgeries in the operating theatre using FOCUS PDCA in Hospital (N):**

**F**ind the problem **(F):**

As a result of monitoring of OR (KPIs) we found that average of cancelled surgeries in OR on August & Sept. is 13% which is away from the target.

Milestones of the project:

The project shows that project plan during the period from Aug 2018 till the improvement completed in March 2019

**Table 2** OR project chart for hospital (N)

| | Aug 2018 | Sept 2018 | Oct 2018 | Nov 2018 | Dec 2018 | Jan 2019 | Feb 2019 | Mar 2019 |
|---|---|---|---|---|---|---|---|---|
| F | **F** | **F** | | | | | | |
| O | | **O** | | | | | | |
| C | | **C** | **C** | | | | | |
| U | | | | **U** | | | | |
| S | | | | **S** | | | | |
| P | | | | | **P** | | | |
| D | | | | | | **D** | | |
| C | | | | | | | **C** | |
| A | | | | | | | | **A** |

**Organize the team (O):**

All staff related to operations department will be involved and engaged in project improvement:

**Table 3** OR project member in hospital (N)

| **Members** | |
|---|---|
| OR secretary | Medical director |
| Quality supervisor | OR manager |
| Improvement project facilitator | Inpatient manager |
| Quality specialist | OR nursing supervisor |

To analyze the effect and relation of each member in the success of project will using Stakeholder analysis ( gain from stakeholder analysis that the consultants changed from resistant to neutral by showing them that this project will affecting on patients' satisfaction and increasing revenue also change patients' condition from neutral to supportive by showing them that the project will reducing delay and cancellations in OR.

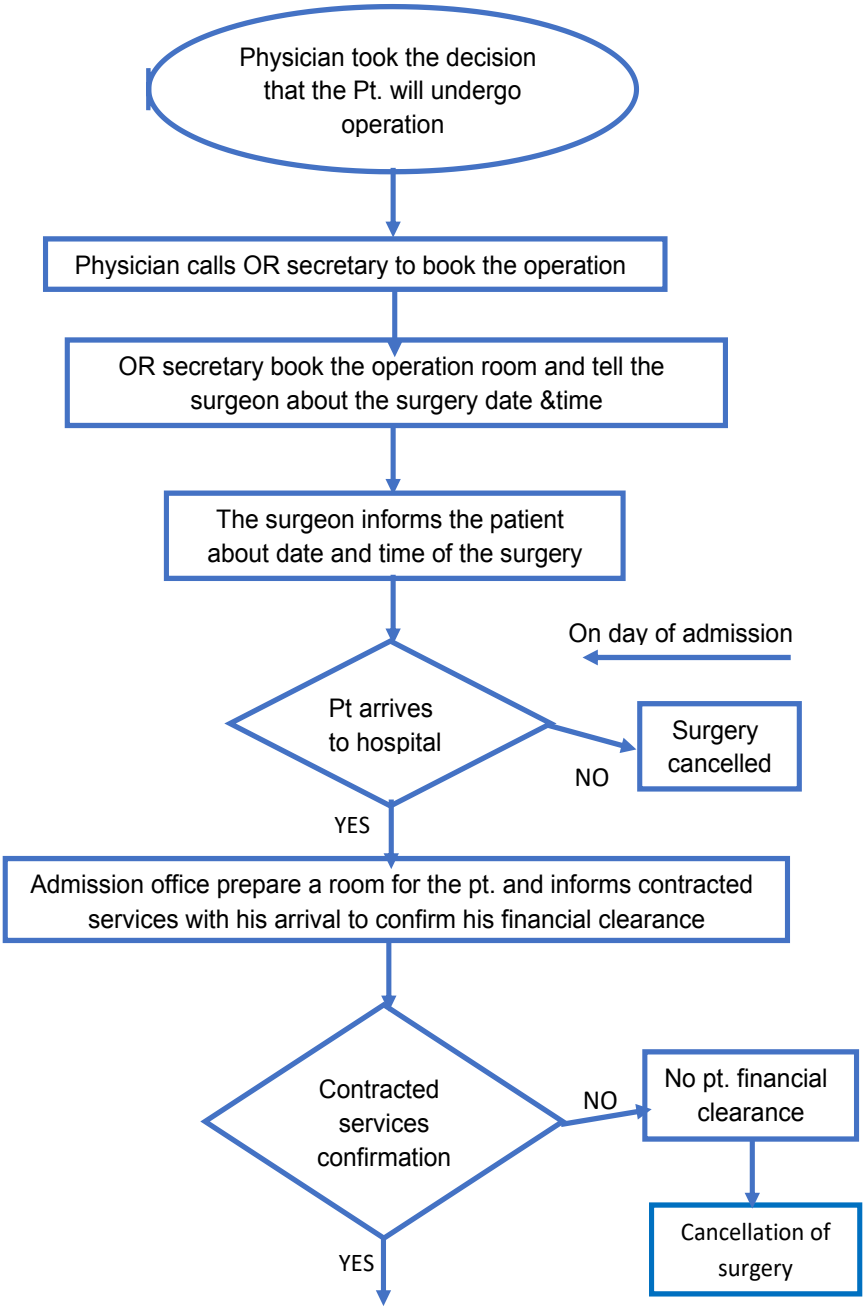
**Table 4** Stakeholder analysis in OR project improvement in hospital (N)

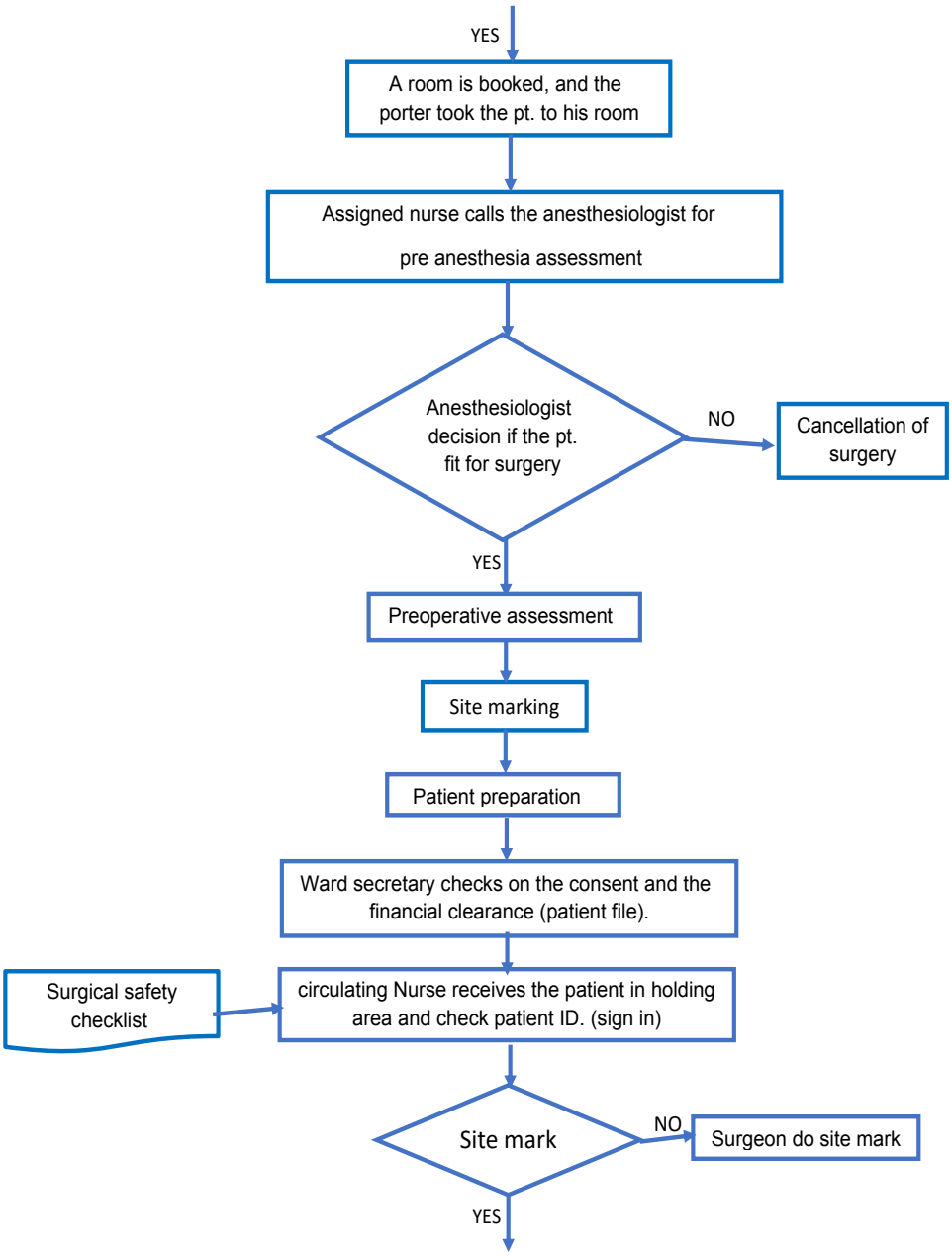
| Stakeholder | Initial condition | Wins | Changed condition | Communication frequency |
|---|---|---|---|---|
| Medical director | supportive | | Supportive | weekly |
| OR manager | supportive | | Supportive | Weekly |
| consultants | resistant | Increasing pt. satisfaction & revenue | Neutral | monthly |
| Hospital Nursing head | supportive | | Supportive | Weekly |
| Patients | Neutral | NO delay or cancellation in surgeries | Supportive | |
| Contracted services | supportive | | Supportive | |

**Clarify the process (C):**

Clarify the operations processes by using (OR Flow chart) which started from OR booking till surgery completed.

A flow chart representing OR booking procedures




YES
A room is booked, and the porter took the pt. to his room
Assigned nurse calls the anesthesiologist for pre anesthesia assessment
Anesthesiologist decision if the pt. fit for surgery
NO
Cancellation of surgery
YES
Preoperative assessment
Site marking
Patient preparation
Ward secretary checks on the consent and the financial clearance (patient file).
Surgical safety checklist
circulating Nurse receives the patient in holding area and check patient ID. (sign in)
Site mark
NO
Surgeon do site mark
YES

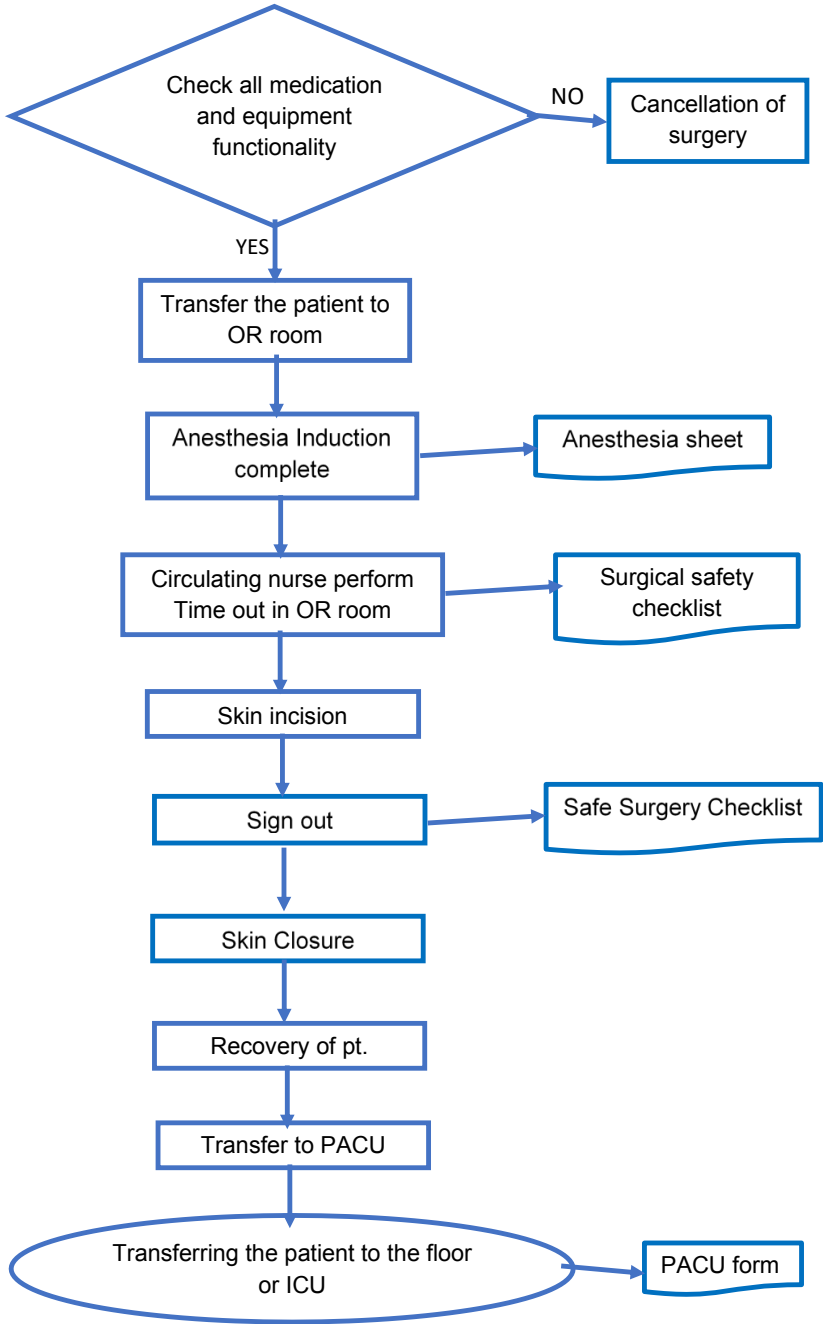



**Figure 9** OR processes flow chart

From Operation processes flow chart can summarized the common causes of surgeries cancellation:

**Table 5** Summarized of cancelled surgeries from August,2018 – Dec 2018

| Most Common Cause | August | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|
| Pt. no show | 30 | 35 | 38 | 21 | 17 |
| Anesthesia decision that the patient is not fit for surgery | 1 | 3 | 1 | 3 | 2 |
| Lack of financial clearance | 5 | 3 | 1 | 1 | 1 |
| Break down of equipment | 1 | 1 | 1 | 1 | 1 |
| Critical results | 3 | 1 | 41 | 2 | 2 |
| **Total** | **40** | **43** | **38** | **29** | **23** |

Then analysis this common causes for OR cancellation by fishbone analysis used to identify potential root causes to problems. Because of its function it may be referred to as a cause-and-effect diagram. In a typical Fishbone diagram, the effect is usually a problem to be resolved, and is placed at the "fish head". The causes of the effect are then laid out along the "bones" and classified into different types along the branches. Further causes can be laid out alongside further side branches.

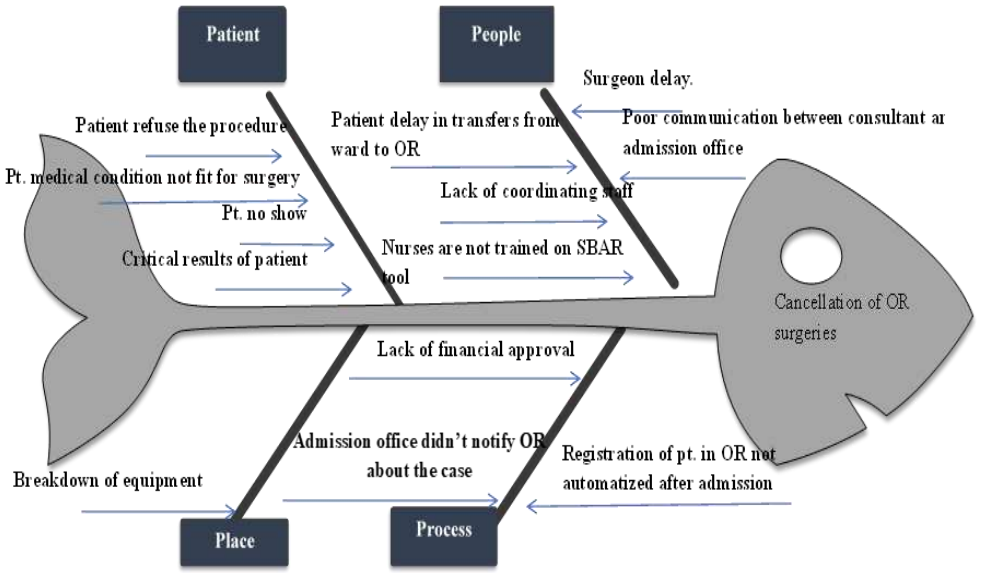


**Figure 10** Fishbone analysis for cancellation of OR surgeries in hospital (N)

**Pareto chart:**

Hospital (N) interview 10 OR staff who related to our problem to get the most common problems they face from cancelling of surgeries.

- 1 OR manager - 1 OR secretary - 6 Consultants - 1 coordinating staff - 1 nursing supervisor

- Each staff member give score from 0 to 10 for each cause. (10 most important, 0 less important)

**Table 6** common cause of OR cancellation faced by OR staff

| Cause | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Lack of financial approval | 10 | 10 | 8 | 10 | 10 | 9 | 9 | 9 | 10 | 10 | 95 |
| Lack of coordinating staff | 10 | 10 | 10 | 10 | 9 | 9 | 9 | 10 | 9 | 10 | 96 |
| Critical results of patient | 9 | 9 | 10 | 9 | 10 | 10 | 10 | 8 | 7 | 9 | 91 |
| Pt. medical condition not fit for surgery | 9 | 9 | 9 | 9 | 10 | 10 | 9 | 8 | 7 | 9 | 89 |
| Breakdown of equipment | 10 | 9 | 9 | 9 | 8 | 10 | 9 | 7 | 8 | 7 | 86 |
| Pt. no show | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 100 |
| Poor communication between consultant and admission office | 6 | 7 | 9 | 10 | 9 | 7 | 7 | 9 | 10 | 9 | 83 |
| Patient refuse the procedure | 1 | 4 | 1 | 4 | 1 | 1 | 4 | 1 | 8 | 1 | 26 |
| Admission office didn't notify OR about the case | 3 | 3 | 1 | 5 | 1 | 1 | 1 | 4 | 3 | 5 | 27 |
| Registration of pt. in OR not automatized after admission | 3 | 4 | 2 | 4 | 5 | 3 | 1 | 2 | 3 | 1 | 28 |
| Surgeon delay. | 1 | 2 | 4 | 1 | 4 | 3 | 2 | 3 | 4 | 2 | 26 |
| Nurses are not trained on SBAR tool | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 4 | 5 | 20 |
| Patient delay in transfers from ward to OR | 1 | 1 | 1 | 1 | 2 | 3 | 1 | 3 | 2 | 3 | 18 |
| Patient delay in transfers from ward to OR | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 2 | 1 | 2 | 17 |

To know the most common causes correctly which faced by OR staff can draw pareto chart. A pareto analysis is a QC tool that ranks the data classifications in the descending order from the highest frequency of occurrences to the lowest frequency of occurrences. The total frequency is equated to 100 per cent. The "vital few" items occupy a substantial amount (80 per cent) of cumulative percentage of occurrences and the "useful many" occupy only the remaining 20 per cent of occurrences:

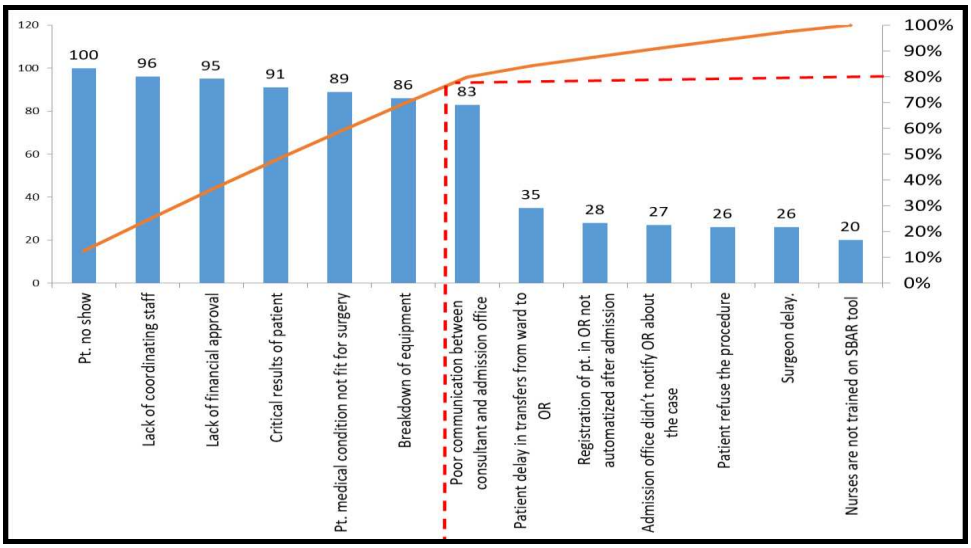



**Figure 11** Pareto chart for common causes of OR cancellation

Then solving the vital problems shown in pareto chart like (patient no. show, Lack of coordinating staff, Lack of financial approval, Critical results of patient, Pt. medical condition not fit for surgery and breakdown of equipment) with a suitable solution

**Table 7** Solving the Vital problems shown by Pareto chart

| Problem | Solutions |
|---|---|
| Lack of financial clearance | more coordinating staff will be hired to facilitate communication between consultants, contracted services, |
| Lack of coordinating staff | |
| Poor communication between | |

| | |
|---|---|
| consultant and admission office | admission office and OR |
| Critical results of patient | Anesthesia clinic will be made for pre-anesthesia assessment with full labs and x-rays before day of surgery |
| Pt. medical condition not fit for surgery | |
| Breakdown of equipment | Daily check up on equipment before start of surgeries by biomedical engineering, and training of OR technicians on usage of equipment |
| Pt. no show | Developing new process involving confirmation with pt. several times before day of surgery |

Then prioritization matrix of solutions by give score for cost, effectiveness and achievable, this score from (1 to 5) and the high score will get the prioritization.

**Table 8** prioritization matrix of solutions

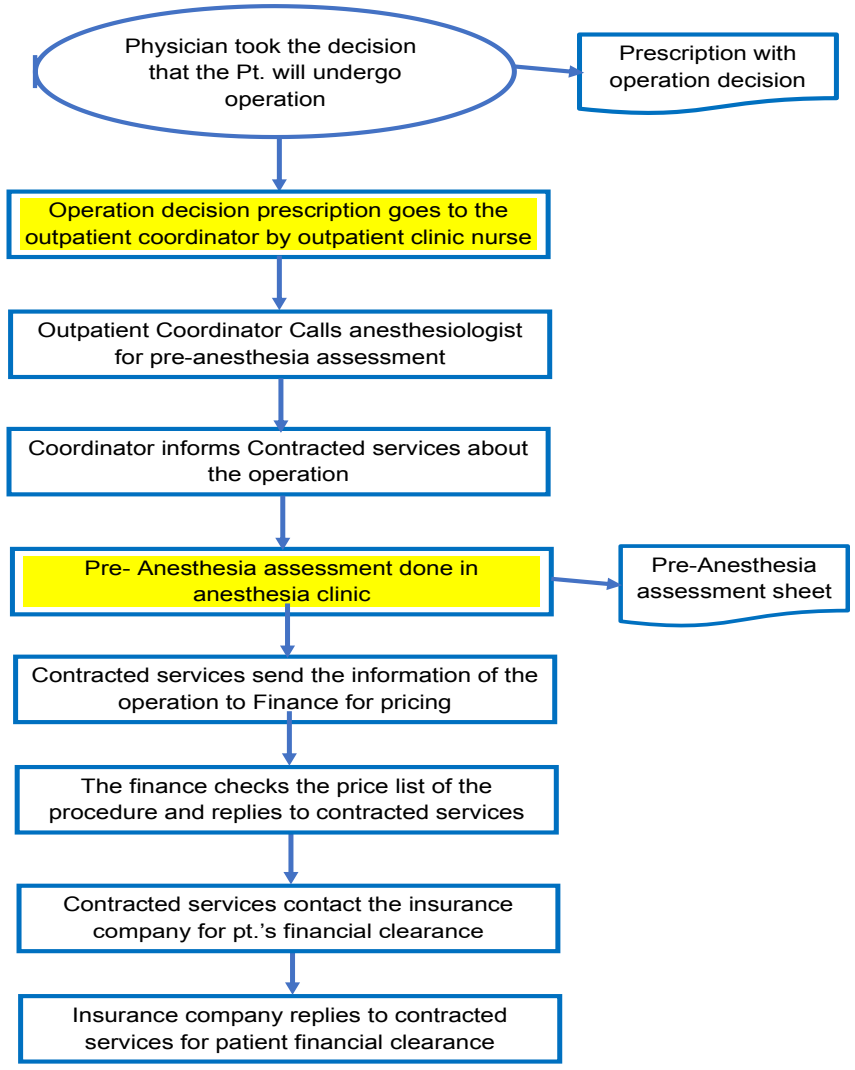
| Item | Cost (1-5) | Effectiveness (1-5) | Achievable (1-5) | Score | Who | When |
|---|---|---|---|---|---|---|
| more coordinating staff will be hired to facilitate communication between consultants, contracted services, admission office and OR | 3 | 5 | 4 | 60 | HR manager | Nov 2018 |
| Anesthesia clinic will be made for pre-anesthesia assessment with full labs and x-rays | 3 | 5 | 5 | 75 | Outpatient manager | Nov 2018 |
| Daily checkups on equipment before start | 4 | 4 | 3 | 48 | Biomedical engineering | Nov 2018 |

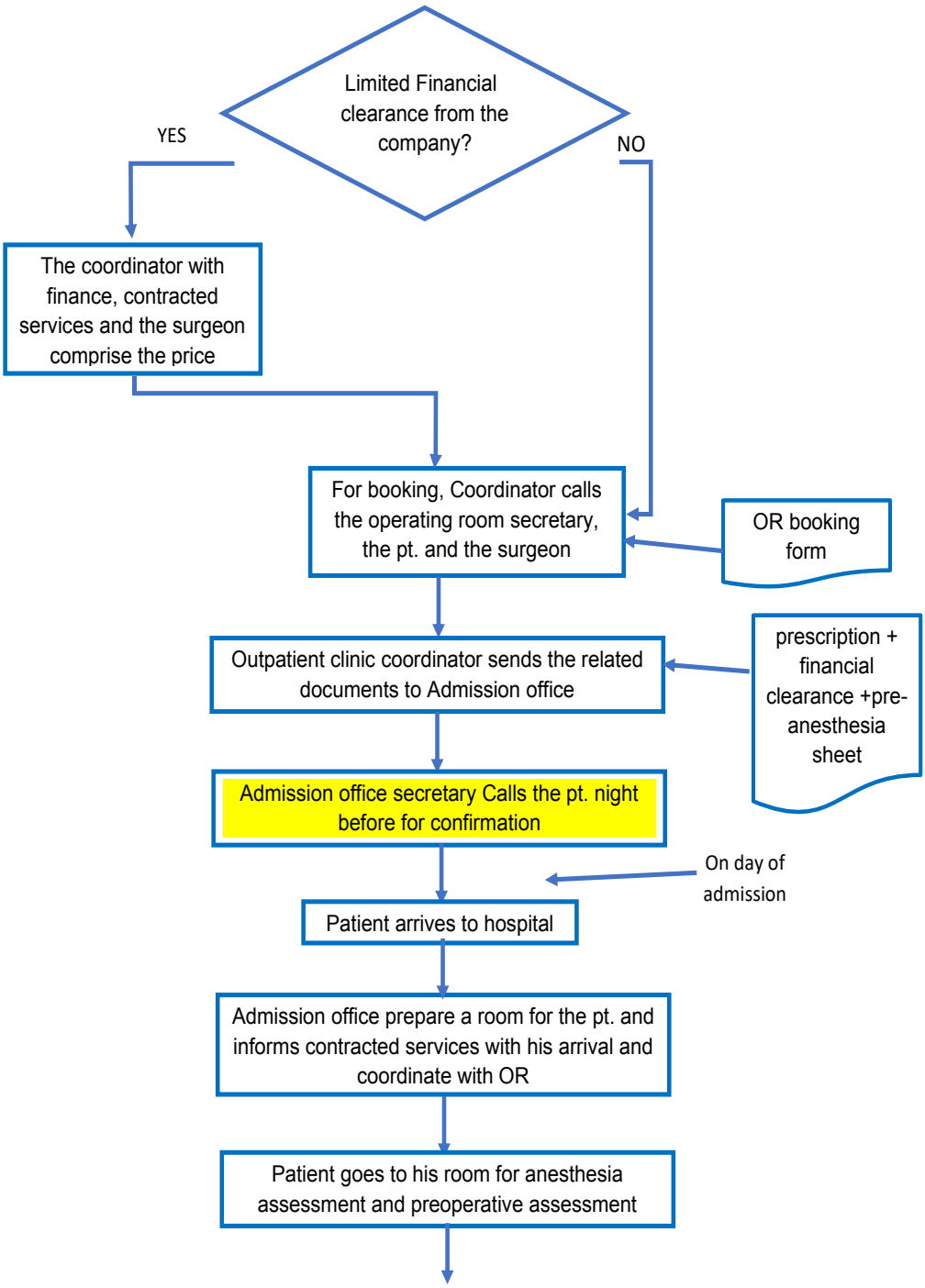
| | | | | | | |
|---|---|---|---|---|---|---|
| of surgeries by biomedical engineering, and training of OR technicians on usage of equipment | | | | | | |
| Developing new process involving confirmation with pt. several times before day of surgery | 4 | 4 | 5 | 80 | OR manager, admission manager and contracted services manager | Nov 2018 |

**Dos:**

- 4 coordinators have been hired
- Anesthesia clinic is available for pre-anesthesia assessment of pt.
- Daily check up on equipment before start of surgeries by biomedical engineering, and training of OR technicians on usage of equipment
- new process is developed by admission office, OPD, Contracted services and OR to ensure pt. arrival.

After solving the vital problem will draw again OR booking processes flow chart.


Physician took the decision that the Pt. will undergo operation
Prescription with operation decision
Operation decision prescription goes to the outpatient coordinator by outpatient clinic nurse
Outpatient Coordinator Calls anesthesiologist for pre-anesthesia assessment
Coordinator informs Contracted services about the operation
Pre- Anesthesia assessment done in anesthesia clinic
Pre-Anesthesia assessment sheet
Contracted services send the information of the operation to Finance for pricing
The finance checks the price list of the procedure and replies to contracted services
Contracted services contact the insurance company for pt.'s financial clearance
Insurance company replies to contracted services for patient financial clearance


Limited Financial clearance from the company?
YES
NO
The coordinator with finance, contracted services and the surgeon comprise the price
For booking, Coordinator calls the operating room secretary, the pt. and the surgeon
OR booking form
Outpatient clinic coordinator sends the related documents to Admission office
prescription + financial clearance +pre-anesthesia sheet
Admission office secretary Calls the pt. night before for confirmation
On day of admission
Patient arrives to hospital
Admission office prepare a room for the pt. and informs contracted services with his arrival and coordinate with OR
Patient goes to his room for anesthesia assessment and preoperative assessment

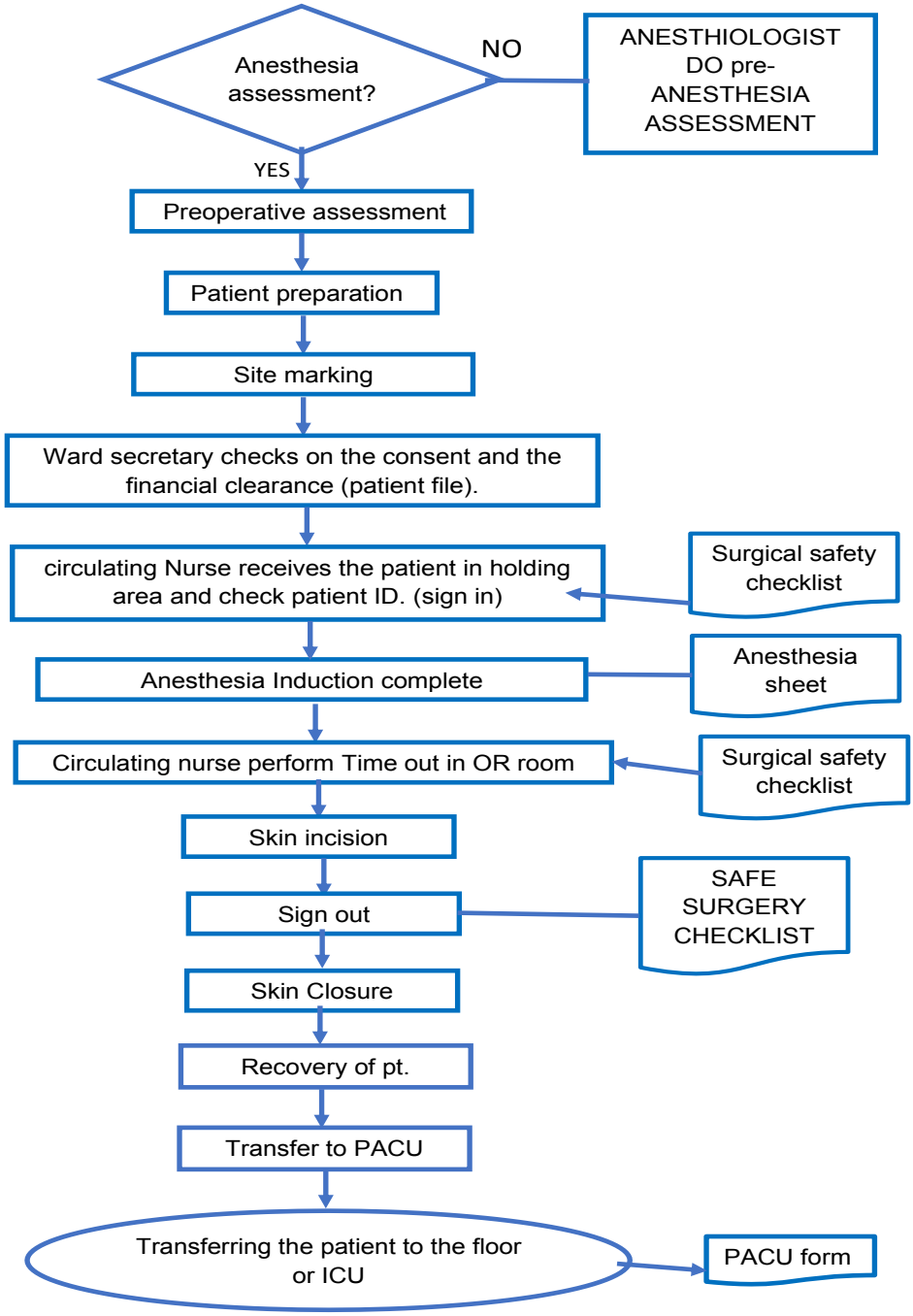

Anesthesia assessment?
NO
ANESTHIOLOGIST DO pre-ANESTHESIA ASSESSMENT
YES
Preoperative assessment
Patient preparation
Site marking
Ward secretary checks on the consent and the financial clearance (patient file).
circulating Nurse receives the patient in holding area and check patient ID. (sign in)
Surgical safety checklist
Anesthesia Induction complete
Anesthesia sheet
Circulating nurse perform Time out in OR room
Surgical safety checklist
Skin incision
Sign out
SAFE SURGERY CHECKLIST
Skin Closure
Recovery of pt.
Transfer to PACU
Transferring the patient to the floor or ICU
PACU form

**Figure 12** OR booking processes flow chart after improvement

## 4- Results:

checked the data after implementing the solution and these were a huge different (OR cancellations were 14 % at the beginning of the project in August 2018 then we reached to 4% after finished project in March 2019 and put plan to monitoring the process.

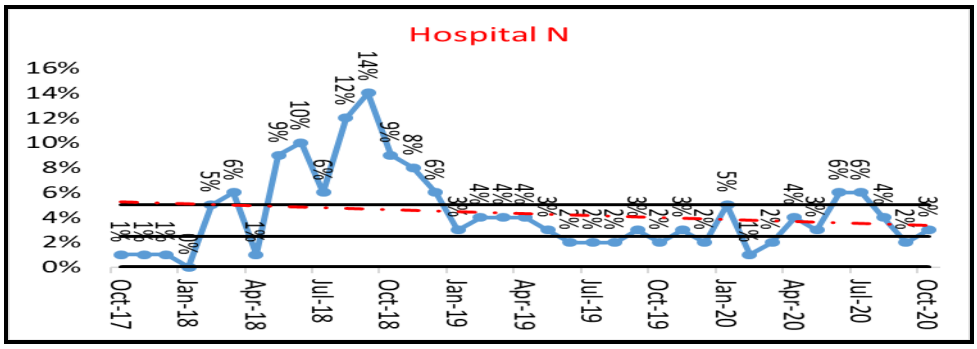



**Figure (13)** Percentage of the OR cancellation in hospital (N)

To see the percentage of OR cancellations in details during the period of OR booking processes improvement.

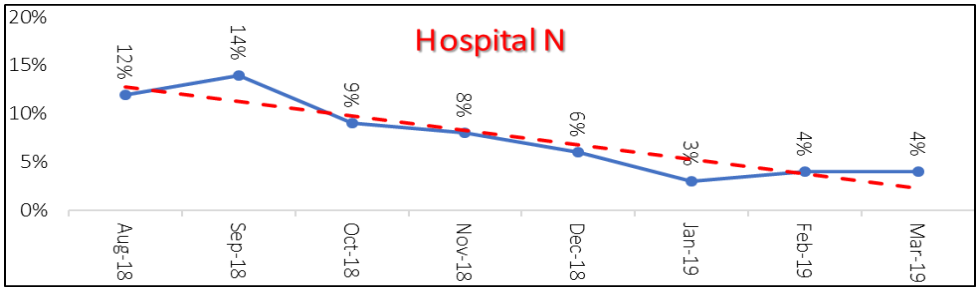



**Figure 14** Percent of OR cancellations during (August 2018 till March 2019)

## 5- Recommendations and future work:

- Apply the same project improvement in other hospitals after achieved satisfactory results.
- Apply the same methodology in hospital OPDs to reduce the percentage of booking cancellation.

## References


1- Walker, K. B. & Dunn, L. M. (2006). Improving hospital performance and productivity with the balanced scorecard. Academy of Health Care Management Journal. Retrieved April 16, 2008, from http://findarticles.com/p/articles/mi_m1TOQ/is_2/ai_n25009491/pg_2.

2- Shaw, C. (2003). How can hospital performance be measured and monitored? Retrieved May 1, 2008, from http://www.euro.who.int/document/e82975.pdf

3- Thanyaphut, A. & Wattanapa, P. (2006). Key performance indicators: Strategic into action. Journal of Quality Guarantee. Khon Kaen university. 7(1): 1-12.

4- M. Seifi, (2010) "Importance of KPI in BI Systems, Case Study: Iranian", Seventh International Conference on Information Technology, Sharif University of Technology, Tehran, Iran.

5- [7] W. Hur, (2009) "Developing Enterprise Dashboard", Asian Journal of Information Technology, Medwell Journals, vol. 8, no. 2, pp. 55-60.

6- Stefenson, T. (2004). Performance measurement at DHL solution towards and improved performance measurement system consisting of relevant and well-designed Measure. Master's Thesis, The Northernmost University of Technology in Scandinavia. Retrieved November 10, 2007, from http://epubl.luth.se/14021617/2004/294/index-en.html.

7- Huang, J.; Zhu, Y.; Cheng, B.; Lin, C.; Chen, J (2016). A PetriNet-based approach for supporting traceability in cyber-physical manufacturing systems. Sensors 2016, 16, 382.

8- Decharin, P (2002). From strategy to action with balanced scorecard and key performance indicator. Bangkok: Chulalongkorn University.

9- Parmenter, D. (2007). Key performance indicators: developing, implementing, and using winning KPIs. NJ: John Wiley & Sons.

10- Srisuttiyakorn, S. (2003). Key performance indicators. [CD]. Bangkok: Thirdwaive Education and Extreme Media.

11- Dragana Velimirovića, Milan Velimirovićb and Rade Stankovića. (2011). Role and Importance of Key Performance Indicators Measurement. Serbian Journal of Management 6 (1) 63 – 72.
12- S. Malik, (2005) "Enterprise Dashboards: Design and Best Practices for IT. Hoboken", John Wiley & Sons, Inc.
13- Donabedian, A (2005) Evaluating the Quality of Medical Care, The Milbank Quarterly, 83(4):691-729.
14- Koopman, R.J., Kochendorfer, K.M.,Moore, J.L., Mehr, D.R., Wakefield, D.S., Yadamsuren, B., Coberly, J.S., Kruse, R.L.,Wakefield, B.J. and Belden, J.L. (2011), "A diabetes dashboard and physician efficiency and accuracy in accessing data needed for high-quality diabetes care", The Annals of Family Medicine, Vol. 9 No. 5, pp. 398-405.
15- Miguel Pestanal, Ruben Pereira & Sérgio Moro, (2020) "Improving HealthCare Management in Hospitals Through a Productivity Dashboard: Journal of Medical Systems (2020) 44: 87.

Website: https://doi.org/10.1007/s10916-020-01546-1

16- OLA Y. HASSAN, (2018) "Quality of Nursing Care Provided to Patients in the Operating Room, Based on Ministry of Health Standard of Care" The Department of Nursing Administration, Faculty of Nursing, Cairo University, Med. J. Cairo Univ., Vol. 86, No. 4, June: 2001-2010, 2018.
17- Vahid Roshanaei, (2017) "Large-scale decomposition strategies for collaborative operating room planning and scheduling", Graduate Department of Mechanical & Industrial Engineering, University of Toronto.