FMEA APPROACH TO REDUCE PATIENT DELAY IN EMERGENCY DEPARTMENT

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Master of Business Administration (MBA)

in

Hospital and Health Management

By

Shikha Kumari

Under the Supervision and Guidance of

Dr. Alok Kumar Mathur

2024

Dated: 18th June, 2024

TO WHOMSOEVER IT MAY CONCERN

This is to certify that **Ms Shikha Kumari has** successfully completed her internship in the Department of Operations, Gurugram from 18th March, 2024 till 17th June, 2024.

During this internship, she was found to be sincere and hardworking.

We wish her all the best for future.

For Artemis Medicare Services Ltd,

Flt. Lt. Saras Malik
(Chief People Officer)

Wg Cdr. Yogesh Sharma
(General Manager – Security & Operations)

DECLARATION BY STUDENT

I hereby declare that this dissertation titled "**FMEA approach to reduce patient delay in emergency department"** is the bonafide record of my original research work. I declare that it has not been submitted to any other university or institution for the award of any degree or diploma. Information derived from the published or unpublished work of others has been duly acknowledged in the text.

Shikha Kumari

Shikha Kumari

Date 3/7/2024

IIHMR UNIVERSITY

CERTIFICATE

This is to certify that dissertation titled "**Fmea Appproach to reduce patient delay in Emergency department at Artemis Hospital, Gurgaon** is a record of the research work undertaken by **Ms. Shikha Kumari** in partial fulfillment of the requirements for the award of the degree of MBA (Hospital and Health Management) from the IIHMR University, Jaipur under my guidance and supervision and her approach to the research study has been sincere, scientific, and analytical.

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Shikha Kumari

Date

ABSTRACT

Introduction: Emergency departments (EDs) are crucial entry points for patients with acute medical emergencies. They require swift and adaptable staff due to the unpredictable nature of patient arrivals and the time-sensitive nature of interventions. Delays in EDs, caused by factors like unpredictable patient influx, and diagnostic bottlenecks, can worsen patient outcomes, decrease patient satisfaction. These delays have far-reaching consequences for both individual patients and the healthcare system. FMEA, a proactive risk assessment technique, can be used to identify and address potential reasons of ED delays.

Method: The Failure Modes and Effects Analysis (FMEA) technique is used to evaluate and prioritize these delays. A time-based motion research and a questionnaire survey were administered to patients who visited the ED at Artemis Hospital between March and June 2024, yielding a sample size of 105. The time motion study tracked how long patients stayed in the ED for various causes, whilst the questionnaire assessed patient happiness and experiences. The data was then processed to assess the severity, frequency, and detectability of each delay factor. This information was utilized to calculate the Risk Priority Number (RPN) of each detected delay cause, allowing us to prioritize which delays should be addressed first.

Result: This FMEA analysis in an Indian emergency department highlighted key causes of delays, such as insurance clearance and test turnaround times. The most significant delays stemmed from the admission (e.g., insurance with RPN of 32 and frequency of 12%) and diagnosis (e.g., test reports with RPN of 24 and frequency of 14%) subsystems.

Conclusion: FMEA identified key causes of delays in an emergency department, like slow diagnoses and insurance issues. Delays in test results, diagnosis times, and admission due to insurance were most concerning. Improvements in diagnostics, insurance processes, and departmental workflows can significantly reduce wait times and improve patient care.

Keywords:

Failure mode and effects analysis method, Emergency departments, Patient visit time, Delay in ED.

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In closing, I would want to express my gratitude to all the hospital staffs who so kindly donated their time, shared about their personal experiences and helped during the entire process.

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ABBREVIATIONS

FMEA	Failure Mode and Effect Analysis
ED	Emergency Department
TM	Time Motion
TMA	Time Motion Analysis
RPN	Risk Priority Number
IPD	In-Patient Department
ATS	Australasian Triage Scale
SEV	Severity
OCC	Occurrence
DET	Detection

FMEA approach to reduce patient delay in emergency department

CHAPTER 1: INTRODUCTION

Emergency departments (EDs) are designed to function as a safety net for the healthcare system, providing immediate medical intervention for a wide range of critical conditions. They are operated by highly trained personnel and equipped with cutting-edge technology to stabilize and treat patients with acute illnesses or injuries. However, a disturbing trend is emerging increased patient delays in receiving this critical therapy. These delays can have a severe negative impact on individuals and the entire healthcare system. Identifying an efficient approach for spotting concerns and causes is critical in this case. FMEA, or failure mode and effect analysis, is a method for detecting and investigating errors and underlying problems. FMEA is a proactive method for detecting and managing potential risks in a system. In the context of emergency departments, it enables staff to conduct a systematic analysis of the many procedures involved in patient care, identifying potential delays. This could range from triage and registration to diagnostic testing and bed availability.

1.1 BACKGROUND

Emergency departments (EDs) play an important role in the healthcare system, serving as the first point of contact for a wide range of patients experiencing acute medical emergencies or unexpected injuries. These fast-paced situations necessitate a high level of reactivity and adaptation from staff, who are responsible for providing time-sensitive and potentially life-saving interventions. Even a slight delay in ED treatment can have serious consequences, jeopardizing patient outcomes and putting a major strain on the healthcare system. Extended wait times have been linked to increased death rates, particularly in patients with time-sensitive diseases such as stroke or heart attack, according to studies. Delays can potentially result in complications, extended hospital stays, and lifelong impairment.

EDs are characterized by excessive pressure due to a variety of reasons. For starters, the patient population that presents to emergency departments is inherently unpredictable. Unlike scheduled visits in other healthcare settings, EDs see a steady stream of patients with a variety of ailments, ranging from minor injuries to life-threatening situations. This diversity involves a high degree of flexibility and quick assessment to guarantee that patients are triaged and

treated based on the urgency of their needs. Second, emergency departments frequently encounter staffing shortages, especially during peak hours or in remote locations. This can cause bottlenecks in patient flow as overworked personnel attempt to keep up with the ever-increasing demand for care. Finally, emergency departments rely significantly on a sophisticated network of diagnostic instruments and specialized consultations to provide definitive diagnoses and treatment recommendations. Delays in collecting test results or gaining appointments with experts can extend a patient's stay in the ED, increasing overall wait times.

The implications of patient delays in EDs are far-reaching and complex. Clinically, even slight delays can have a severe impact on patient outcomes. Patients suffering from time-sensitive diseases, such as a stroke or a heart attack, require prompt intervention to limit tissue damage and enhance recovery possibilities. Delays in treatment might drastically harm the patients' prognosis. Furthermore, excessive wait times can cause patient discontent and dissatisfaction with the healthcare system. This may prevent individuals from getting prompt medical assistance for future health concerns, potentially leading to more significant complications later on. Furthermore, overcrowding in EDs due to patient delays can put a burden on hospital resources and make it difficult to provide effective care to all patients. This ripple effect can have a substantial financial impact on healthcare systems, as overloaded emergency departments often run at a lower efficiency.

1.2 AIM & OBJECTIVES

The purpose of the study was to assess these delay factors leading to patient delays in emergency department through failure mode and effects analysis. The objectives of this study are as follows:

1. Employing an FMEA to systematically recognize potential failure modes that result in increased patient visit time or delays within the emergency department.
2. Assessing the severity, frequency, and detectability of each identified failure mode relevant to wait times in the ED.
3. Calculating a Risk Priority Number (RPN) to rank delay or failure according to their potential impact on patient wait times in the ED.
4. Formulating interventions and mitigation strategies to address high-risk failure modes that contribute to extended wait times in the ED.

1.3 ARTEMIS HOSPITAL

The study was carried out in the emergency and trauma department of Artemis Hospital in Gurgaon. Established in 2007, Artemis Hospital has become a Gurgaon hallmark for high-quality medical services. Artemis has quickly emerged as a pioneer in the industry, altering healthcare norms around the region. Recognized for great patient care and cutting-edge technology, it has become a beacon for individuals seeking advanced medical and surgical treatments. Artemis Hospital, which spans nine acres, boasts cutting-edge facilities and more than 550 beds. It houses a staff of approximately 400 highly skilled and experienced doctors from 40 different specialties. This diversified pool of experience enables Artemis to provide a wide range of medical and surgical services, including cardiac care, cancer, minimally invasive surgery, and organ transplants. Their emphasis on super-specialties such as bone marrow transplants, liver transplants, and difficult joint replacements ensures that patients receive the most modern treatments available.

One of the primary reasons for Artemis' success is its consistent commitment to patient-centered treatment. The hospital carefully plans its facilities and processes to ensure patient comfort and well-being. This results in a warm and welcoming environment, shortened admission procedures, and an emphasis on personalized care plans. Furthermore, Artemis' international patient services provide a comfortable experience for people seeking medical care from afar.One of the primary reasons for Artemis' success is its consistent commitment to patient-centered treatment. The hospital carefully plans its facilities and processes to ensure patient comfort and well-being. This results in a warm and welcoming environment, shortened admission procedures, and an emphasis on personalized care plans. Furthermore, Artemis' international patient services provide a comfortable experience for people seeking medical care from afar.

Apart from individual patient care, Artemis Hospital actively contributes to the progress of healthcare in India. Their dedication to research-driven procedures and new medical advances puts them at the forefront of the medical sector. Artemis Hospital seeks to set new standards for quality healthcare delivery through its accreditation with the National Accreditation Board for Hospitals and Healthcare Providers (NABH) and the Joint Commission International (JCI).

Artemis Emergency & Trauma Center is a fully functional, well-maintained institution that offers comprehensive emergency and trauma care 24 hours a day, seven days a week. It believes

in offering 'Life-Saving Care, Tailored to Patient Needs'. From life-threatening crises to catastrophic injuries, the Emergency Centre provides advanced cardiac care, Level 1 trauma care, maternal and child care, and a dedicated stroke center.

Australasian Triage Scale

Australasian Triage Scale (ATS) is a tool used by nurses in emergency departments (EDs) to prioritize patients based on the urgency of their medical condition. The ATS categorizes patients into five triage categories, each with a different time frame for being seen by a doctor.

Australasian Triage Scale Category	Response Time	Category Description
Category 1 (Red)	Immediate Simultaneous Assessment and Treatment	Immediate Life-Threatening
Category 2 (Orange)	Assessment and Treatment starts within 10 mins	Imminently Life-Threatening
Category 3 (Green)	Assessment and Treatment starts within 30 mins	Potentially Life-Threatening
Category 4 (Blue)	Assessment and Treatment starts within 60 mins	Potentially Serious/ Situational Serious/ Significant Complexity
Category 5 (White)	Assessment and Treatment starts within 120 mins	Less Urgent

Figure 1.1: *Australasian Triage Scale for patients in emergency department*

CHAPTER 2: REVIEW OF LITERATURE

S. No.	Authors	Study Location	Sample Size	Sampling Technique	Salient Features
1.	Shahrami A Rahmati F Kariman H	Imam Hossein Hospital, Tehran, Iran	100	The study employed a prospective cohort design. Sampling entailed focused and frequent conversations with staff working in different subsystems, producing defect reports, meetings with staff from the next subsystem to identify concerns based on studied documents.	The study's goal was to look into FMEA as a tool for identifying & solving problems that cause ED revenue loss. Conducted for about 24 months (Oct 2007 to Nov 2009). The department was organized into one major system and six classified subsystems. The study was divided into two phases: **First Phase:** Identified defects in the subsystems and prioritized them based on Risk Priority Number (RPN). This phase lasted for the first six months. **Second Phase:** Solutions to the defects were implemented based on priority.

					Key results included a significant increase in ED revenue (from 73.1 thousand US dollars per month to 320 thousand US dollars per month by the end of the study, a 337.75% increase The study found that FMEA is an effective strategy for identifying and resolving financial system faults in the medical setting, resulting in enhanced profitability.
2.	Sheikhbardsiri H. Fatemeh Rezaei Yasamin Molavi Taleghani	Imam Hossein Hospital, Tehran, Iran	The hospital averages about 4,500 visits per month. However, the exact number of records reviewed or the sample size is not explicitly mentioned	Data were acquired using three basic methods: Meetings with personnel from each subsystem are held on a regular and concentrated basis, and defect reports are compiled.	The study employed Failure Mode and Effect Analysis (FMEA) to uncover issues causing revenue loss in the ED. Key concerns highlighted were the nursing unit's failure to document services and a lack of particular identifying codes for patients' files when they moved from the ED to other departments. The study attempted to provide answers to these

				Regular meetings with the team of the next subsystem to identify problems in the previous subgroup using studied files. The researchers randomly selected and analyzed files in the presence of connected people.	issues in order to ensure dependability and validity in raising income in the emergency department. The study indicated that FMEA might be regarded an effective approach for enhancing ED revenue by addressing identified difficulties.
3.	Ehsan Ullah Mirza Mansoor Baig Hamid GholamHosseini Jun Lu	Taranaki Base Hospital, New Plymouth, New Zealand	The study utilized the knowledge of 6 frequent users of the Rapid Response System (RRS)	The study employed a purposive sampling technique by recruiting 6 frequent users of the RRS as subject matter experts (SMEs) to participate on a voluntary	**Objective**: The study's goal was to use Failure Mode and Effect Analysis (FMEA) to locate and fix possible problems with a hospital's Rapid Response System (RRS). **Methodology**: Using the Risk Priority Number (RPN) technique, 6 common users of the RRS, including doctors and

				basis. These experts were selected based on their hands-on knowledge and experience with the RRS process	nurses, assessed potential failures and identified 35 failure modes and 101 failure mode effects over 13 process phases. **Afferent vs. Efferent Limb**: The afferent limb of the RRS (the part responsible for detecting and responding to patient deterioration) was found to be more susceptible to failures compared to the efferent limb (the part involved in the subsequent management of the patient). **Causes of Failures**: Human mistake, staff workload, staffing numbers, the drawbacks of paper-based charts, and organizational problems were among the main causes of the failures. **Electronic System Benefits**: Research has indicated that an electronic system has the capacity to eliminate or reduce 70.2% of failures that are recognized; the remaining problems require focused

					corrective actions, such as education, scenario-based training, and changed calling criteria.
4.	Ronald E. Warnick, MD, Amy R. Lusk, MSN, John J. Thaman, MS, Elizabeth H. Levick, MD, Andrew D. Seitz, BSN	Cincinnati, OH, USA	The study describes the analysis and implementation of FMEA based on the treatment of 1,400 patients using the Gamma Knife Perfexion® system	The study does not explicitly mention a sampling technique. It focuses on the entire process of Gamma Knife radiosurgery and the identification of potential failure modes within that process.	**Objective:** The goal of the study was to use Failure Mode and Effects Analysis (FMEA) to improve the safety and effectiveness of Gamma Knife radiosurgery. Process: The Gamma Knife process tree was thoroughly mapped by the FMEA team, who also identified possible failure modes and assigned a Risk Priority Number (RPN). Process Tree: included 177 steps and 14 subprocesses that together identified 31 possible failure modes. Of these, 7 had a high score (RPN ≥150), and 3 other modes were chosen by physicians as mitigation techniques. Mitigation Strategies: Designed to address high-risk failure modes; the efficacy of these tactics was

					reevaluated after a period of 18 months. Outcome: The impact of the FMEA mitigation techniques was confirmed by the significant reduction in RPN scores that was seen. For both newly opened and already-operating Gamma Knife institutions seeking to improve their quality management systems, the report offers a road map. Documentation: There are five quality control documents available that any Gamma Knife clinic can alter.
5.	- Andy Yuanguang Xu - Jagdish Bhatnagar - Greg Bednarz - John Flickinger - Yoshio Arai	- University of Pittsburgh Cancer Institute, Pittsburgh, PA, USA - University of Pittsburgh Medical Center, Pittsburgh, PA, USA	The study does not specify the exact number of cases analyzed, but mentions that over 600 patients receive single-	The study does not specify a sampling technique. It focuses on the process and failure modes of Gamma Knife radiosurgery as performed	Objective: To formulate a risk-based quality management program utilizing the FMEA tool, which is suggested by AAPM Task Group 100, for Gamma Knife radiosurgery. Process Tree: A process tree with 53 steps total, 10 subprocesses, including stages for the frame-based

	- Jonet Vacsulka - Wenzheng Feng - Edward Monaco - Ajay Niranjan - L. Dade Lunsford - M. Saiful Huq	- New York Presbyterian Hospital/Columbia University Medical Center, New York, NY, USA	fraction Gamma Knife radiosurgery treatments annually at their institution.	at their institution.	aspect of Gamma Knife radiosurgery, including steps for frame installation. Failure Modes Identification: Detected 86 failure modes, 40 of which were unique to Gamma Knife radiosurgery and may have resulted from improper use of the Gamma Plan treatment planning system's features, imaging fiducial boxes, Gamma Knife helmets, plugs, and other items. Risk Priority Number (RPN): Each failure mode was scored based on the probability of occurrence, severity, and probability of no detection. The overall RPN for each failure mode was calculated. Hazard Scores: The machine mechanical failure that went unnoticed throughout the morning QA process, improperly attached frame adaptors,

					defective fiducial box assembly, loose plugs or inserts, and neglected target regions were the failure types that had the greatest risk ratings. Outcome: Professionals were able to gain a deeper grasp of the Gamma Knife radiosurgery procedure and potential limitations were identified by the study. It offers a foundation for creating a risk-based focussed system on quality management program for radiosurgery using gamma knives.
6.	- Alix J.E. Carter, MD, MPH - James B. Gould, BSc - Peter Vanberkel, PEng, PhD - Jan L. Jensen, ACP, MAHSR - Jolene Cook, MD	- Emergency Health Services, Dartmouth, Nova Scotia - Dalhousie University, Halifax, Nova Scotia - IWK Health Centre, Halifax, Nova Scotia	- The study identified 78 failure modes (FM) in the offload zone process.	The study used Health Care Failure Mode and Effect Analysis (HFMEA) to identify failure modes, determine their probability and severity, calculate hazard scores,	Objective: In order to assess the unloading zone's (OZ) efficiency and safety, the study intends to create a process map of EDs and carry out a hazard analysis. Process Mapping: The OZ procedure consists of six main steps: patient study in OZ, patient care in OZ, patient in-transfer out of OZ, patient out-transfer via

	- Steven Carrigan, MPA - Mark R. Wheatley, ACP - Andrew H. Travers, MSc, MD			and propose mitigations for high-risk scores.	ambulance, and arrival to the ED. Hazard Analysis: After conducting a Health Care Failure Mode and Effect Analysis (HFMEA), 78 failure/factors modes (FM) were found, of which 28 were deemed to be high priority. Failure Modes: The high-priority failure or delay modes were classified into impacts on patient safety (25%), process efficiency (35.7%), and both (39.3%). Mitigations: Seventeen mitigations was recommended for the identified high-risk failure modes to improve safety and efficiency. Offload Delay: The study addresses offload delay, a significant issue where ambulances experience prolonged waiting times to transfer patient care due to ED crowding, impacting

					patient outcomes and EMS availability. Policy Implications: The findings are intended to inform current policies and practices, aiming to reduce offload delays and improve overall ED and EMS efficiency.
7.	1. Ming Leung 2. Kenny Kin Chung Chan 3. Wing Leung Wong 4. Alexander Chun Bon Law	- Princess Margaret Hospital, Hong Kong	The study was conducted over two phase: pre-IPMOE and post-IPMOE.	Prospective observation study of individual nurses over 8-hour shifts	Objective: Evaluate the impact of the In-patient Medication Order Entry (IPMOE) system on nursing tasks in the medical ward, particularly on time devoted to tasks related to medicine. Study Design: A time-motion study conducted before and after the implementation of IPMOE, measuring the duration of time nurses dedicated to duties associated with medicine. Setting: The study was conducted in two busy acute medical wards at Princess Margaret Hospital in Hong Kong, where IPMOE was first implemented in 2013.

					Data Collection: The study involved 8-hour observation periods of nurses, focusing on pre-defined standards. Results: Following the introduction of IPMOE, the average number of tasks connected to medication per duty dramatically lowered, falling from 61.07 to 29.81. While the time required to provide medication increased slightly, the time required for these chores also decreased. Statistical Analysis: Changes in task patterns were found before and after IPMOE deployment using interrupted time series analysis, which revealed a delayed effect signifying a system ramp-up period. Conclusion: The IPMOE system effectively reduced the number and time of medication-related tasks, suggesting improvements in efficiency and safety in the

					clinical setting. The study's methodology and findings can be applied to similar evaluations in other clinical systems.
8.	Michael W. Seymour Charlotte G. Henshaw Andrew C. Marshall Juliet M. Harrison Sophie L. Roberts Nicholas J. Walker Alexander M. Berry Christopher D. Smith Thomas J. A. Cullen Paul G. R. Bagnall	The study was conducted in Ghana, Africa	The study analyzed data from 4,696 emergency department (ED) attendances	The study employed a systematic sampling technique to review causes, consequences, and solutions to ED crowding based on available literature and data.	**Objective**: The study aimed to review and analyze the causes, consequences, and potential solutions to ED crowding. **Data Collection**: Data was collected through a systematic review of existing literature and ED attendance records. **Causes of ED Crowding**: Identified causes included increased patient volume, inefficient processes, lack of inpatient beds, and limited resources. **Consequences of ED Crowding**: Highlighted consequences included longer wait times, increased patient mortality, decreased patient satisfaction, and increased stress among healthcare staff.

					Proposed Solutions: Suggested solutions encompassed process improvements, resource allocation, policy changes, and the implementation of ED-specific interventions to improve patient flow and reduce crowding (PLOS)
9.	William K. M. Lau, Warren J. McIsaac, and Doug G. Manuel	The research was carried out in Ontario, Canada	The study utilized data from more than 25,000 respondents in each cycle.	The CCHS deployed technique of multi-stage stratified cluster design	**Data Source**: The study used data from the CCHS, cycles 1.1 to 5.1, conducted by Statistics department of Canada from the year 2000 to 2010. Respondents' CCHS responses were linked with personal health care utilization data using their Ontario health card numbers. **Outcome Variables**: The number of trips to the emergency room over the course of the 365 days that followed the interview date was the main result. The visits were categorized as potentially avoidable or unavoidable based on the

					Canadian Triage system and Acuity Scale metrics. **Assessment of Comorbidity**: Comorbidity was assessed using the John Hopkins University Ambulatory Care Groups Case Mix Adjustment System, summarizing the degree of comorbidity and expected resource utilization. **Predictors Analyzed**: Various individual-level predictors were included in the regression models such as gender, age, household income, education, number of chronic medical conditions, perceived health status, and comorbidity measures. **Study Objective**: The key objective was to compare various approaches in order to gain a better understanding of the factors impacting the demand for emergency department

					services in Ontario through modeling.
10.	COVIDSurg Collaborative	Global, covering multiple countries	The study does not provide a specific sample size for individual patients but mentions the use of data from 359 hospitals across 71 countries	Senior surgeons were contacted through the global COVID Surg network and asked to estimate the percentage of elective procedures that would be canceled during the peak 12-week COVID-19 disruptions. This strategy, known as the expert response study method, was used in this study.	**Modeling of Elective Surgery Cancellations:** The study aimed to model the global cancellations of elective surgeries due to the COVID-19 pandemic. Surgeons provided estimates based on their experience and projections for their hospitals. **HDI as a Predictor:** A Bayesian β-regression model was developed using the Human Development Index (HDI) as a predictor. This model provided estimates for cancellation rates of elective surgeries across different countries. **Types of Surgeries Analyzed:** The study focused on three types of surgeries: cancer surgery, surgery for benign diseases, and obstetric (elective caesarean section) operations. These categories were used to calculate and compare cancellation rates.

					Data Sources: The study used case mix data from previous global surgical outcome studies, which involved a total of 102,539 patients across 64 countries. **Impact on Surgical Services:** The results indicated a significant impact on surgical services, with varying cancellation rates based on the country's HDI. The study provided crucial data to help inform surgical recovery plans and prioritize resources effectively post-pandemics.
11.	Patrick Aboagye-Sarfo Qun Mai Frank M. Sanfilippo David B. Preen Louise M. Stewart Daniel M. Fatovich	Western Australia (WA), Australia	The study analyzed seven years of monthly emergency department (ED) presentation data from all public hospitals in Western Australia, covering the period from	Population-based time-series analysis using monthly ED presentations from the WA Emergency Department Data Collection (EDDC) database	The goal of the project was to create multivariate vector-ARMA (VARMA) forecast models for ED demand prediction and evaluate them against Winters' and univariate ARMA models. For the model fitting study and in-dpeth descriptive analysis, it made use of graphical and VARMA modeling techniques.

			2006/07 to 2012/13		According to the study, compared to ARMA and Winters' techniques, VARMA models produced forecasts that were more exact and accurate, had lower confidence ranges, and had superior accuracy metrics. Variables including age group, treatment location, triage category, and disposition were included in the data.

CHAPTER 3: METHODOLOGY

The method used to gather and analyze the data is thoroughly explained to the readers in this Chapter. It enables the reader to comprehend the sample techniques utilized, the population analysed, the research design, and the data gathering, and analysis procedures used. The data was collected through time motion study, assessed the severity, frequency, and detectability of each identified failure/delay factors mode relevant to wait times in the ED.

3.1 RESEARCH QUESTION

Can a Failure Mode & Effect Analysis (FMEA) be employed to systematically identify and prioritize potential sources of delays within the emergency department (ED), ultimately leading to the development of interventions that can effectively reduce these delays and enhance patient care?

3.2 RESEARCH DESIGN

The research design outlines the overall methodological approach employed and the specific course of action adopted to achieve the study's objectives and investigate the research question. The detail of the study is provided below:

3.2.1 STUDY SETTING

The study was conducted in the Gurgaon region at Artemis Hospital- a multi-speciality hospital with nearly 550 beds. It houses a team of over 400 highly skilled and experienced doctors across a staggering 40 specialties. The research study was conducted under the supervision of the General Manager - Security & Operation, taking place between March and June 2024.

3.2.2 RESEARCH APPROACHES

This prospective cohort study investigated the reasons for the patient delay, throughout a 3-month period, from March 2024 to June 2024, in the emergency department. The delay factors were used to perform & calculate FMEA analysis. A time motion study and questionnaire survey were used during the study. Patients who visited the emergency departments in advanced cardiac care, Level 1 trauma care, mother and childcare, and a dedicated stroke centre during the study period made up the participants. To choose individuals who met the inclusion

requirements, a practical sampling technique will be used. Based on practicality and time availability during the time period, the sample size was chosen.

3.2.3 DATA COLLECTION METHODS

a) Time Motion Analysis: TMA was used to calculate the total time taken by patient visiting the ED. The time was observed from the entry of the patient in the department till final settlement of bill and exit of patient. The duration of patient in ED was observed and recorded by trained researcher using a stopwatch. The TMA data of 105 patients was observed as a sample size for the study. The TMA data contained the details for patients like the reason for visit, door-in time, doctor visit time and door-out time.
b) Questionnaire Survey: The patients who were observed in the time motion analysis, were surveyed. Patients were given a structured questionnaire to complete to gather information about their satisfaction and experiences. A variety of factors, including reason for delay, admission services experience, the billing experience, and overall experience in the emergency department, was evaluated using the questionnaire. A total of 105 patients' responses were observed as a sample. Using both online and offline modes, the responses were collected in person.

3.2.4 DATA ANALYSIS

a) Time Motion Analysis: For the time motion study, the information gathered through observation was manually collected into Excel. The mean time of the patient duration was calculated for different categories like triage category, day of visit, severity level. The number and proportion of cases falling into different parameters were also calculated. The mean time calculated was utilized to assess the RPN factors for the FMEA analysis.
b) Questionnaire Survey Analysis: The data obtained from the questionnaire comprised of the delay factors, satisfaction level of patient during the visit and areas of consideration. The data from the questionnaire survey was imported into Excel for analysis. Each question's replies were compiled using descriptive statistics. Thematic analysis was also used to find recurring themes and patterns in the qualitative data collected from close-ended and open-ended questions that relate to patient satisfaction. The subjective understanding of the different factors was used to determine factors for FMEA analysis.

The methodology described above enables a thorough assessment of the patient delay in emergency department. TMA and questionnaires together provide both objective and subjective insights on assessing the parameter for FMEA study. The data analysis procedure produced insightful information about the advancements made and supported the development of fact-based judgements.

c) Failure Mode and Effects Analysis:

1. Pre-work:

The data collated in the time motion study and questionnaire survey was utilized in determining the delay factors and RPN for these factors. The delays factor in each of the broader subsystems were identified and given priority according to the FMEA study.

Every delay factor was evaluated according to how it would affect the system's end result. This weight, which was determined using the following formula, was known as the risk priority number (RPN):

RPN= Severity x Occurrence x Detection

Process flow diagram for FMEA:

The process flow diagram explains the methodology followed in the study to obtain RPN for FMEA study. The figure is given below:

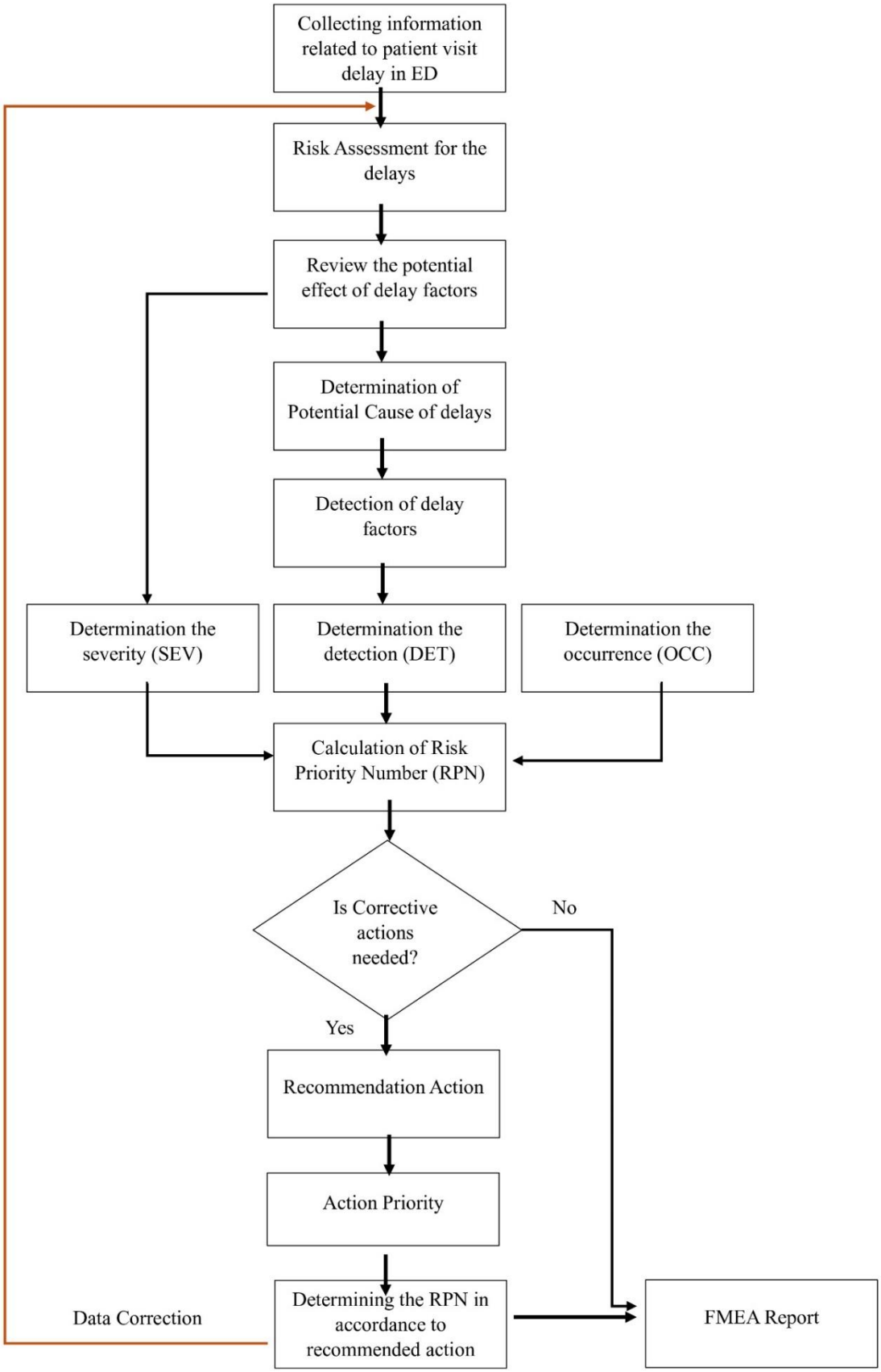

Figure 3.1: *Process flow diagram of FMEA study*

2. *Path 1 development:*

Path 1 involves determining the severity of delay factors. The data collected in the TMA and Questionnaire survey helps in the risk assessment of delay factors, potential effects of the determined delay factors. FMEA severity table is prepared.

Severity Impact	Criteria Severity of Delay on Patient	Rank
Catastrophic Event	Potential failure mode causes death of the patient or major loss of physiological function	4
Major Event	Potential failure mode leads to potential worsening of condition, exposed to increased risk of complications	3
Moderate Event	Patient experiences prolonged pain or discomfort, delayed treatment, medication errors or missed diagnoses	2
Minor Event	Patients need to have increased length of stay, ED have reduced capacity for new patients	1

Table 3.1: *FMEA Severity table*

3. *Path 2 development:*

Path 2 involves determining the occurrence of delay factors. The data collected in the TMA provides the frequency of occurrence of different delay factors and potential cause of the delay factors are determined. FMEA occurrence table is prepared.

Likelihood of Occurrence	Criteria Occurrence of cause	Rank
High	Potential failure mode have frequency of occurrence more than 12	4
Moderate	Potential failure mode have frequency of occurrence ranges between 8 to 10	3
Low	Potential failure mode have frequency of occurrence between 6 to 8	2
Very Low	Potential failure mode have frequency of occurrence less than 6	1

Table 3.2: *FMEA Occurrence table*

4. *Path 3 development:*

Path 3 involves determining the detection of delay factors. The data collected in the TMA and Questionnaire survey provides the detection controls of different delay factors during patient visit of ED. FMEA detection table is prepared.

Opportunity for Detection	Criteria Likelihood of detection of delays	Rank
No detection	The potential failure mode is not detection in process	4
Low	Low possibility of detecting the delay factor during patient visit	3
Moderate	Moderate possibility of detecting the delay factor during patient visit	2
High	High possibility of detecting the delay factor during patient visit	1

Table 3.3: *FMEA Occurrence table*

5. *Calculation of RPN:*

Risk Priority Number is calculated by multiplying severity factor rank, occurrence factor rank and detection factor rank for all of the delay factors. Delays with RPN > 24 were assigned as the 1st priority category; RPN between 14 and 24 were assigned as the 2nd priority; RPN 8 to 14 were assigned as the 3rd priority; and RPN < 8 were assigned as the 4th priority problems.

	PATH 1				PATH 2		PATH 3								
Process Step /Subsystems	Potential Failure Mode	Potential Effect of failure	SEV	Potential Cause/Mechanism of Failure	OCC	Detection of Failure Mode	DET	RPN	Recommended Action	Action Priority	SEV	OCC	DET	RPN

Table 3.4: *Sample FMEA worksheet*

6. *Recommended Action and Action Priority:*

Recommended action is provided to each of the delay factors along with action priority based on the RPN. The FMEA actions are closed when actions are taken towards the delay factor with most priority and reassessment of the failure modes are done.

3.2.5 PROCESS FLOW IN EMERGENCY DEPARTMENT

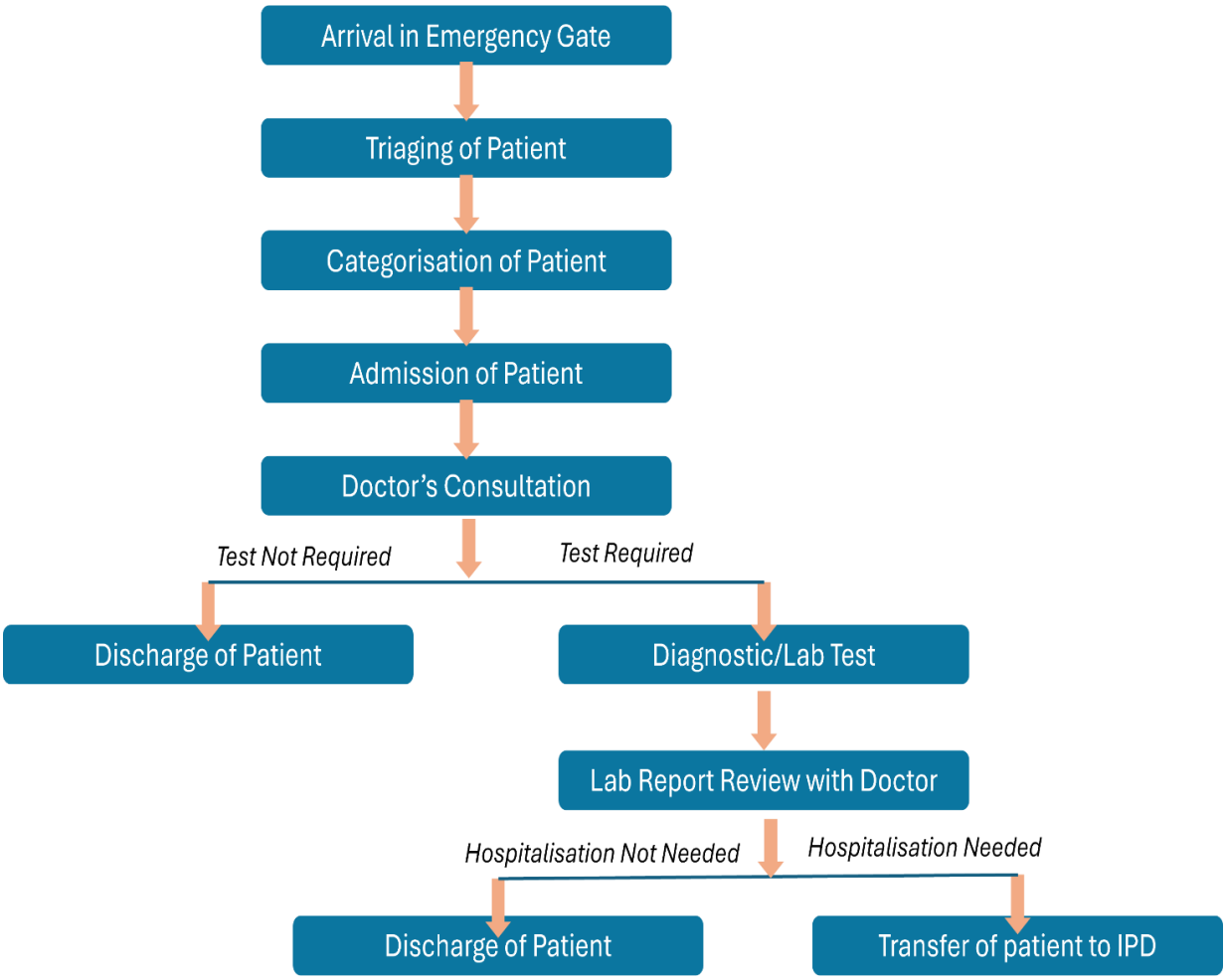

Figure 3.2: *Process flow of patients in emergency department*

3.2.6 ETHICAL CONSIDERATION

While conducting the research, the following ethical issues was considered:

1- The study's aim, the participants' voluntary participation, and the confidentiality of their data were all clearly communicated to them prior to their informed consent.
2- To protect participants' privacy, data analysis and reporting were conducted anonymously.
3- The study was carried out with the utmost respect for participants' privacy and dignity, resulting in a welcome and respectful setting for data collection.
4- The study followed all applicable research laws, norms, and directives, including those controlling data protection and human subject rights.

CHAPTER 4: RESULTS

During the study which comprised of 105 sample of patient visits at the emergency department of Artemis hospital, the assessment of the FMEA for the patient delay provided insights to address the study's questions.

4.1 FMEA STUDY

The delay factors in the patient factors in subsystems were detected, assessed and prioritized. The subsystems for the delay factors were admission, consultation, discharge, patient and diagnosis.

The list of delay factors identified during the study were:

1. Delay in admission due to Insurance
2. Admission process took time
3. Beds not available
4. Time taken to diagnosis problem
5. Delay during treatment
6. Rush in emergency
7. Partial Documentation
8. Delay due to Insurance clearance
9. Late in sending the documents to discharge unit
10. Lack of unique identifying code in patients' files
11. Patient took time to leave
12. Patient attendant unavailable
13. Delay in providing test report
14. Delay in conducting tests

The identified delay factors were used in assessing the severity, frequency, and detectability of each identified failure mode relevant to wait times in the ED. Every delay factor was evaluated according to how it would affect the system's end result. This weight, which was determined using the following formula, was known as the risk priority number (RPN):

RPN= Severity x Delay Probability x Delay Degree

	PATH 1			PATH 2		PATH 3									
Process Step /Subsystems	Potential Failure Mode	Potential Effect of failure	SEV	Potential Cause/Mechanism of Failure	OCC	Detection of Failure Mode	DET	RPN	Recommended Action	Action Priority	SEV	OCC	DET	RPN
Admission	Delay in admission due to Insurance	Increased wait time, anxiety, Potential worsening of condition	4	Complex insurance verification procedures, Lack of trained staff for insurance verification	4	Moderate	2	32	Collaborate with insurance companies to streamline pre-authorization processes.	1st Priority Category	4	3	2	24
Admission	Admission process took time	Frustration for patient, Perception of inefficiency	2	Lengthy intake forms Inadequate staffing	2	Moderate	2	8	Optimize paperwork by reducing unnecessary steps and duplications.	3rd Priority Category	2	2	2	8
Admission	Beds not available	Extended wait time in ED, Potential need for care in non-ideal setting	1	Lack of effective bed management system	1	High	1	1	Implement a real-time bed tracking system to improve visibility of bed availability across departments. Establish better communication between the ED and inpatient wards to coordinate bed allocation.	4th Priority Category	1	1	1	1
Consultation	Time taken to diagnosis problem	Delayed treatment, Potential for complications	2	Complex medical conditions Difficulty obtaining a complete medical history	3	Low	3	18	Implement clinical decision support systems to aid in diagnosis by providing clinicians with quick access to patient data and treatment guidelines.	2nd Priority Category	2	2	3	12
Consultation	Delay during treatment	Prolonged pain or discomfort, Increased risk of complications	2	Waiting for test results Complex treatment procedures	2	Moderate	2	8	Streamlining processes for medication access within the ED can minimize delays in administering necessary medications.	3rd Priority Category	2	2	1	4
Consultation	Rush in emergency	Increased wait time for non-critical cases, Potential for errors	2	Seasonal variations in patient volume (e.g., flu season) Major accidents or disasters	1	Low	3	6	Increase operational efficiency by converting underutilised areas of hospital as temporary emergency area and transfer of less prior cases (as per the Triage Categorisation) to these areas of hospital	1st Priority Category	2	1	3	6
Discharge	Partial Documentation	Incomplete medical record, potential for medication errors or missed diagnoses	2	Lack of timely communication from insurance companies Errors or missing information in insurance requests	2	Moderate	2	8	Implement standardized templates for documentation to ensure all necessary information is captured during the initial assessment.	2nd Priority Category	2	2	1	4
Discharge	Delay due to Insurance clearance	Anxiety about cost, Delayed access to necessary care	4	Complex pre-approval process for certain procedures by some insurance companies Lack of timely communication from insurance companies	2	High	1	8	Implement a dedicated insurance liaison within the ED to handle insurance issues and expedite clearances.	2nd Priority Category	4	2	1	8
Discharge	Late sending of the files to the discharge unit	Delayed discharge of patient	1	Inefficient communication between departments (ED and discharge planning) Incomplete discharge paperwork	2	High	1	2	Implement a dedicated discharge coordinator to oversee the discharge process and ensure timely file transfer.	4th Priority Category	1	2	1	2
Discharge	Lack of specific identifying code for the patients files moving from the ED to any other department	Increased risk of lost or misplaced files, Delays in patient care	1	Manual filing system with potential for human error	1	High	1	1	Generate an error check when identifying codes are not entered while transfering files to other departments	4th Priority Category	1	1	1	1
Patient	Patient took time to leave	Reduced bed availability for new patients	2	Waiting for medications or prescriptions	3	Moderate	2	12	Ensure timely completion of necessary paperwork by streamlining processes.	3rd Priority Category	2	2	2	8
Patient	Patient attendant unavailable	Delays in decision-making, Potential for missed information	2	Elderly patients without readily available family Patients with mental health conditions who may not have reliable support	2	Low	3	12	Assist patients in coordinating transportation if needed to facilitate a smooth discharge process.	3rd Priority Category	2	2	3	12
Diagnosis	Delay to provide test report	Delayed diagnosis and treatment, anxiety	3	High volume of tests in the laboratory Equipment malfunction	4	Moderate	2	24	Prioritize turnaround times for critical tests to ensure timely results. Ensure adequate staffing levels in the laboratory departments to avoid delays in processing tests.	1st Priority Category	3	3	1	9
Diagnosis	Delay to conduct tests	Potential worsening of condition, Delayed treatment	4	Need for specialized tests requiring referral to another facility Limited availability of testing equipment	2	Moderate	2	16	Explore the use of rapid diagnostic tests for specific conditions where appropriate.	2nd Priority Category	4	2	1	8

Table 4.1: *FMEA worksheet with delay factors in ED*

Subsystem	Delay Factor	RPN	Frequency
Admission	Delay in admission due to Insurance	32	13 (12%)
	Admission process took time	8	6 (6%)
	Beds not available	1	2 (2%)
Consultation	Time taken to diagnosis problem	18	9 (9%)
	Delay during treatment	8	7 (7%)
	Rush in emergency	6	5 (5%)
Discharge	Partial Documentation	8	8 (8%)
	Delay due to Insurance clearance	8	6 (6%)
	Late in sending the documents to discharge unit	2	7 (7%)
	Lack of unique identifying code in patients' files	1	2 (2%)
Patient	Patient took time to leave	12	10 (10%)
	Patient attendant unavailable	12	7 (7%)
Diagnosis	Delay to provide test report	24	15 (14%)
	Delay to conduct tests	16	8 (8%)

Table 4.2: *Frequency and priority of delays present in each sub system*

Insurance delays are a major contributor to waiting times for patients in the Emergency Department (ED). This is evident from the finding that "Delay in admission due to Insurance" has the highest RPN score (32) in the table.

The high RPN (18) for "Time taken to diagnose the problem" highlights a critical area for improvement in the ED. This suggests that patients are experiencing significant delays in receiving a diagnosis. Potential reasons could be complex cases requiring extensive investigation. Addressing this factor could involve implementing clinical decision support systems or exploring rapid diagnostic tests to expedite diagnoses.

The diagnosis subsystem has significant room for improvement. This is because one factor related to diagnosis, "Delay to provide test reports" (RPN=24), have the second highest RPN scores with the highest frequency of occurrences.

Streamlining paperwork and communication could improve efficiency in several areas of the ED. Factors such as "Partial Documentation" (RPN=8) in the Consultation subsystem and "Late sending of the files to the discharge unit" (RPN=2) in the Discharge subsystem both suggest that inefficiencies with paperwork and communication are contributing to delays.

4.2 TIME MOTION ANALYSIS

The data gathered during the time motion analysis draw insights on various parameters. According to data, 77% of the cases observed in ED (81 cases) have observed some of form of delays during the period of study.

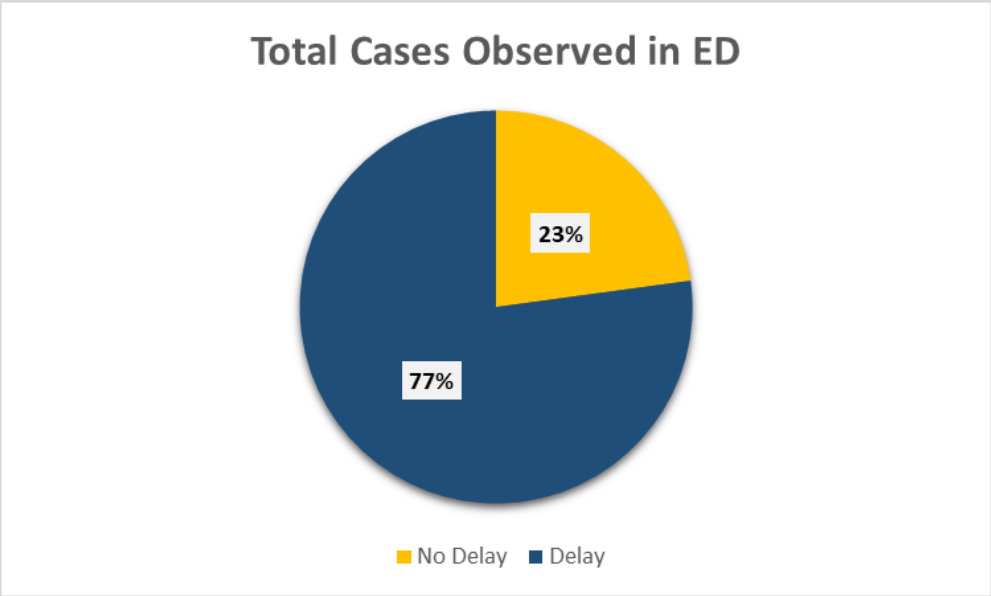

Figure 4.1: *The total cases observed in emergency department for the study*

The average time duration for which 24 respondents have considered as "No delay" is 59 minutes whereas 81 respondents have considered as "Delay" with average patient time in ED is 4 hours 3 minutes.

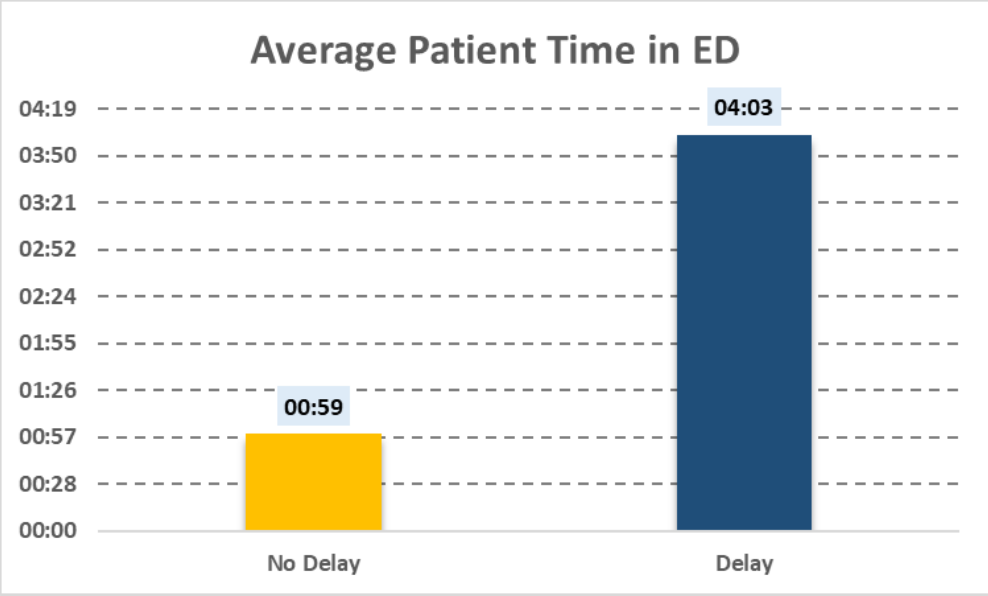

Figure 4.2: *Average patient time in ED for delayed and not delayed cases*

According to the data, out of the patients experiencing delays, 56% linked these delays to one delay factor whereas 44% have considered more than 1 factors leading to the delays.

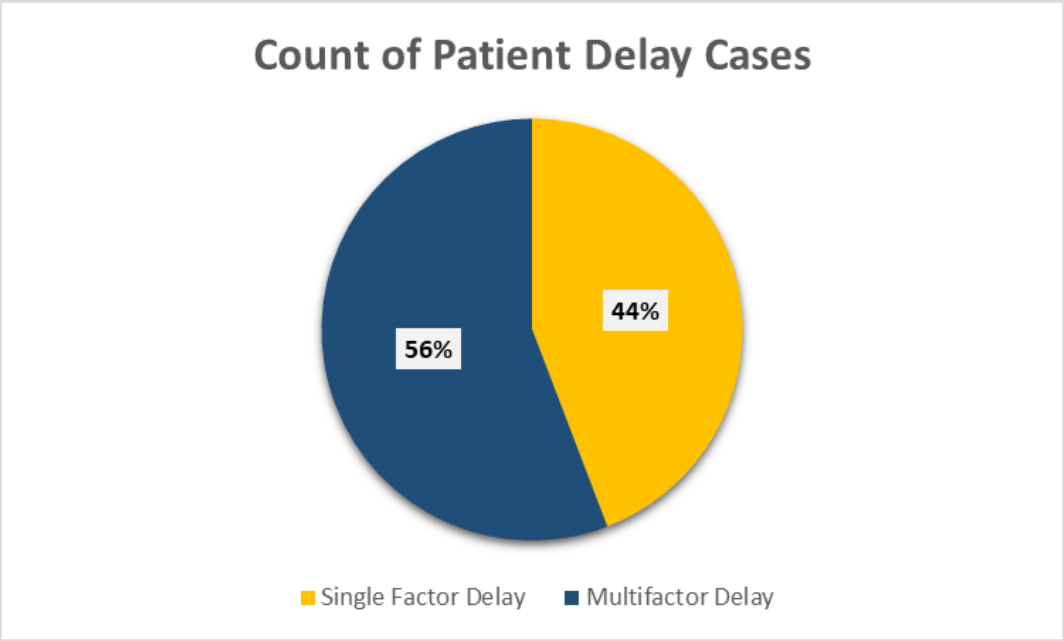

Figure 4.3: *Distribution of patient delay cases in single factor & multi factor*

The data insights generated on analysis of average time taken by patient in ED when they faced delays is different in case of single factor associated with delay or multiple factors. For single factor delay time is 3 hours 28 minutes whereas for multiple factors delay it is 4 hours 18 minutes.

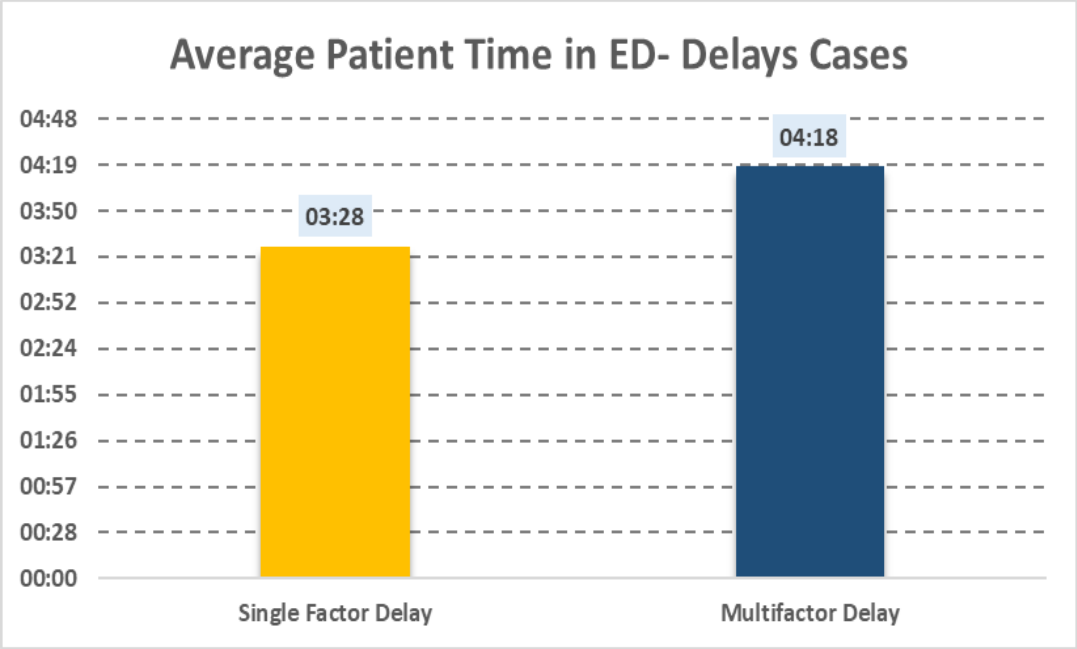

Figure 4.4: *Average patient time in emergency department for single factor & multi factor*

In the FMEA study, 5 subsystems for the delays in patient visits were considered. The graph below represents the proportion of delay classified in these subsystems. Diagnosis subsystem has the highest percentage of delay being contributed to, as 29%.

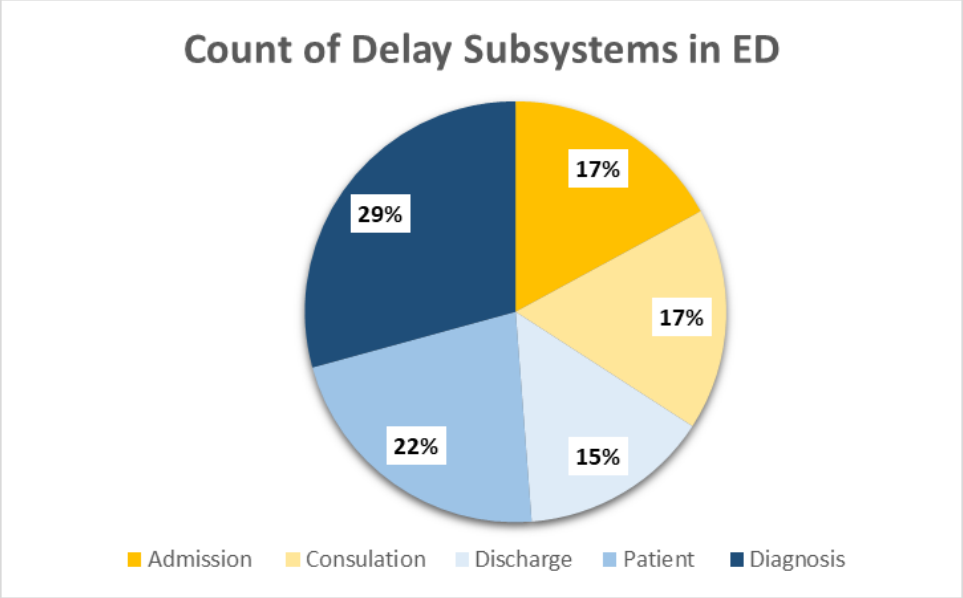

Figure 4.5: *Distribution of delayed cases according to delay subsystems*

According to the detailed data analysis, average patient time in ED as per the different subsystems can be observed in below figure. The highest time taken is for Admission subsystem (4 hours 47 minutes) followed by Diagnosis subsystem (4 hours 14 minutes). Although the count percentage for the admission subsystem is 17%, it has the highest average time.

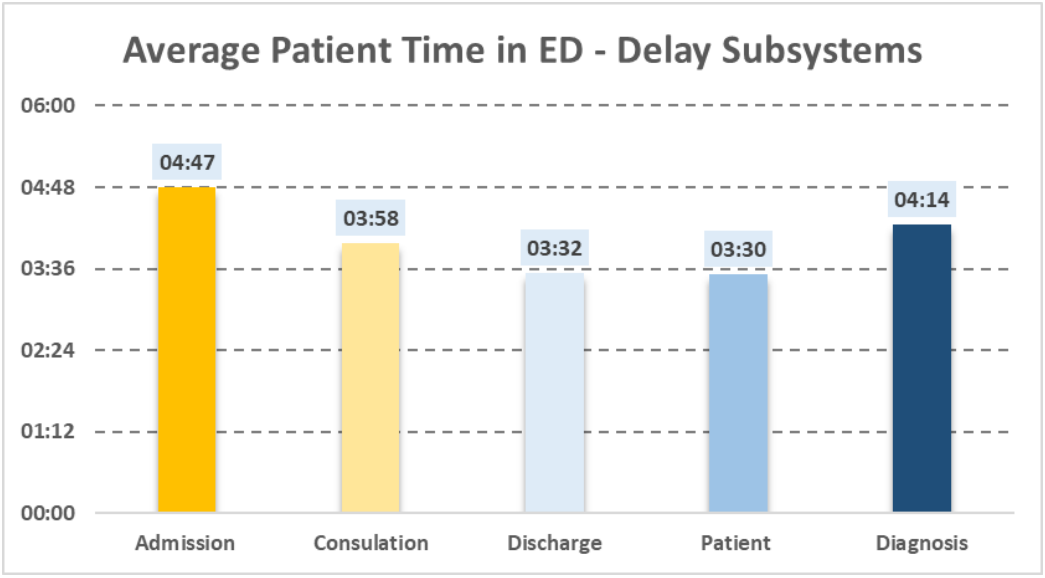

Figure 4.6: *Average patient time in emergency department for delay subsystems*

In the FMEA study, the delay factors in ED have been categorised into 14 categories. The below figure depicts the counts percentage contributing to these 14 delay factors. It can be observed that 14% of delay cases is due to delay in providing test reports and 12% due to delay in admission due to insurance.

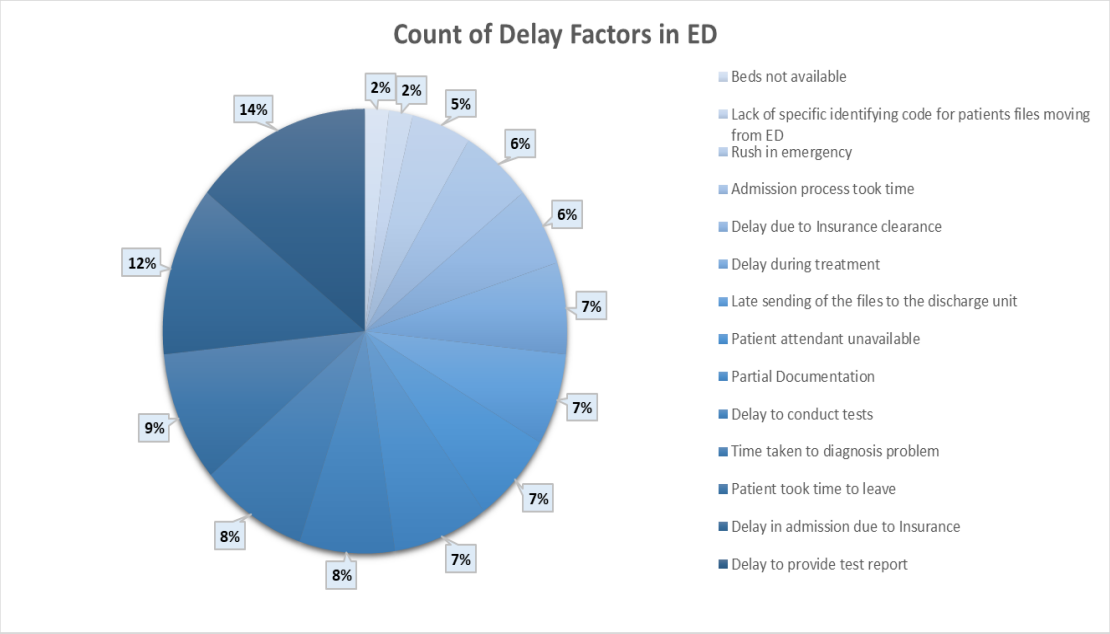

Figure 4.7: *Distribution of delayed cases according to delay factors*

According to data from the TMA study, highest delay experienced by the patients was due to bed not being available. The count percentage of these delay factor was only 2% but the average time taken was 5 hours and 46 minutes

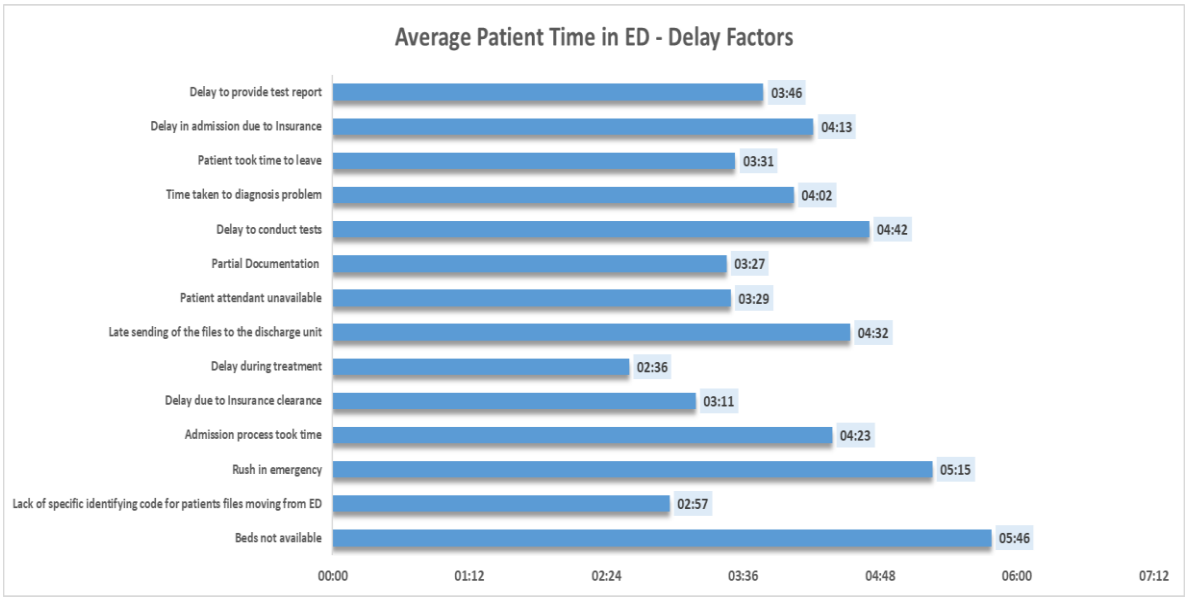

Figure 4.8: *Average patient time in emergency department for delay factors*

According to the data, different days of the week observed different proportion of patient delays. The highest delay was observed on Friday (21%)

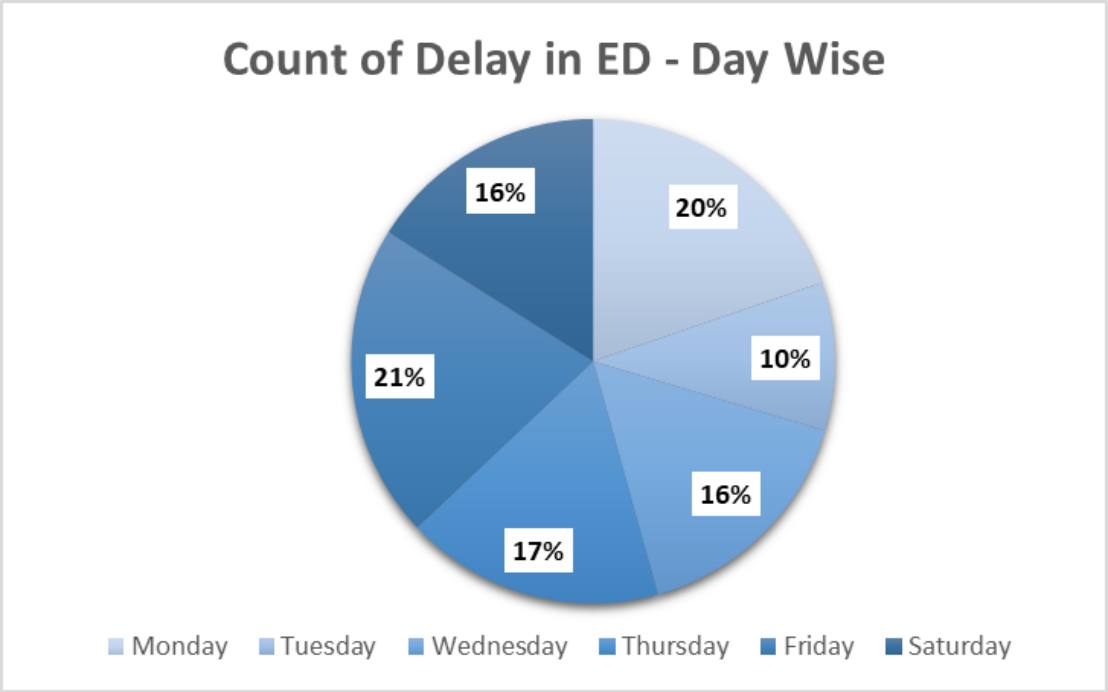

Figure 4.9: *Distribution of delayed cases to delay factors - day wise trend*

The average time taken by patients in ED who have observed delay on different days of the week are given in the figure below. The highest patient visit time was observed on Saturday i.e., 4 hours and 56 minutes followed by Wednesday i.e., 4 hours and 24 minutes.

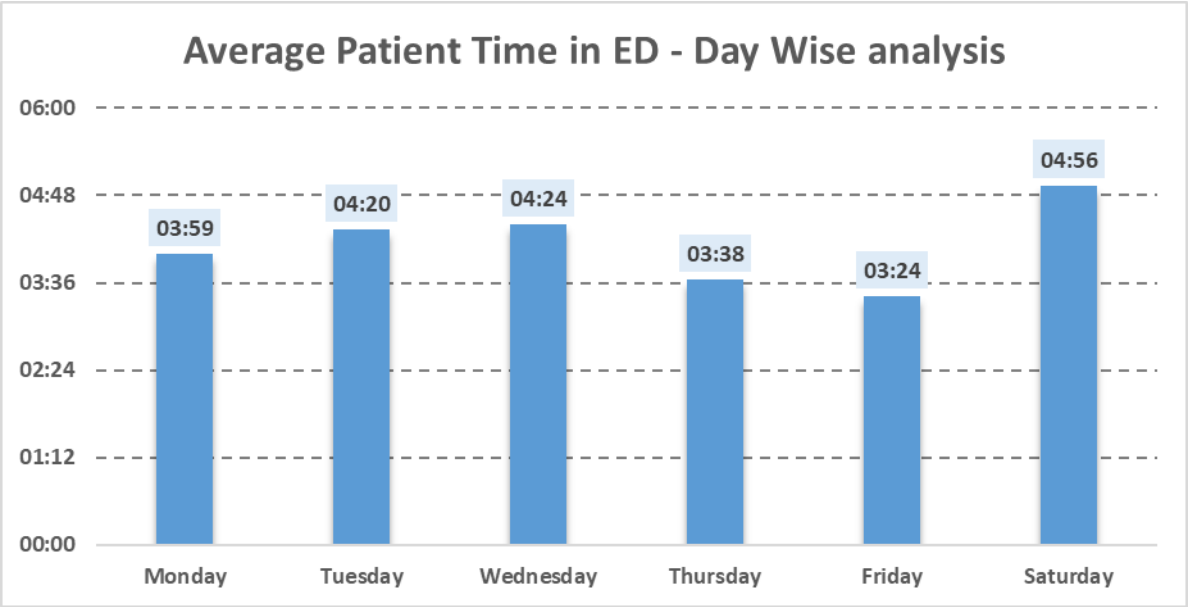

Figure 4.10: *Average patient time in ED for delay factors - day wise trend*

The patients in the ED were categorized as per the criticality of the situation. The triage categorisation was considered as a parameter to analyse the delay pertaining to different categories. Maximum cases of delays were observed in Category 4 i.e., 42% of overall delay cases.

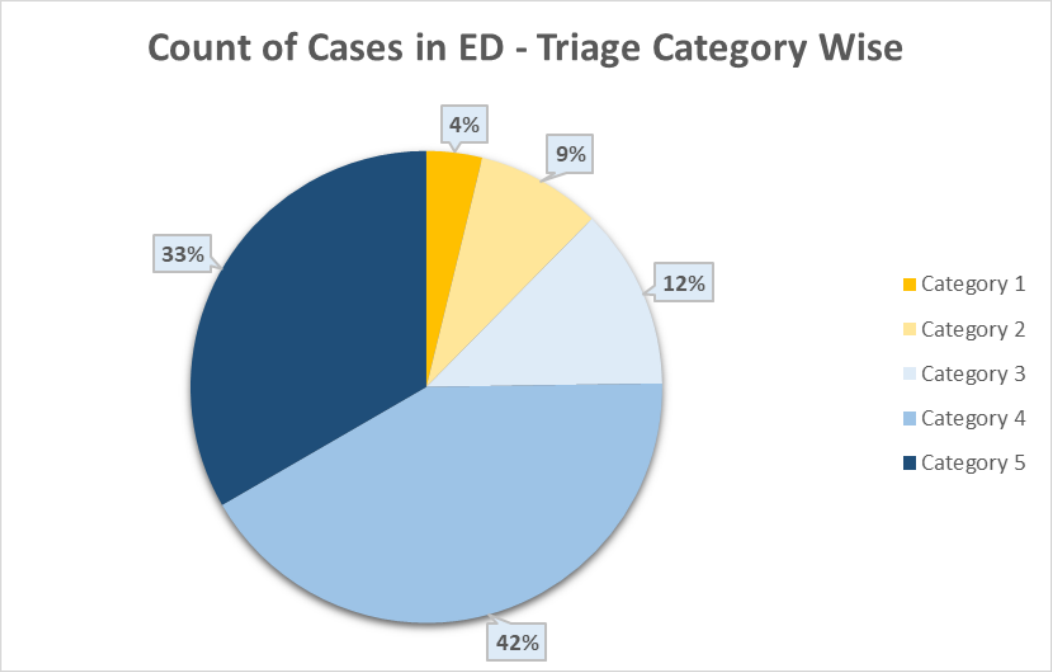

Figure 4.11: *Distribution of delayed cases to delay factors – Triage category wise*

According to the data, the highest time taken by patient was in category 5, which was coherent with the definition of category. The patient visit time for category 5 was 5 hours 25 minutes.

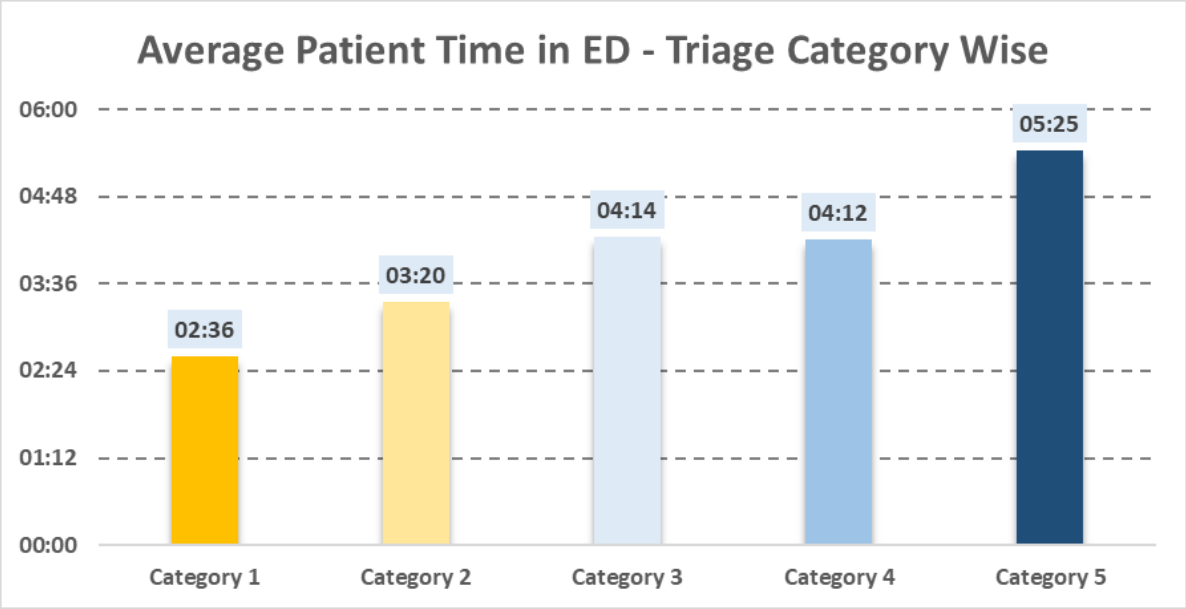

Figure 4.12: *Average patient time in ED for delay factors - Triage category wise*

4.3 PATIENT SATISFACTION ASSESSMENT

According to patient overall satisfaction assessment, more patients were inclined towards the good experience (38% patients considered rating 4 & 5). It was observed that for all the parameters the highest proportion of patients were neutral.

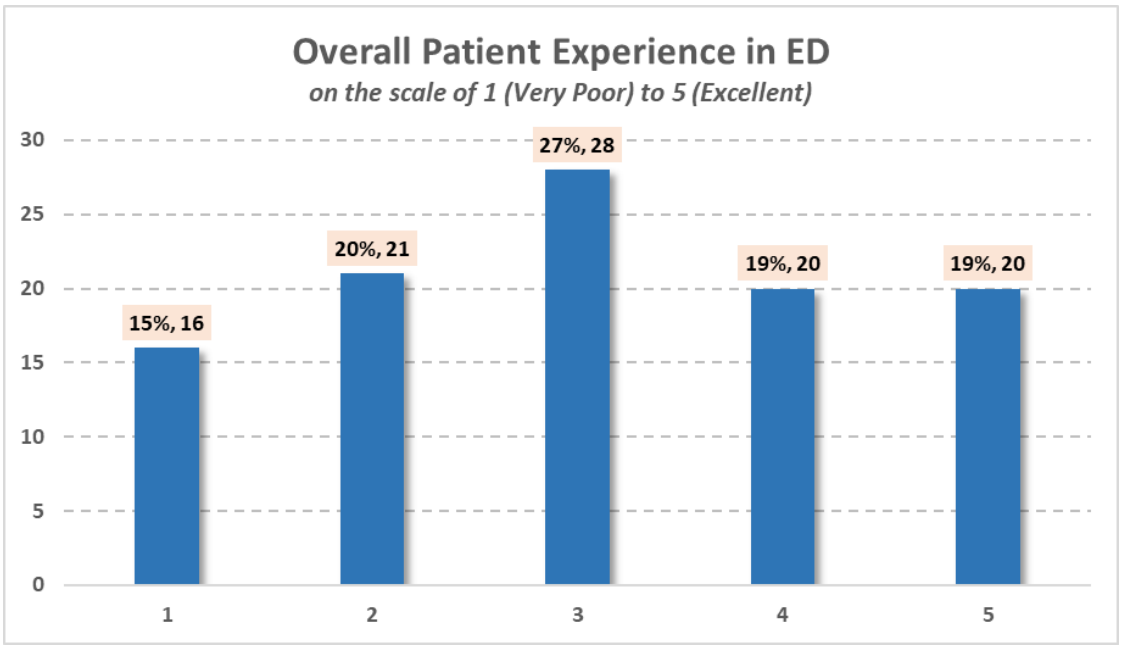

Figure 4.13: *Overall patient experience in emergency departments*

According to data for patient admission experience, patients were inclined towards the good experience (41% patients considered rating 4 & 5).

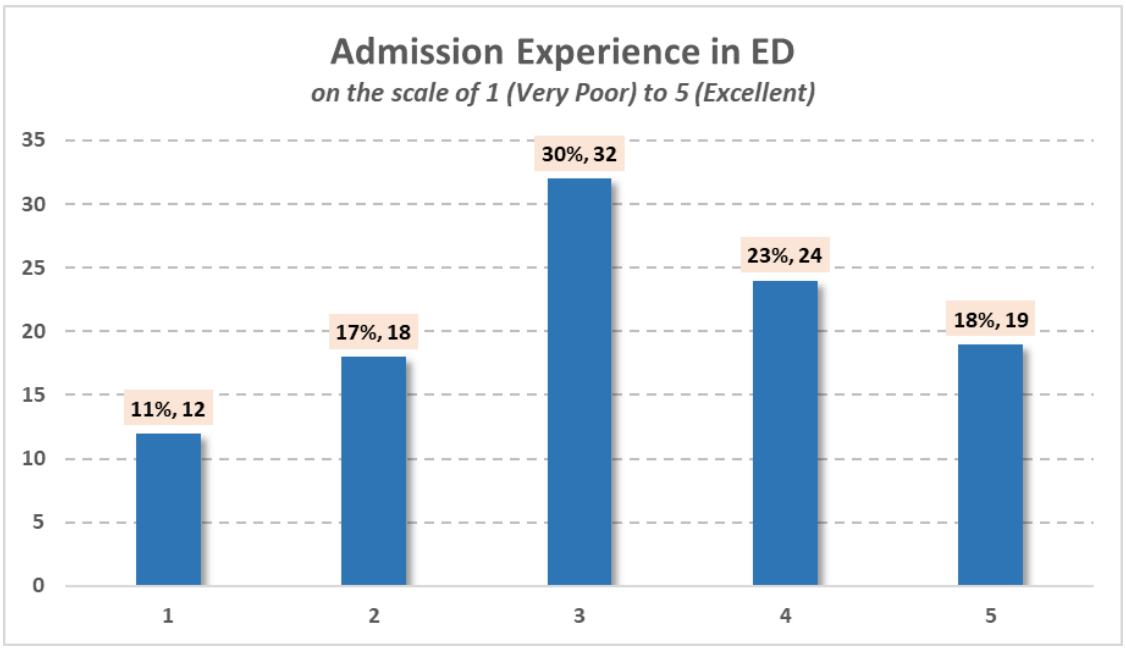

Figure 4.14: *Patient admission experience in emergency departments*

According to the data for patient consultation experience, patients were inclined towards the good experience (48% patients considered rating 4 & 5). It implies that the treatment provided by the doctors is preferred by the patients.

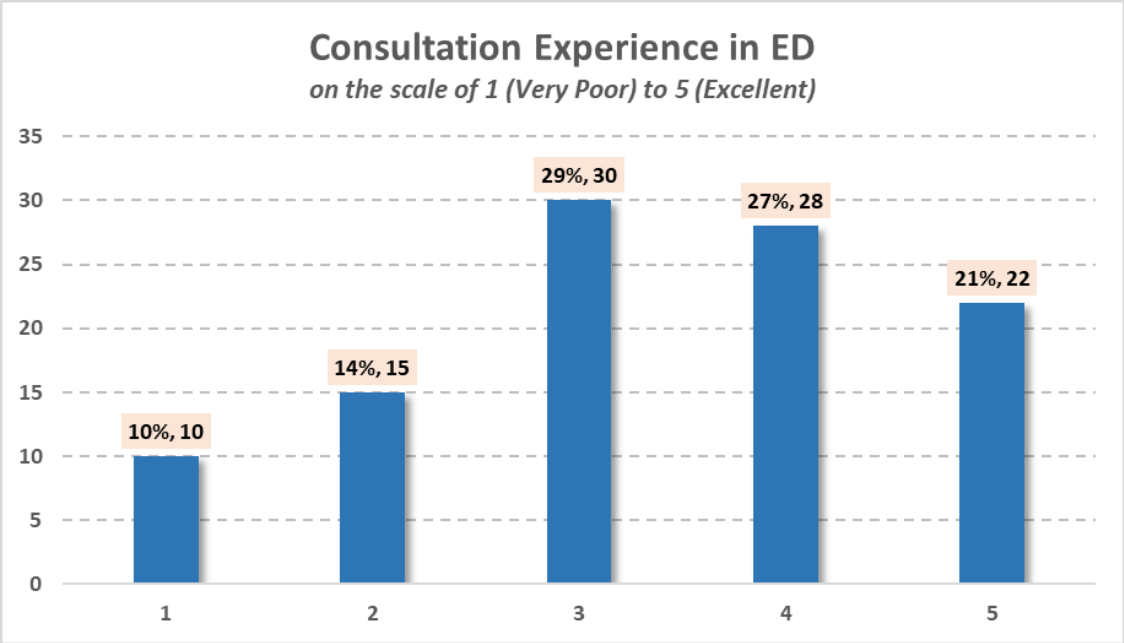

Figure 4.15: *Patient consultation experience in emergency departments*

According to the data for patient discharge experience, patients were disappointed with the experience (44% patients considered rating 1 & 2).

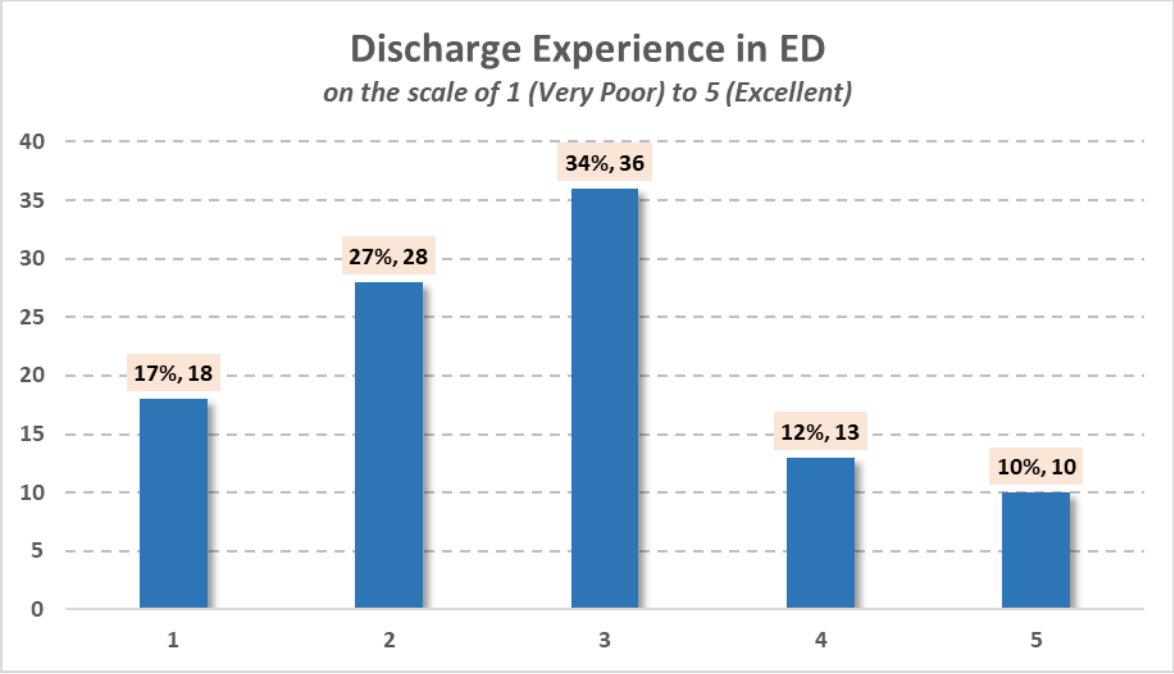

Figure 4.16: *Patient discharge experience in emergency departments*

CHAPTER 5: DISCUSSION

This study employed Failure Mode & Effect Analysis (FMEA) to systematically determine and prioritize factors contributing to delays in the ED, with the objective of enhancing patient care. The research was conducted at a multi-specialty hospital in Gurgaon, India, spanning a three-month period. Data collection incorporated time motion analysis and a questionnaire survey administered to 105 patients. The analysis unveiled a multitude of factors influencing ED delays, with the most prominent being holdups in admission due to insurance (Admission subsystem, RPN = 32), tardiness in providing test reports (Diagnosis subsystem, RPN = 24), and extended time taken to diagnose the underlying medical condition (Consultation subsystem, RPN = 18).

These findings highlight the potential for considerable reductions in patient wait times in the ED by improving diagnostic process efficiency and streamlining insurance clearance procedures. The study also identified other areas for potential intervention, such as reducing delays caused by incomplete documentation (Consultation subsystem, RPN = 8) and lateness in delivering files to the discharge unit (Discharge subsystem, RPN = 2). By addressing these issues, hospitals can aim to improve patient satisfaction and speed up patient flow through the ED.

Furthermore, the investigation revealed a cluster of characteristics that contribute to delays in the admissions subsystem. These included insurance-related delays (RPN = 32), beds not being available (RPN = 1), and the admission process taking an excessive amount of time (RPN = 8). The reasons for insurance-related delays might be investigated further to discover potential solutions, such as establishing a dedicated insurance liaison within the ED or working with insurance companies to speed pre-authorization processes. Implementing a real-time bed tracking system or improving communication between the ED and inpatient wards are two potential strategies for increasing bed availability. Finally, simplifying the admission process may entail optimizing documentation, utilizing technology to accelerate processes, and ensuring enough workforce levels.

Delays in the diagnosis subsystem were also a source of worry, with the top concerns identified as delays in providing test reports (RPN = 24) and conducting tests (RPN = 16). Implementing clinical decision support technologies to aid in diagnosis, prioritizing turnaround times for key tests, and ensuring proper laboratory and radiology staffing levels are all possible answers to

these problems. Furthermore, investigating the usage of fast diagnostic tests may be advantageous in specific circumstances. The investigation also revealed delays in the consultation subsystem, with the primary cause being the time required to diagnose the problem (RPN = 18). This could be addressed by implementing clinical decision support systems to assist in diagnosis by giving clinicians quick access to patient data and treatment guidelines, ensuring that all necessary information is captured during the initial patient assessment, and training staff on the importance of thorough examination.

Finally, delays in the discharge subsystem were identified, with the most prominent factor being patient taking time to leave (RPN = 12). Strategies to address patient-related discharge delays might involve providing clear discharge instructions, ensuring timely completion of necessary paperwork, and helping patients who require help coordinating transportation or social services.

5.1 LIMITATION

1. *Limited Sample Size:* The data collected for the TMA and questionnaire to identify factors were only 105. This sample size of patients may not be large enough to detect all possible sources of delay.

2. *Time period of study:* The study was completed in just three months, which is quite a brief time frame.

3. *Single Healthcare Setting:* Since just a single emergency department (Artemis Hospital) was used for the study, it's possible that the results cannot be applied to other healthcare environments. It is more probable that different hospitals' emergency departments have unique characteristics and processes that affect patient wait times and satisfaction.

4. *Potential Bias:* The cohort study relied on self-reported data from patients, which may be subject to bias. As questionnaires and TMA study were employed to collect data, there is a possibility that respondents' responses were skewed. Patients may offer socially acceptable answers or recall events wrongly. In addition, patients' actions and responses may be influenced by researchers' presence during data collection.

5. *Limited Range of factors:* The study focused on a small number of aspects of the emergency department (ED) process, such as streamlining procedures for patient admission, optimizing consultation flow between healthcare providers, ensuring

efficient discharge processes, and developing clear protocols for patient categorization based on medical urgency. The study did not take into account a number of other aspects.

6. *Subjectivity of FMEA:* The FMEA score system used in this study assigns weightage (severity, probability, and delay degree) according to a preset scale. While this strategy offers an organized approach to prioritizing criteria, it is necessarily subjective. The provided values may not fully represent all of the criteria associated with each delay factor. This subjectivity has the potential to underestimate or overestimate the true impact of some events in creating delays in the emergency department.

CHAPTER 6: CONCLUSION

Finally, this study used Failure Mode and Effect Analysis (FMEA) to systematically identify and prioritize variables causing delays in the emergency department (ED), with the goal of improving patient care. The study was carried out at a multi-specialty hospital in India and used a combination of time motion analysis and a patient survey to collect information.

The investigation found numerous major factors that contribute to ED delays, the most significant of which are in the diagnosis and admission subsystems. The most concerning issues were delays in receiving test results, lengthy diagnosis times, and insurance-related admittance hold-ups. The study also identified the need for improved documentation methods in the consultation subsystem and file transfer procedures in the discharge subsystem.

These data show that there are tremendous chances to minimize patient wait times in the emergency department. Hospitals may greatly increase patient satisfaction and speed up patient flow through the ED by focusing on enhancing diagnostic efficiency, expediting insurance clearance processes, and optimizing various departmental workflows.

More research is needed to dive deeper into the underlying causes of various delays, such as insurance concerns. This would enable the creation of more specific solutions, such as specialist insurance liaisons or increased communication with insurance companies. Additionally, investigating the introduction of new technology, such as clinical decision support systems and rapid diagnostic procedures, could help to speed up diagnosis.

Overall, this study provides useful insights into the numerous factors that contribute to ED delays, as well as a road map for adopting targeted interventions to improve patient care and ED operations.

6.1 RECOMMENDATIONS

The FMEA study assessed the risk priorities for all the delay factors and assigned priority categories. As per the study, delays with RPN > 24 were assigned as the 1st priority category; RPN between 14 and 24 were assigned as the 2nd priority; RPN 8 to 14 were assigned as the 3rd priority; and RPN < 8 were assigned as the 4th priority problems

Delay Factors	Action Priority
Delay in admission due to Insurance	1st Priority Category
Delay in providing test report	1st Priority Category
Time taken to diagnosis problem	2nd Priority Category
Delay conducting tests	2nd Priority Category
Admission process took time	3rd Priority Category
Delay during treatment	3rd Priority Category
Partial Documentation	3rd Priority Category
Delay due to Insurance clearance	3rd Priority Category
Patient took time to leave	3rd Priority Category
Patient attendant unavailable	3rd Priority Category
Beds not available	4th Priority Category
Rush in emergency	4th Priority Category
Late in sending the documents to discharge unit	4th Priority Category
Lack of unique identifying code in patients' files	4th Priority Category

Table 6.1: *Delay Factors according to action priority*

In the table below represents the recommendations that can be implemented for each delay factors to improve the patient visit time in the emergency department.

Subsystems	Delay Factors	Recommendations
Admission	Delay in admission due to Insurance	Collaborate with insurance companies to streamline pre-authorization processes.
	Admission process took time	Optimize paperwork by reducing unnecessary steps and duplications. Leverage technology to automate tasks where possible, such as electronic health records.

		Ensure adequate staffing levels to handle admissions efficiently.
	Beds not available	Implement a real-time bed tracking system to provide visibility of bed availability across departments. Improve communication between the ED and the inpatient wards to manage bed allocation.
Consultation	Time taken to diagnosis problem	Implement clinical decision support systems to aid in diagnosis by providing clinicians with quick access to patient data and treatment guidelines.
	Delay during treatment	Streamlining processes for medication access within the ED can minimize delays in administering necessary medications.
	Rush in emergency	Increase operational efficiency by converting underutilised areas of hospital as temporary emergency area and transfer of less prior cases (as per the Triage Categorisation) to these areas of hospital
Discharge	Partial Documentation	Implement standardized documentation templates to ensure that all relevant information is collected during the initial evaluation. Provide staff training on the need of comprehensive and accurate documentation.
	Delay due to Insurance clearance	Implement a dedicated insurance liaison within the ED to handle insurance issues and expedite clearances.
	Late in sending the documents to discharge unit	Set up a designated discharge coordinator to oversee the discharge process and ensure timely file transfers. Use a digital system to electronically transfer patient information to increase efficiency.
	Lack of unique identifying code in patients' files	Generate an error check when identifying codes are not entered while transferring files to other departments
Patient	Patient took time to leave	Provide clear and concise discharge instructions to patients. Ensure timely completion of necessary paperwork by streamlining processes.
	Patient attendant unavailable	Ensure that patient's attendant is available during the entire discharge procedure. Assist patients in coordinating transportation if needed to facilitate a smooth discharge process.

Diagnosis	Delay in providing test report	Prioritize turnaround times for critical tests to ensure timely results. Ensure adequate staffing levels in the laboratory departments to avoid delays in processing tests.
	Delay in conducting tests	Explore the use of rapid diagnostic tests for specific conditions where appropriate.

Table 6.2: *Recommendation for Delay Factors*

REFERENCES

1. Sorrentino, P. (2016). Use of Failure Mode and Effects Analysis to Improve Emergency Department Handoff Processes. *Clinical Nurse Specialist*, *30*(1), 28-37. https://doi.org/10.1097/nur.0000000000000169

2. Teklewold, B., Anteneh, D., Kebede, D., & Gezahegn, W. (2021). Use of Failure Mode and Effect Analysis to Reduce Admission of Asymptomatic COVID-19 Patients to the Adult Emergency Department: An Institutional Experience. *Risk Management and Healthcare Policy*, *Volume 14*, 273-282. https://doi.org/10.2147/rmhp.s284835

3. Shahrami, A., Rahmati, F., Kariman, H., Hashemi, B., Rahmati, M., Baratloo, A., Forouzanfar, M. M., & Safari, S. (2013, January 1). *Utilization of Failure Mode and Effects Analysis (FMEA) Method in Increasing the Revenue of Emergency Department; a Prospective Cohort Study*. PubMed Central (PMC). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4614557/

4. Gur-Arieh, S., Mendlovic, S., Rozenblum, R., & Magnezi, R. (2023). Using Failure Mode and Effect Analysis to Identify Potential Failures in a Psychiatric Hospital Emergency Department. *Journal of Patient Safety*, *19*(6), 362-368. https://doi.org/10.1097/pts.0000000000001127

5. *Human Verification*.

(n.d.). https://www.semanticscholar.org/paper/Utilization-of-Failure-Mode-and-Effects-Analysis-in-Shahrami-Rahmati/5e76d287d22cf205eac691b9bf5bd31c77b57b0b

6. Chanamool, N., & Naenna, T. (2016). Fuzzy FMEA application to improve decision-making process in an emergency department. *Applied Soft Computing*, ***43***, 441-453. https://doi.org/10.1016/j.asoc.2016.01.007

7. Journal, I. (2022). FAILURE MODE AND EFFECT ANALYSIS (FMEA) WITH SPECIAL REFERENCE TO ICU, EMERGENCY DEPARTMENT AND BIO-MEDICAL ENGINEERING DEPARTMENT IN ONE OF THE LEADING HOSPITALS IN COIMBATORE.

8. Sorrentino, P. (2022, October 19). *Use of failure mode and effects analysis to improve emergency department handoff processes.* PSNet. https://psnet.ahrq.gov/issue/use-failure-mode-and-effects-analysis-improve-emergency-department-handoff-processes

9. Chanamool, N., & Naenna, T. (2016b). Fuzzy FMEA application to improve decision-making process in an emergency department. *Applied Soft Computing*, ***43***, 441-453. https://doi.org/10.1016/j.asoc.2016.01.007

10. Ullah, E., Baig, M. M., Hosseini, H. G., & Lu, J. (2022). Failure mode and effect analysis (FMEA) to identify and mitigate failures in a hospital rapid

response system (RRS). *Heliyon*, *8*(2), e08944. https://doi.org/10.1016/j.heliyon.2022.e08944

11. Shahrami, A., Rahmati, F., Kariman, H., Hashemi, B., Rahmati, M., Baratloo, A., Forouzanfar, M. M., & Safari, S. (2013b, January 1). *Utilization of Failure Mode and Effects Analysis (FMEA) Method in Increasing the Revenue of Emergency Department; a Prospective Cohort Study*. PubMed Central (PMC). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4614557/

12. El-Awady, S. M. M. (2023). Overview of Failure Mode and Effects Analysis (FMEA): A Patient Safety Tool. *Global Journal on Quality and Safety in Healthcare*, *6*(1), 24-26. https://doi.org/10.36401/jqsh-23-x2

13. Simsekler, M. C. E., Kaya, G. K., Ward, J. R., & Clarkson, P. J. (2019). Evaluating inputs of failure modes and effects analysis in identifying patient safety risks. *International Journal of Health Care Quality Assurance*, *32*(1), 191-207. https://doi.org/10.1108/ijhcqa-12-2017-0233

14. Payne, K., Risi, D., O'Hare, A., Binks, S., & Curtis, K. (2023). Factors that contribute to patient length of stay in the emergency department: A time in motion observational study. *Australasian Emergency Care*, *26*(4), 321-325. https://doi.org/10.1016/j.auec.2023.04.002

15. Gill, D., Galvin, S., Ponsford, M., Bruce, D., Reicher, J., Preston, L., Bernard, S., Lafferty, J., Robertson, A., Rose-Morris, A., Stoneham, S., Rieu, R., Pooley, S., Weetch, A., & McCann, L. (2010). Laboratory sample turnaround times: do they cause delays in the ED? *Journal of Evaluation in Clinical Practice*, *18*(1), 121-127. https://doi.org/10.1111/j.1365-2753.2010.01545.x

16. Bashkin, O., Caspi, S., Haligoa, R., Mizrahi, S., & Stalnikowicz, R. (2015). Organizational factors affecting length of stay in the emergency department: initial observational study. *Israel Journal of Health Policy Research*, *4*(1). https://doi.org/10.1186/s13584-015-0035-6

17. *Emergency department care activity*. (n.d.). Australian Institute of Health and Welfare. https://www.aihw.gov.au/reports-data/myhospitals/intersection/activity/ed

18. Fatovich, D. M. (2005). Access block causes emergency department overcrowding and ambulance diversion in Perth, Western Australia. *Emergency Medicine Journal*, *22*(5), 351-354. https://doi.org/10.1136/emj.2004.018002

19. Morley, C., Unwin, M., Peterson, G. M., Stankovich, J., & Kinsman, L. (2018). Emergency department crowding: A systematic review of causes,

consequences and solutions. *PloS One*, ***13*(8),** e**0203316.** https://doi.org/**10.1371/**journal.pone.**0203316**

20. Bein, K. J., Russell, S. B., Bhraonáin, S. N., Seimon, R. V., **&** Dinh, M. M. **(2021).** Does volume or occupancy influence emergency access block**?** A multivariate time series analysis from a single emergency department in Sydney, Australia during the COVID-**19** pandemic. *Emergency Medicine Australasia*, ***33*(2), 343-348.** https://doi.org/**10.1111/1742-6723.13717**

21. Bain CA, Taylor PG, McDonnell G, Georgiou A. Myths of ideal hospital occupancy. *Med. J. Aust.* **2010; 192: 42-3**

22. Moineddin R, Meaney C, Agha M, Zagorski B, Glazier RH. Modeling factors influencing the demand for emergency department services in Ontario: a comparison of methods. *BMC Emerg. Med.* **2011; 11: 13**

23. Keegan AD. Hospital bed occupancy: more than queuing for a bed. *Med. J. Aust.* **2010; 193: 291-3**

24. Aboagye-Sarfo P, Mai Q, Sanfilippo FM, Preen DB, Stewart LM, Fatovich DM. A comparison of multivariate and univariate time series approaches to modelling and forecasting emergency department demand in Western Australia. *J. Biomed. Inform.* **2015; 57: 62-73**

25. Dinh MM, Arce CP, Berendsen Russell S, Bein KJ. Predictors and in-hospital mortality associated with prolonged emergency department length of stay in New South Wales tertiary hospitals from **2017** to **2018.** *Emerg. Med. Australas.* **2020; 32: 611-7**

26. Rathlev NK, Chessare J, Olshaker J *et al*. Time series analysis of variables associated with daily mean emergency department length of stay. *Ann. Emerg. Med.* **2007; 49: 265-71**

27. Geelhoed GC, de Klerk NH. Emergency department overcrowding, mortality and the **4-**hour rule in Western Australia. *Med. J. Aust.* **2012; 196: 122-6**

28. Forster AJ, Stiell I, Wells G, Lee AJ, van Walraven C. The effect of hospital occupancy on emergency department length of stay and patient disposition. *Acad. Emerg. Med.* **2003; 10: 127-33**

29. Howell E, Bessman E, Kravet S, Kolodner K, Marshall R, Wright S. Active bed management by hospitalists and emergency department throughput. *Ann. Intern. Med.* **2008; 149: 804-11**

ANNEXURE

Annexure 1: Checklist for time motion analysis

Patient Name
Patient Gender
Date of Visit
Triage Category
Door In Time
Doctor Visit Time
Door Out Time
Total Time in ED

Annexure 2: Questionnaire survey for patient satisfaction assessment.

Patient Satisfaction Assessment

Dear All,
We are conducting a small survey regarding your visit at Artemis Hospital Emergency Department. In order to be able to serve our patients better, we would like to hear from the patients and attendants about their experience.

प्रिय साथियो,
हम आर्टेमिस अस्पताल के आपातकालीन विभाग में आपकी यात्रा के संबंध में एक छोटा सर्वेक्षण कर रहे हैं। अपने मरीजों को बेहतर सेवा देने में सक्षम होने के लिए, हम मरीजों और परिचारकों से उनके अनुभव सुनना चाहेंगे।

kumari.shikha436@gmail.com Switch account

Not shared

Name of Patient/ मरीज का नाम

Your answer

Contact Number/ संपर्क संख्या

Your answer

Gender of patient/ लिंग

Your answer

Reason for visiting emergency department/ आपातकालीन विभाग में जाने का कारण

Your answer

Please rate your experience at admission process on a scale of 1 to 5/ कृपया प्रवेश प्रक्रिया में अपने अनुभव को 1 से 5 के पैमाने पर रेटिंग दें

	1	2	3	4	5	
Poor Experience/ख़राब अनुभव	◯	◯	◯	◯	◯	Excellent Experience/ उत्कृष्ट अनुभव

Please rate your experience at consultation process on a scale of 1 to 5/ कृपया परामर्श प्रक्रिया में अपने अनुभव को 1 से 5 के पैमाने पर रेटिंग दें

	1	2	3	4	5	
Poor Experience/ख़राब अनुभव	◯	◯	◯	◯	◯	Excellent Experience/ उत्कृष्ट अनुभव

Please rate your experience at discharge process on a scale of 1 to 5/ कृपया डिस्चार्ज प्रक्रिया में अपने अनुभव को 1 से 5 के पैमाने पर रेटिंग दें

	1	2	3	4	5	
Poor Experience/ख़राब अनुभव	◯	◯	◯	◯	◯	Excellent Experience/ उत्कृष्ट अनुभव

Please rate your overall experience at emergency department on a scale of 1 to 5/ कृपया आपातकालीन विभाग में अपने समग्र अनुभव को 1 से 5 के पैमाने पर रेटिंग दें

	1	2	3	4	5	
Poor Experience/ख़राब अनुभव	◯	◯	◯	◯	◯	Excellent Experience/ उत्कृष्ट अनुभव