RESEARCH ARTICLE

SAMRIDDHI Volume 15, Issue 1, 2023 Print ISSN: 2229-7111 Online ISSN: 2454-5767

Optimization of Waiting Time in Outpatient Department of an Eye Care Hospital

Sivasankaran R[1*], Samuel Raja A[1], Govardhanan M. S[1], Thirupathi Raj K[2]

[1]Department of Mechanical Engineering, Thiagarajar College of Engineering, Madurai, Tamil nadu, India.

[2]Global payroll specialist, Neeyamo Enterprise Solutions Pvt Ltd, Madurai, Tamil nadu, India.

Abstract

Safety is a universal concern of all fields in healthcare services. Clinical risk analysis is one of the essential tasks of hospital managers worldwide. Risk reduction enhances the healthcare services quality and effective relations between hospital staff and patients, and finally, it will limit lawsuits for malpractice. A time study was carried out at a secondary eye care hospital in the outpatient department to analyze the time taken to complete various procedures. Based on the data collected by direct observation, the reasons for increased waiting time were evaluated and suggestions are given in the current work. The failure mode effective analysis (FMEA) technique was applied to determine the risk priority number (RPN) and to suggest a possible solution.

Keywords: Time study, Waiting time, Risk analysis, Failure mode effective analysis.

SAMRIDDHI : A Journal of Physical Sciences, Engineering and Technology (2023); DOI: 10.18090/samriddhi.v15i01.23

Introduction

Although there is considerable progress in enhancing patients' safety, numerous drawbacks are still experienced in the processes affecting the patients, directly or indirectly. Risk management is the ability to identify the existing factors for risk on one hand, and risks analysis and appropriate strategy selection for controlling and eliminating them on the other hand. Quality of clinical services is always viewed from different perspectives such as safety, acceptability, and reliability. Medical errors and adverse events are one of the greatest challenges for health systems at the international level. In general, there are two approaches to investigating human errors in the service delivery system of hospitals: personal and systematic approaches. The personal approach focuses on human errors, and people with malpractices are always considered agents of adverse events.

In contrast, the systematic approach focuses on the conditions where the fallible man is working. The systems approach assumes that errors are inevitable even in high-level and well-known organizations. Hence, according to the systems approach, optimizing the systems and working processes is the best way to tackle errors. The failure mode effective analysis (FMEA) technique is one of the famous risk management help to make decisions on how to improve an operation was based on the risk priority number (RPN). The RPN is a product of three indices: occurrence, severity, and detectability. Although these techniques are originated from the manufacturing industry, nowadays, they find application in service sectors such as healthcare.

Corresponding Author: Sivasankaran R, Department of Mechanical Engineering, Thiagarajar College of Engineering, Madurai, Tamil nadu, India, e-mail: sivasankaranr80@gmail.com

How to cite this article: Sivasankaran, R., Samuel, R.A., Govardhanan. M.S., Raj, T. (2023). Article Title. *SAMRIDDHI: A Journal of Physical Sciences, Engineering and Technology,* 15(1), 176-181.

Source of support: Nil

Conflict of interest: None

Literature Review

The literature on the FMEA method implemented in healthcare-related processes or medical equipment in a hospital have been summarized is this section. It covers the causes for increased waiting time and suitable suggestions to rectify.

Bagnasco *et al.* (2013) described the attempts to identify appropriate and effective measures taken for patients' safety in neonatal intensive care units (NICU). The situation-background-assessment-recommendation (SBAR) technique was proposed as its strategy and all the model's steps have been implemented. The researchers have concluded that the repeatable and harmful risks were related to inappropriate relationships among the staff, particularly during the patients' transfer and release.

Bonfant *et al.* (2014) described an FMEA model to decrease infections in central veins due to intravenous nutrition in children. The research work attempted to make appropriate

guidelines for children's intravenous nutrition by collecting data related to quality enhancement processes and benchmarking. For implementing the model, first the intravenous nutrition process was divided into 4 activities: 1) ordering the implementation of Total Parenteral Nutrition (TPN), 2) receiving medications at the drug store, 3) quality control, 4) injections done by the nurses. In the next step, TPN therapy is divided into three steps: 1) preparation steps before injection such as washing hands and checking a child's vein, 2) checking connections to the central vein, 3) dressing the central vein's spot such as: dressing change stages to ensure that the conditions are under control. The results showed that the FMEA implementation reduced the infection resulting from the central vein due to intravenous nutrition from ¾ to ¼.

Abike *et al.* (2014) tried to develop new scales for risk evaluation and preventive measures for newborn babies fall from admission to discharge. Different steps of FMEA were taken. Results showed that the number of falls as well as RPN had been reduced after the corrective interventions

Yarmohammadian *et al.* (2014) have focused on identifying and reducing risks and increasing patients' safety in a dialysis unit. The implementation included these stages: 1) the process identification, 2) the analysis of risks and determining RPN, 3) planning and forming an S-O-D (severity-occurrence-detectability) matrix and dividing it into 4 areas (high-risk or urgent, force majeure, programming, and control), 4) the interventions and 5) implementing the model again. Using this model, the researchers realized that the greatest cause of risks in the dialysis unit were miscommunications and organization in the process implementation route; and after implementing the FMEA and corrective interventions such as preparing dialysis instructions and nursing information sheets, the number of failure modes was found to decrease.

Rosen *et al*. (2015) attempted to identify risk cases of anesthesia care and offer strategies to reduce those cases employing the FMEA model. This model has been implemented in several stages: 1) identifying and understanding problems, 2) team-building and brainstorming, 3) risk identifying, and 4) brainstorming to reduce the risks. The study successfully identified the factors affecting the anesthesia machine's effectiveness and develop strategies to reduce the risks.

Han *et al.* (2016) attempted to use the FMEA model to manually and automatically compare the potential risks of blood type determination. To implement the FMEA, the first six laboratories have been selected across South Korea and the target staff received the training to determine blood type manually and automatically. The process was then divided into five steps and each step has been divided into sub-steps, causes, and effects of risks, interventions and RPN of each sub-process was calculated. Finally, these two methods (manual and automatic) were compared. Using this model, the authors highlighted the potential risks of the manual method and concluded that using the automatic method substantially reduces the risks level, and hence it is more effective despite its cost.

Rosen *et al*. (2015) attempted to identify risk cases of anesthesia care and offer strategies to reduce those cases employing the FMEA model. This model has been implemented in several stages: 1) identifying and understanding problems, 2) team-building and brainstorming, 3) risk identifying, and 4) brainstorming to reduce the risks. The study successfully identified the factors affecting the effectiveness of the anesthesia machine and developed strategies to reduce the risks.

Han *et al.* (2016) attempted to use the FMEA model to manually and automatically compare the potential risks of blood type determination. To implement the FMEA, the first six laboratories have been selected across South Korea and the target staff received the training to determine blood type manually and automatically. The process was then divided into five steps and each step was divided into sub-steps, causes, and effects of risks, interventions and RPN of each sub-process was calculated. Finally, these two methods (manual and automatic) were compared. Using this model, the authors highlight the potential risks of the manual method and conclude that using the automatic method substantially reduces the risks level, and hence it is more effective despite its cost.

Funk *et al.* (2016) attempted to identify human failures in the laparoscopy process. The FMEA implementation included the following steps: forming a team, identifying the process, designing the process map, identifying the risks and scoring them, and determining the results. The results provide a base for the application of both medical and human factors on engineering perspectives to yield a comprehensive list of vulnerabilities to human errors and factors that may cause them.

Jabbari *et al.* (2017) attempted to identify, assess and provide appropriate actions to control, reduce and eliminate the potential risks in operating rooms for eye surgery at a hospital. Eight main actions were selected based on the authorities' point of view to analyze the potential risks. 35 failure modes had been identified in the operating rooms. The study scored three criteria named severity, occurrence, and detection

Mazlom *et al.* (2018) attempted to use a risk management model to identify risks in children with cancer who received in-home care from their parents and offer appropriate strategies to reduce the number of failure modes. Implementing FMEA included the following steps: choosing three outpatient oncology clinics, choosing a group of English speaking parents, introducing FMEA to them, brainstorming, choosing the highest risk activity, conducting an evaluation by pediatricians, taking 13 corrective steps for high-risk activities, developing strategies and interventions such as the use of emails and the continuous communication with parents or sending nurses to their homes and providing more training on medications for children. The researchers

developed a better understanding of these children's problems and realized that the parents' willingness to participate in implementing the FMEA model is critical.

Denny *et al*. (2018) made use of a prospective risk management model in the radiotherapy of patients who suffer from cancer and tried to establish a national network for all specialized oncology hospitals. They followed these steps: selecting a process and determining the sub-processes, forming specialized teams, drawing process maps, analyzing risks, implementing the process completely and measuring its consequences. Using FMEA, the radiotherapy process for patients with cancer was evaluated, the risks were identified, and the model was developed and implemented to avoid these risks.

Observation from Literature

The summary of the literature is as follows.

- The results of the studies showed that the FMEA model has been mostly implemented in pediatric and oncology wards and most of the studies have focused on the processes.
- Most of the research tried to mention all the steps of the model, and after implementing the corrective strategies and interventions, they have recalculated RPN to determine the model's effectiveness. However, previous research works have paid little attention to identifying the risk effects.

Most studies have recommended this model and considered it a useful instrument for decreasing the number of risk elements and enhancing the quality of services.

Problem Description

Medical errors are one of the greatest problems in any healthcare systems. The best way to prevent such problems is error identification and their root cause through Failure Mode and Effects Analysis (FMEA).

The problem identified in the current work is delay in the service provided at the outpatient department of a secondary eye care hospital in Madurai, Tamil nadu, India and objectives are to analyse the reasons for the delay and to optimize the waiting time through Industrial Engineering tools such as Ishikawa cause and effect diagram and FMEA.

Project Methodology and Implementation

It was a descriptive observational study. The time data was collected 30 days for outpatients in different processes, starting from their entry into the outpatients' department (OPD) to their departure. The patient entry time, registration, checking vital signs, consultation, billing, and patient leaving time were recorded. The collected data was analyzed to find the various points in the process where the patients were waiting for a long period. The waiting time, in turn, influenced the turnaround time (TAT). Based on the data collected, average waiting time and turnaround time were calculated. Ishikawa's cause and effect diagram and FMEA to determine RPN were chosen to identify errors and their root cause.

Table 1: Human Resource at Hospital (Source: Secondary Eye-care hospital at Madurai)

S. No.	*Designation*	*Strength*
1	Director	1
2	Consultant Ophthalmologist	3
3	Optometrist	3
4	Counselor	1
5	Supervisor	1
6	O.T In-charge / Technicians	5
7	Nurse	2
8	Receptionist	3

Sample Size of patient flow

New Patients: Approximately 80 new patients visit the outpatient Department (OPD) on any working day. About 70% of these patients visit the clinic after taking an appointment, while the rest are walk-in patients (who come without an appointment) for various reasons. The hospital encourages patients to take an appointment before coming to the hospital but has the policy to accommodate the unscheduled ones, as far as possible, during the day. The consultation charge for new patients is Rs. 300. Most new patients typically arrive between 11:00 to 16:00 hours. The patients who do not have appointments usually arrive between 9:00 to 15:00 hours

Follow-up Patients: About 20 patients (visiting the OPD) belong to the category of follow-up patients. These patients usually visit the hospital for follow-up on the treatment or the surgery performed during their previous visit(s) to the hospital. There is no formal appointment system for follow-up patients at the hospital. The hospital usually does not charge them

Appointments: The patient's appointment is managed and coordinated by the receptionist. A patient can take an appointment by phone or by physically visiting the clinic. The hospital also provides the option of taking online appointments through its website. But this mode (website) is not popular. The appointment system at the hospital is completely manual. Depending upon the severity of the health problem and the availability of the slots, a patient is provided an appointment. Typically, 5 patients are accommodated in a 15 minutes slot.

Team at Hospital

The Director leads the professional team at the hospital, and he has performed more than 15,000 cataract surgeries and 1000 retinovitreal surgeries. He is a renowned professional in the field of ophthalmologic. The doctor is actively involved in several training programs for junior ophthalmologic surgeons on intraocular lens (IOL) and phacoemulsification surgeries throughout the country. There are three well-qualified consultant ophthalmologists at the hospital and they perform surgeries. The patients coming to the hospital

Table 2: Calculation of TAT

Date	*Day*	*(A)*	*(B)*	*(C= A + B)*	*D*	*(E= C + D)*	*Average Deviation from the Appointment Time (in Minutes)*	*TAT in hours and minutes*		
								Max	*Min*	*Avg.*
4.10.21	Mon	61	10	71	39	110	36.72	2:50	0:45	1:51
5.10.21	Tue	61	27	88	23	111	19.92	3:55	0:55	2:15
6.10.21	Wed	64	27	91	19	110	23.75	3:40	0:25	1:55
8.10.21	Fri	70	21	91	23	114	30.57	2:55	0:45	1:48
11.10.21	Mon	56	16	72	20	92	20.73	2:20	0:45	1:47
12.10.21	Tue	36	18	54	16	70	30.42	2:30	0:25	1:10
14.10.21	Thu	31	25	56	23	79	28.23	2:30	0:40	1:24
18.10.21	Mon	43	11	54	11	65	38.49	2:30	0:20	1:24
19.10.21	Tue	53	41	94	21	115	26.04	2:35	1:10	2:14
21.10.21	Thu	48	24	72	26	98	36.88	3:35	0:45	2:43
22.10.21	Fri	51	39	90	29	119	34.41	3:55	1:00	2:39
25.10.21	Mon	50	28	78	19	97	27.00	3:00	0:40	2:06
26.10.21	Tue	71	16	87	35	122	53.37	4:20	0:45	2:26
Average		53.46	23.30	76.77	23.38	100.15	31.27			1:59

A - New patients with appointments
B - New patients without appointments
C - New patients (Total)
D - Follow up patients
E - Total patients

Table 3: Summary of time (Source: Secondary Eye-care hospital at Madurai)

S. No	*Designation*	*Consulting Timings (hours)*	*Number*	*Processing time per patient (minutes)*
1	Director	13:00 – 17:00	1	2.22
2	Consultant Ophthalmologist	12:00 – 17:00	3	6.3
3	Optometrist	11:00 – 17:00	3	8.6
4	Nurse (Dilation)	10:00 – 17:00	2	40

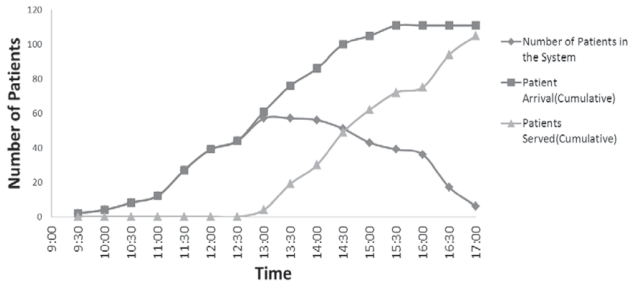

Figure 1: Arrival and Departure time of patients at OPD

invariably expect to see the Director and the Director makes it a point to see every patient for the final consultation. The human resource strength in the hospital is given in the following table.

Study of Patient Waiting Time

The patient waiting time study was carried out with the help of three attendants in the OPD between 4.10.2021to and 26.10.2021. The data regarding the arrival patterns of the patients and the processing times at various stages were collected over a period of two weeks. The data on the total time spent by the new patients in the system from the time of registration until the consultation by the Director (called as turnaround time or TAT), is given in Table 2. The arrival and departure time of patients at OPD based on OPD volume and performance is shown in Figure 1.

The processing times for various stages and the duration in a working day, is summarized in the following table. It is to be noted that even though average processing times added up to less than an hour, few patients were waiting for more than two hours in the system.

SAMRIDDHI : A Journal of Physical Sciences, Engineering and Technology, Volume 15, Issue 1 (2023)

Table 4: FMEA of the processes, Failures and their effects

Process	*Potential failure mode*	*Potential effects of failure*	*Severity*	*Potential causes of failure*	*Occurrence*	*Detectability*	*RPN*	*Recommended action*	*Person responsible*
Patients calls for appointment call goes to the call center	Line busy	Patient gets frustrated	2	Understaffing	3	7	42		
	Staff unaware of doctors	Call center operator not able to connect with available doctor	4	Lack of communication between call center operator and doctor	3	7	84	Proper training given to call center operator	Call center operator and HR Manager
Appointment made	Appointment given at wrong time	Patient dissatisfied due to increasing waiting time	5	Improper communication between patient, call center operator and doctor	3	7	105	Educate the importance of listening skill to the operator	Call center operator and HR Manager
Patient arrives at reception without appointment and doesn't know which doctor to be preferred	Doctor not available at that time	Patient has to leave	2	Patient without appointment	8	1	16	Guide the patient to discuss with available specialist	Main receptionist and HR manager
Patient arrives with appointment	Re registration	Inconvenience of Patient	5	Improper system	7	3	105	Avoid the unnecessary work.	HR manager
Vitals check	Repetition of check	Patient gets irritated	6	Lack of coordination	2	3	36	Take a test if necessary	Nurses and HR manager

FEMA of OP service

Failure Mode Effect Analysis: A failure mode effect analysis (FMEA) was done to find out the probable failure modes, causes and effects of each step in the OPD process. Detailed analysis was done to evaluate the failures' severity, occurrence and detection and the RPN was calculated. The process of FMEA yielded the following results.

The highest risk priority number was for consultant delay, followed by report delivery delay and appointment systems. When performing a process or design FMEA, the RPN calculates the risks from highest to lowest. The RPN is calculated by multiplying the three scoring columns: severity, occurrence and detection

RPN = Severity(S) x Occurrence (O) x Detectability (D)

Each category has a scoring matrix with a 1-10 scale.

- Severity of 1 denotes low risk to the end customer, and a score of 10 denotes high risk to the customer.
- An occurrence of 1 denotes low probability of the risk happening, and a 10 denotes a very high probability of the risk happening.
- A detectability of 1 denotes a failure that will be likely detectable and a 10 means a failure which is hard to detect.

Identified Causes for increased waiting time

- Lack of coordination while scheduling an appointment for patients with multiple providers. - For example, if a patient needs multiple tests, the test with the longest waiting time for results should be scheduled first.
- Lack of manpower
- Lack of communication between various sources while scheduling an appointment for example, between patient care coordinator and doctors, including a surgeon, call center staff in case to change the schedule or any new doctor's appointment
- Patients are not informed about the change in appointment
- Patient sometimes forget to bring their UHID number
- When patients come without an appointment than waiting time is increased
- Wastage of time in searching correct doctor if the patient does not know whom to consult
- Billing is done at different places
- Lack of functional computers where registration is done.

Suggestions made to reduce waiting time

- Improve the communication facility
- Trained patient care coordinator to inform the patient about the importance of appointment, which help to minimize the inconvenience to patient
- Increase the manpower so that employee can do their work effectively
- Reduce the number of steps in the process, particularly those that do not add value
- Registration can be done at any wing/section, to reduce crowd in the reception.
- Mismatched scheduling should be monitored and avoided.

A summary of the processes and suggestions to overcome the issues, are shown in the following table (Table 4), through causes of failure, its effects and RPN.

Conclusion

In the outpatient services in an eye care hospital, many factors were identified to cause delays in providing the services on time. These delays cause patient dissatisfaction. A significant reduction in waiting time can be achieved in the outpatient service by using the quality process approach. Registration forms can be modified, additional staff can be appointed to handle the telephone in OPD with basic training on telephone etiquette. Further data collection through the voice of the customer (VoC) will help to monitor and control any variance.

References

[1] Abike F, Tiras S, Dünder I, Bahtiyar A, AkturkUzun O, Demircan O. A new scale for evaluating the risks for in-hospital falls : A failure modes and effects analysis study. International Journal of Pediatrics. 2014.

[2] Bagnasco A, Tubino B, Piccotti E, Rosa F, Aleo G, Di Pietro P, *et al.* Identifying and correcting communication failures among health professionals working in the Emergency Department. International Emergency Nursing. 2013; 21(3): 168- 72.

[3] Bonfant G, Belfanti P, Paternoster G, Gabrielli D, Gaiter AM, Manes M, *et al.* Clinical risk analysis with failure mode and effect analysis (FMEA) model in a dialysis unit. JN Journal of Nephrology. 2014; 23(1): 111-8.

[4] Denny DS, Allen DK, Worthington N, Gupta D. The use of failure mode and effect analysis in a Cancer Treatment Centers of America Experience. Journal for Healthcare Quality. 2018; 36(1):18-28

[5] Funk KH, Bauer JD, Doolen TL, Telasha D, Nicolalde RJ, Reeber M, *et al.* Use of modeling to identify vulnerabilities to human error in waiting time study. Journal of Minimally Invasive Gynecology. 2016; 17(3):311-20

[6] Han TH, Kim MJ, Kim S, Kim HO, Lee M, Choi JS, *et al.* The role of failure modes and effects analysis in showing the benefits of automation in the queuing 2016; 53(5): 1077-82.

[7] Jabbari A, Rezvani F, Khorasani E, Fattahi M. Risk assessment in eye surgery: A hospital in Iran. International Journal of Health System and Disaster Management. 2017; 1(4): 237-42.

[8] Mazlom S, Hashemizadeh M, Dadpoor B, Ebrahimi M. Identification and assessment of common errors in the admission and transportation process of patients in the Central Emergency Department of Imam Reza Hospital applying the approach of "Failure Mode and Effects Analysis" (FMEA). Evidence-Based Care Journal. 2017; 3(4): 7-18.

[9] Rosen M, Sampson J, Jackson E, Koka R, Chima A, Ogbuagu O, *et al.* Failure mode and effects analysis of the universal machine in two tertiary care hospitals in Sierra Leone. British Journal of Anaesthesia. 2015; 113(3): 410-5.

[10] Yarmohammadian MH, JafarianJazi M, Khorasani E, Atighechian G. Risk, Causes and Preventive Action Assessment in the ICU of a Teaching Hospital. Health Information Management. 2014; 11(5): 633-44.