ASSESSMENT OF THE TURNAROUND TIME (TAT) AND PROCESS FLOW OF PNEUMATIC TUBE SYSTEM IN A HOSPITAL SETTING

Dissertation Submitted to

The IIHMR University, Jaipur

for the partial fulfilment for the award of the degree of

Master of Business Administration (MBA)

in

Hospital and Health Management

By

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Under the Supervision and Guidance of

Dr. Arindam Das

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Kokilaben Dhirubhai Ambani
hospital & medical research institute
MUMBAI
Every Life Matters

KDAH/HR/OL/2024/06/471 Date: 14.06.2024

TO WHOMSOEVER IT MAY CONCERN

This is to certify that **Ms. Shweta Prabhakar Kale** has successfully completed her **2 months and 18 days** period of **Internship** from 26.03.2024 to 14.06.2024 in the **Department of Clinical Quality** at **Kokilaben Dhirubhai Ambani Hospital & Medical Research Institute,** under the guidance of Chief Manager - Clinical Quality, Ms. Krishnaveni Nimmakayala.

She has completed her tenure entirely to the satisfaction of the hospital management.

We wish her all the best in her future endeavor.

Best Regards,
For Kokilaben Dhirubhai Ambani Hospital & Medical Research Institute,

Rashme

Rashma Nathani
Asst. General Manager - Human Resources

DECLARATION BY STUDENT

I hereby declare that this dissertation titled **Assessment of the Turnaround Time (TAT) and Process Flow of Pneumatic tube System in a Hospital Setting** 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 Information derived from the published or unpublished work of others has been duly acknowledged in the text.

ShuKale.

(Signature)

Name of Student Shweta Prabhakar Kale

Date 03/07/2024

IIHMR UNIVERSITY

CERTIFICATE

This is to certify that dissertation titled **Assessment of the Turnaround Time (TAT) and Process Flow of Pneumatic tube System in a Hospital Setting** is a record of the research work undertaken by **Ms. Shweta Prabhakar Kale** 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.

Arindam Das.

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ABSTRACT

Title

Assessment of the Turnaround Time (TAT) and Process Flow of Pneumatic Tube System in a Hospital Setting.

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Objective

The study's goals are to evaluate the pneumatic tube system's (PTS) turnaround time (TAT) and process flow at Kokilaben Dhirubhai Ambani Hospital and Medical Research Institute, Mumbai, to identify the main reasons for delays, & create Standard Operating Procedures (SOPs) to improve the system's performance and ensure the efficient delivery of medications.

Methodology

43 pneumatic tube transactions were involved in an observational and analytical study over a span of 2 months and 18 days. Data collection methods included timed observations, staff interviews, and departmental transaction logs from (BME). Systematic sampling method was adopted to project a representative sample. The informed consent of the participants and confidentiality of the data were some of the ethical considerations taken into consideration. Data obtained was analysed on Microsoft Excel.

Results

The TAT study showed significant variation, ranging from a minimum TAT of 1 minute to an average TAT of 15 minutes to a maximum TAT of 56 minutes. System overload, operational inefficiencies, staffing problems, and technical malfunctions were the major factors for the observed delay. Peak hours generated overload on the system, which delayed capsule dispatches and deliveries. Operational inefficiencies included operating the process with overload capsules and loads which loaded improperly caused bottlenecks and breakdowns in the system. Some of the staffing issues that contributed to delays were a lack of workers, demands on the system during times, and poor training. Breakdowns of a technical nature also affected the operation of the system, which included mechanical failures and blockages to sensors.

Conclusion

This study looks at how targeted improvements to the PTS are to be implemented to be more effective and more reliable. Such measures that will reduce variability in TAT and system delay include standardization of capsule loading operations, planning routine maintenance, training of staff members, and providing protocols. If all of the above suggestions are put into effect, the PTS will be optimized to enable prompt delivery for drugs and improve the welfare of patients.

Keywords

Pneumatic Tube System, Turnaround Time, Hospital Logistics, Operational Efficiency, Healthcare Delivery.

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I want to thank Dr P. R. Sodhani (President, IIHMR University-Jaipur) for providing me with this wonderful opportunity.

I want to thank my university mentor, Arindam Das, PhD, Professor at IIHMR University, for his active participation and her constructive feedback which guided me in making this report a successful project.

Ms. Shweta Prabhakar Kale

MBA in Hospital and Healthcare Management

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LIST OF ABBREVIATIONS

Sr. No.	Abbreviations	Terms
1	PTS	Pneumatic Tube System
2	HPS	Hospital Pneumatic System
3	HBT	Human-based transport
4	CBC	Complete Blood Count
5	SOP	Standard Operating Procedure
6	BME	Biomedical Engineering
7	HIS	Hospital Information System
8	PPE	Personal Protective Equipment
9	RFID	Radio Frequency Identification
10	LDH	Lactate Dehydrogenase
11	AST	Aspartate Aminotransferase
12	Hb	Haemoglobin
13	HCA	Healthcare Assistant

TITLE

Assessment of the Turnaround Time (TAT) and Process Flow of Pneumatic Tube System in a Hospital Setting.

CHAPTER 1

INTRODUCTION

About Pneumatic Tube System

PTS, are mechanical systems for pushing cylindrical containers through networks of tubes with vacuum or compressed air. Engineer Josiah Latimer Clark developed the first workable system, which was deployed in the London Telegraph Office in 1853. It revolutionized quick deliveries of letters, telegrams, and small parcel services by placing them in cylindrical containers through the tubes, thus establishing fast and effective delivery pathways.

Over time, the applications of pneumatic tube systems spread across many industries, and it still is core to any hospital. The ones that operate in light of the advancement of medical technology assure timely and secure transport of goods, critical for staff productivity, patient care, and overall operational efficiency.

Advantages of a pneumatic tube:

<u>High Security and Speedy Transportation-</u>

Reduces the time required which the transport of valuable entities takes.

<u>Lower Chances of Contamination-</u>

By minimizing the handling system, the risks of infection are reduced.

<u>Conservation of Resource and More Effectiveness-</u>

The manual transportation reduces time as well as energy.

<u>More Time to Patients and Relief to Medical Staff-</u>

Gives the healthcare workers enough time to take care of their patients and services rather than administrative problems.

Components of PTS

Carriers or Capsules

Carriers are cylinder-shaped containers that are used to move goods from one place to another. They come in varied sizes to fit different types of goods and items. Plastic is frequently used over metal for these containers due to its ability to reduce static electricity and maintain cleanliness. Leak-proof, lockable containers with RFID chips provide hospitals a safe and secure way to transfer delicate goods. Furthermore, containers frequently include fabric bands and plastic bumpers to safeguard their contents while in transit.

Figure 1.1- PTS carrier or capsule

Station

Pneumatic tube stations used for transmitting or receiving carriers. An interface panel and a loading port are features of standard stations. Modern designs have auto unloaded features to increase efficiency. Users are able to select the required station as per there requirements. Transport is made safe and secure with accessories including arrival indications, carrier storage, and receiving baskets. Operating flexibility is made possible by the variety of stations. Pneumatic tube systems are very versatile and effective because of these characteristics.

Figure 1.2- PTS Station

Diverters for Pneumatic Tubes

Diverters are essential components of PTS because they allow packages to change directions and navigate corners inside the tube network. Efficient route management is necessary because modern systems frequently require complicated setups with several transmit and receive stations. The diverters branching off at each intersection of the zones act to direct air through the system so that carriers take the path of least resistance. They can be remotely controlled once set up to make the system easier and more versatile to use.

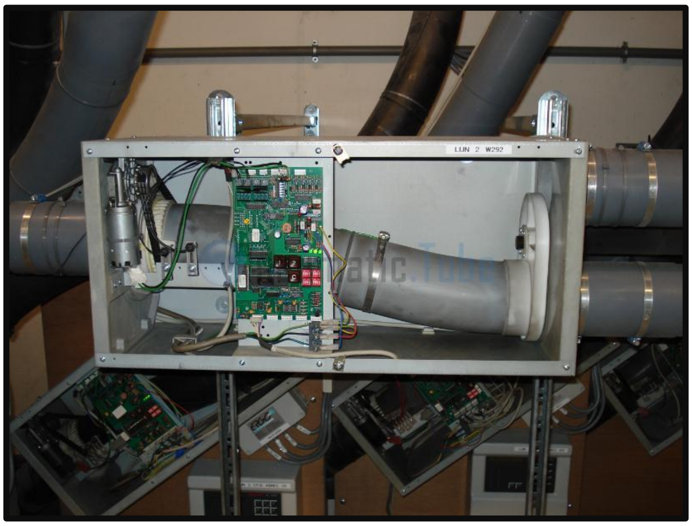


Figure 1.3- Diverters for Pneumatic Tubes

Blowers of Pneumatic Tubes

In pneumatic tube systems, the blower acts as the primary power source by providing the air needed for operation. It refers to the fans that create air pressure and a vacuum inside the transport tubes to help carriers move. These fans push or pull the carriers through the tube by producing different air densities throughout its length. Blowers ensure effective conveyance throughout the system by pushing containers at up to 25 feet per second.

Figure 1.4- Blowers of Pneumatic Tubes

Turn Around Time

Turn Around Time is the total amount of time needed to finish a task or operation, including all stages from start to finish. Although having benefited from many advancements in medical technology, ineffective pneumatic tube systems (PTS) paralyze a hospital nearly, delay critical operations like sample transfers and drug distribution, exhaust staff, and put relevantly high-risk patient care at stake. Efficient PTS is essential for delivering drugs and samples in time. Research in this area has oriented towards TAT evaluation, root cause analysis of delays, process flow analysis, and formulation of SOPs to enhance efficiency. The common causes of delay are system overload, operational inefficiencies, and labour shortages. Optimizing PTS and dealing with such concerns will help hospitals improve staff productivity, operational performance, and overall patient care delivery.

AIM of the Study

To analyse and improve the efficiency of the hospitals PTS, focusing on reducing turnaround times for medication delivery and addressing operational challenges through the implementation of standardized procedures and strategic enhancements.

RESEARCH QUESTION

How can the efficiency of the pneumatic tube system be improved in the hospital to ensure timely and effective medication delivery?

OBJECTIVE

- Determine the TAT for pneumatic tube capsules in the hospital.

- To identify the primary causes of delays in the PTS.

- To analyse the current process flow of the PTS

- To develop a SOP for the optimal use of the PTS in pharmacy.

CHAPTER 2

REVIEW OF LITERATURE

Sr. no.	Author/ Year of Publish	Study Location/ Sample Size/ Sampling Technique	Review Title	Abstract
1	Dr. Arun. Seetharam, Dr. Somu, Dr. Sudhakar. Kantipudi, Mr. Jibu **(2013)**	**Location**- Kasturba Hospital, Manipal **Sample Size-** 1500 samples from Women & Child block to Clinical Lab. 650 samples from Main Hospital to Biochemistry Lab. **Sampling Technique-** Convenience sampling over a three-month period	PTS in healthcare: A study of innovative ways to improve hospital efficiency.	The literature review looks into the hospital logistics inefficiencies in India, advocating that PTS is a remedy that can be applied over and above HBT. In particular, it reviews problems relating to HBT, such as errors, delays, and security risks, despite India's advanced medical technology. Then, it points out that PTS is an innovative solution for fast and safe material transport, with cost savings. Because of the layout and operations of the hospital, the implementation of PTS at Kasturba Hospital was full of problems related to planning, vendor selection, and installation. It is after implementation that a lot of time and labour gets saved, hence offering the possibility of improving the efficiency of the hospitals as well as care offered to patients. The review would, therefore, highly recommend early adoption of the PTS into infrastructure planning in any hospital, especially large vertically structured facilities like Kasturba Hospital, for the beneficial features to be tapped effectively.
2	Devi Subbarayan, Chittode Kodumudi Anantha Lakshmi, Chidambharam Choccalingam **(2018)**	**Location-** hospital with Swisslog's PTS. **Sample Size-** 75 samples for CBC, 25 samples for a coagulation analysis	The Impact of PTS transport on Standard Haematology & Coagulation Testing.	This study evaluated the changes in coagulation parameters and CBC with 75 paired CBC samples and 25 paired coagulation samples transferred using PTS & hand delivery to investigate whether PTS has an impact on the same. Changes according to the results were observed in red cell indices and platelet counts in PTS samples; although statistically increased, changes observed

		Sampling Technique- Simple Random Sampling		were not clinically significant. The findings of this research imply that PTS is a safe method for the transportation of blood samples for coagulation and CBC tests. It was proposed that further study on platelet count variability and the effects of different transit lengths should be conducted in order to be certain of accuracy and safety.
3	Mark W. Isken, Steven J. Littig **(2002)**	**Location-** Hospital in United States. **Sampling Technique-** Systematic Review	Simulation Analysis of PTS	The article considers hospital pneumatic transportation systems moving laboratory specimens and drugs between stations at high speeds with vacuum-powered tubes. It points out that as much as the PTSs are integrated into many facilities and their running is very costly, there is still a performance evaluation challenge, or even design, without comprehensive tools. It proposes that system efficiency be improved by monitoring traffic patterns, delivery times, wait times, blower usage, and transaction volumes with the detailed transaction data obtained from the computer-controlled PTS. This will involve developing a simulation model to project the performance of the PTS under different scenarios, thus helping in making decisions related to system growth and carrier management optimization. A case example is cited to prove the use of data and simulation in an effort to enhance the care given to patients within hospitals, showing how these strategies managed to increase speed in transactions and decrease the costs in the PTS of a large hospital.
4	C Wunder, G Langer **(2019)**	**Location-** University Hospital St. Polten, Austria **Sample Size-** 60 **Sampling Technique-** Purposive Sampling Technique	Is it safe to distribute medications using pneumatic tubes?	It investigates the stability and safety of drugs to hospitals that are transported via PTS. These devices are quite potent in drug delivery, especially in an emergency, but the strong forces of gravity they create while running at high speeds may alter the stability of the substance. The changes in temperature were recorded by accelerometers who

				assessed these forces with models of worst-case conditions across isolated wards with regular deliveries. Notably, the tests showed a raft of problems such as formulation separation, leakage from plastic cylinders, and viscosity-induced emulsion breakdown. Cytotoxic drugs and protein-based drugs were ruling out instable against physical stress. According to this study, hospital pharmacists should develop specific SOPs to guarantee safe delivery of the products to patients and avoid quality problems and harm to patients since primary packaging may not be sufficient to protect the products from these factors.
5	Bursa Takgil Resul Kara **(2024)**	**Location-** covers studies conducted in various healthcare facilities and research institutions globally. **Sample Size-** includes a diverse range of studies with sample sizes **Sampling Technique-** Stratified Sampling	Offering an innovative mathematical model for the pneumatic system in a hospital.	A critical review of the literature on HPS clearly indicates that while these systems bring improvement to healthcare facilities, including the effective transport of samples, reduced labour costs, and decreased risks of contamination, they also have drawbacks such as sample deterioration and being energy-inefficient. Literature indicates that control of the pneumatic system can be rather complex due to the non-linearity of the components, and control of pressure and velocity needs to be done with precision based on the nature of samples, lest breakup occurs. Numerous mathematical models have been published in efforts to optimize these systems for energy and to reduce sample degradation. Variables used in such models include material weight, transit distance, and width of pipes. In this work, a model is proposed that applies multivariable nonlinear regression to solve these problems and offers very encouraging results regarding energy efficiency and sample integrity along transportation in HPS.
6	Supriya Dhar, Subir Sinha,	**Location-** haemato-oncologic centre with a	An assessment of the PTS for	The study assessed the impact on the quality of packed red blood cell units

	Subhosmito Chakraborty, Sabita Basu **(2015)**	bone marrow transplant unit **Sample Size**- 50 packed red blood cell (PRBC) **Sampling Technique-** stratified sampling	packed red cell units during transit.	during transportation using a PTS. There were fifty PRBC units total- 50 irradiated and 50 non-irradiated that were compared with control units that were not transported by PTS. Hb, lactate dehydrogenase, potassium, and plasma haemoglobin were among the parameters that were evaluated before to and during PTS transfer. The PTS-transported and control units' parameters did not change statistically significantly, and the haemolysis levels remained below advised values. This suggests that PRBC quality is not negatively impacted by the PTS. A few delivery mistakes and abandoned bags were among the logistical problems that were found and fixed. Compared to human courier conveyance, the PTS offered a faster turnaround time, increasing productivity and personnel usage. The study emphasizes that in order to guarantee blood product safety, PTS validation must be completed before adoption. Findings demonstrate the validity of PTS with appropriate validation and procedure adherence, despite the paucity of literature on its application for blood products.
7	Dr. Amna Moulana, Shadi Ibrahim Misky Mamdouh Alhazmi, Alya Almatrafi, Dr. Asim Khogeer, Dr. Riyazuddin Ansari, Ayman Qashgari, Samah Saba, Dr. Mohammad Alobaidy, Faisal Alshalihi **(2023)**	**Location-** Maternity and Children Hospital, Makkah, Saudi Arabia **Sample Size-** 20 healthy adult volunteers **Sampling Technique-** Convenience sampling	Comparison of the Validation of the Hand-Carried Blood Sample and the PTS	The literature review highlights the significance of assuring sample stability to preserve the reliability of test results, particularly those that are sensitive to movement like LDH, AST, potassium, CBC, and coagulation tests. It also discusses the significance of validating PTS for the quick delivery of specimens in clinical laboratories. The analysis highlights that by reducing the requirement for physical specimen transfer, PTS can dramatically shorten specimen turnaround times, improving hospital staff time management. It emphasizes that samples carried manually and by PTS are usually compared as part of the validation process in order to evaluate any possible influence on sample quality, especially

				the danger of haemolysis. In order to comply with legal requirements and enhance patient care, the study also highlights the distinctive design features of every PTS installation and urges internal validation. Some publications support the claim that PTS can indeed affect non-centrifuged samples; however, even in centrifuged samples, no appreciable quality differences have been documented with PTS transport comparing to the manual transport. The argument thus stands in favour of the widespread implementation of PTS towards facilitating an increase in speed of operations in a clinical setup without affecting sample integrity.
8	P. O. Collinson, C.M. John, D.C. Gaze, L.F. Ferrigan, D.G. Cramp **(2002)**	**Location-** UK District Hospital **Sample Size-** Phase 1- 20 samples Phase 2- 37 samples Phase 3- 40 samples **Sampling Technique-** Consecutive sampling	Modifications in blood gas samples generated by a pneumatic tube apparatus	This study is set out to determine the effect of the presence of a PTS on blood gas analysis results, assessing more specifically differences in pH, pO2, and CO2 between samples from an ICU and a central laboratory. This three-phase trial compared samples that were sent to the laboratory by hand, examined right away in the intensive care unit, and transferred via PTS with and without a pressure-sealed container. The results showed that samples transmitted via PTS without a pressure-sealed container showed substantial changes in pO2 values, but pCO2 and pH values remained steady independent of the transportation method. Using a pressure-sealed container helped to reduce the pressure differential in pO2, which was caused by contaminants in the air and pressure fluctuations during transportation. As a result, in order to ensure accurate blood gas analysis, samples should either be manually handled or examined on-site to avoid artifacts in pO2 assessments, or they should be transported utilizing pressure-sealed containers within the PTS.

CHAPTER 3

METHODOLOGY

Study Design:

The present study is an observational and analytical study.

Study Setting:

The study was conducted in a hospital setting, specifically focusing on the pharmacy department and various hospital floors where pneumatic shoot systems are installed.

Study Population:

Pharmacy staff and nurses utilizing the Pneumatic Tube System.

Study Tools:

Observation and transaction logs from Biomedical Engineering department were used as study tools. Also, informal interviews were conducted with the head of the Pharmacy of the hospital.

Duration Of Study:

2 months 18 days

Sample Size:

A total of 43 pneumatic tube transactions were observed and analysed.

Sampling Technique:

Data was collected on April 5th (3-5 pm), 6th (12-1 pm) and 12th (11 am-12 noon) as per the instructions from the authority. All the observations on these days were used for the analysis.

Data Collection Procedure:

-Timed observations of Pneumatic Tube Transactions. Interview with the head of the Pharmacy.

-Analysis of transaction logs from Biomedical Engineering Department.

Data Analysis Plan:

Data was analysed using Microsoft Excel.

CHAPTER 4
RESULTS

TAT ANALYSIS

A total of 43 pneumatic tube transactions were observed and analysed to determine the TAT within the hospital setting. The recorded times were as follows:

Minimum TAT: 1 minute

Average TAT: 15 minutes

Maximum TAT: 56 minutes

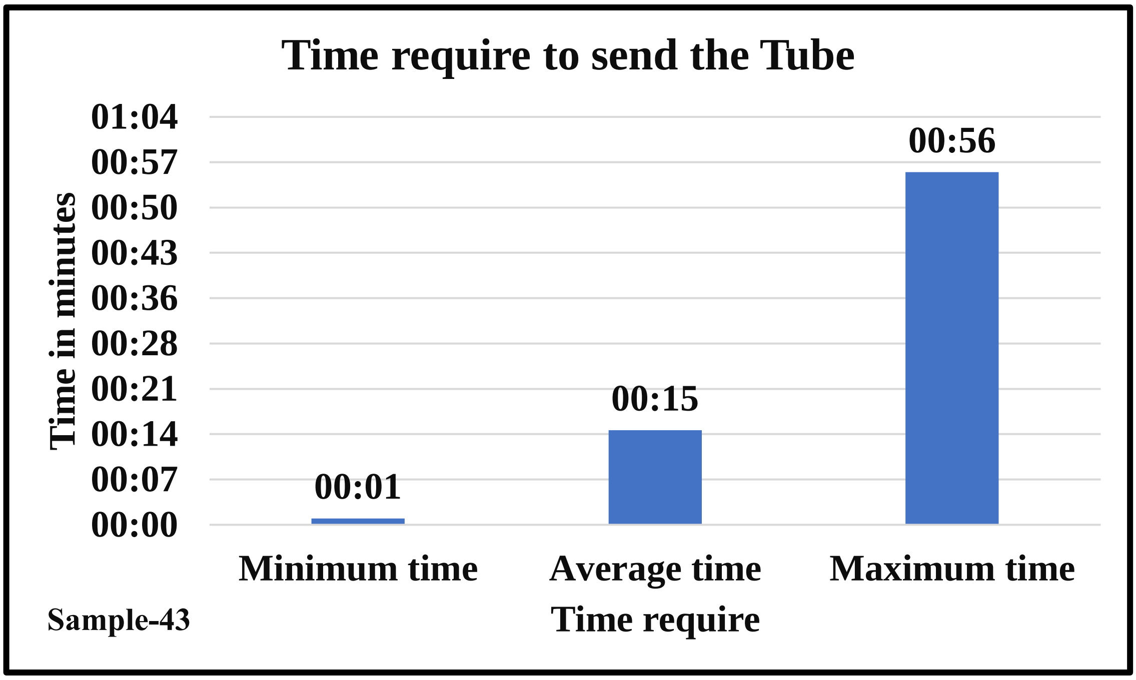


Figure 4.1- Time require to send the tube

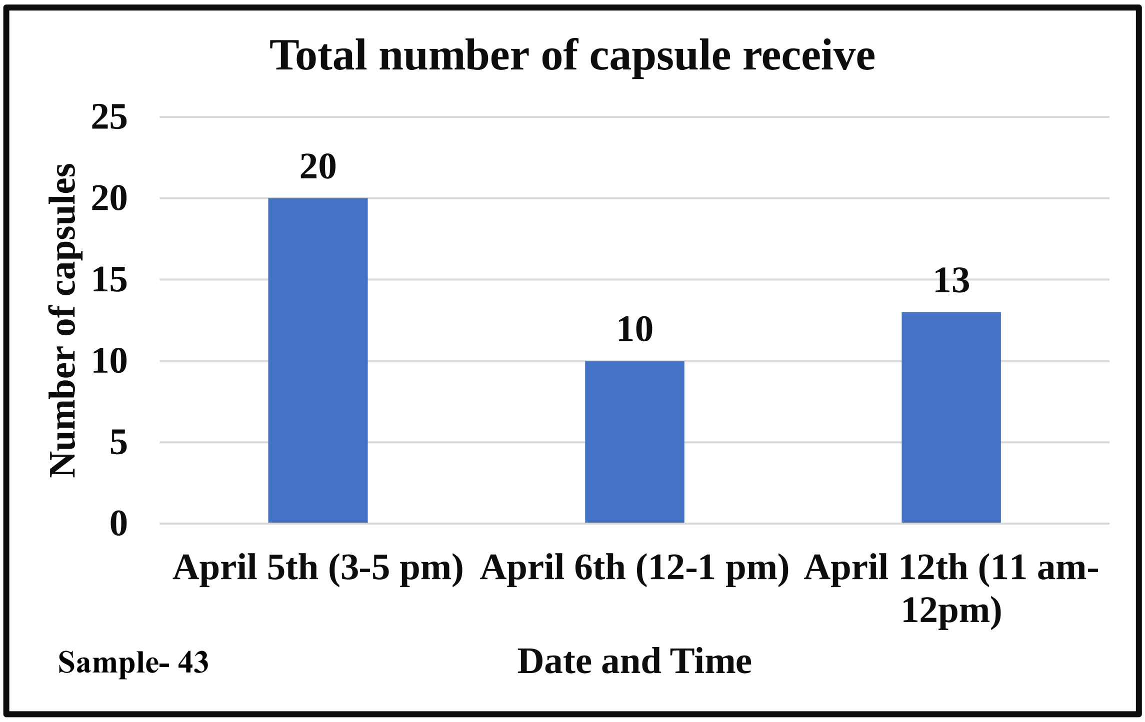


Figure 4.2- Total Number of Capsule receive

The following data was recorded regarding the number of capsules received from an observation of 43 pneumatic tube samples:

April 5th (3-5 pm): 20 capsules
April 6th, (12-1 pm): 10 capsules
April 12th, (11 am-12 pm): 13 capsules

During these periods, a total of 43 capsules were received—an average of approximately 10 per hour.

CAUSES OF DELAYS

Through timed observations and BME transaction log analysis were used to determine the main reasons why the pneumatic tube system delays, which are as follows:

System Overload

When there is heavy traffic, particularly during rush hours, the system becomes overloaded and delays the capsules delivery and dispatch.

Operational inefficiencies

Blockages and system failures were caused by incorrect capsule loading, which included going beyond weight limitations or sealing them improperly.

Problems with Staffing

Processing and shipping of capsules were delayed during periods of high demand due to a shortage of personnel.
Inadequate training was another factor in the system's incorrect use.

Technical Malfunctions

Occasionally, the system's operation was interfered with by technical problems including mechanical breakdowns or blockages in sensors.

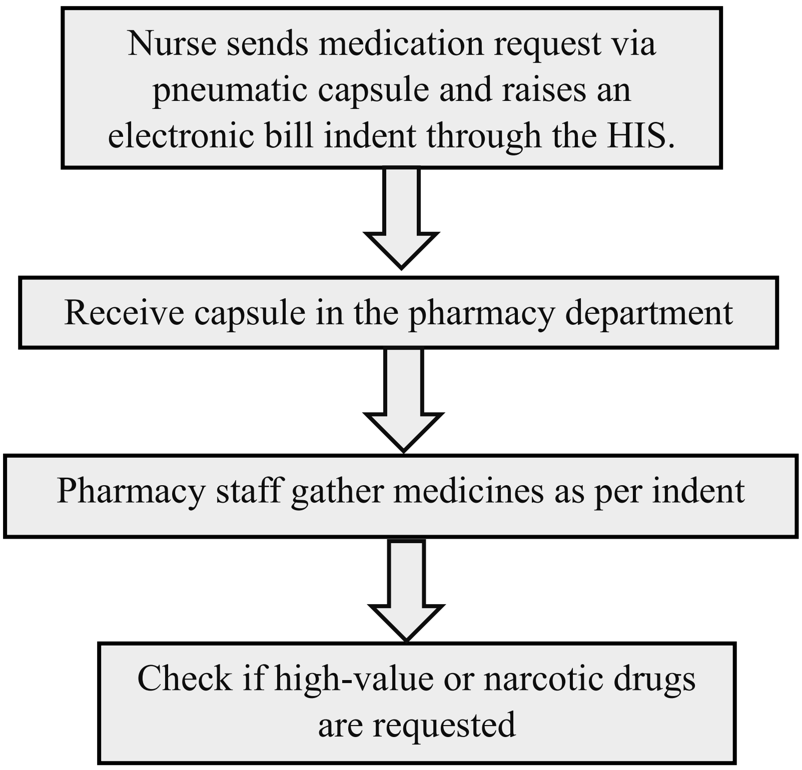
Pharmacy Dispatch

During peak hours, there were delays at the pharmacy dispatch unit because of a high volume of requests and insufficient manpower.

Receiving Units

A number of receiving units reported delays, especially when capsules were misdirected or encountered obstructions.

Process Flow Diagram based on the observation



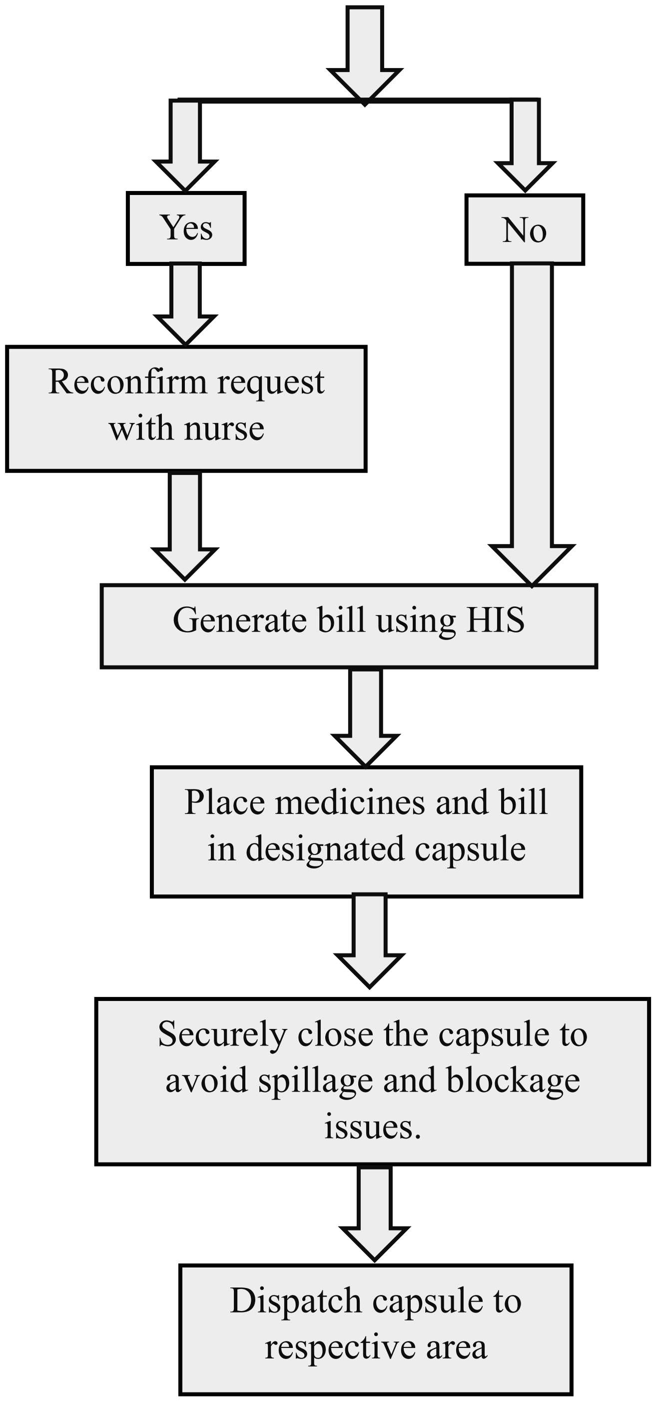


Figure 4.3- Process Flow of PTS

SOP DEVELOPMENT

The following SOPs were created in order to resolve the issues found and improve the pneumatic tube system's efficiency:

Purpose

In order to ensure the safe transportation of medical products while reducing related hazards, a standardized process for the effective and safe use of PTS in the pharmacy department needs to be established.

Scope

This SOP is applicable to pharmacy staff and nursing personnel involved in the transport of medications via the PTS within the facility.

Procedure

Location Details

Each pneumatic tube station has a combined dispatch/ receiving unit.

This are as follows-

STATION	STATION DESCRIPTION	FLOOR
9	Pharmacy	LB Floor
10	Report Dispatch	Ground Floor
11	A & E	Ground Floor
101	Sample Collection	First Floor
301	ICU-1/2 PCICU	Third Floor
302	OT	Third Floor
501	ICU-4	Fifth Floor
502	ICU-5	Fifth Floor
503	OT	Fifth Floor
702	Lab Sample Receiving	Seventh Floor
801	NICU/ PICU	Eight Floor
901	WARD-9	Nine Floor
1001	ICU-6/7/8	Tenth Floor
1101	WARD-11	Eleven Floor
1201	WARD-12	Twelve Floor
1301	WARD-13	Thirteen Floor
1401	WARD-14	Fourteen Floor
1501	WARD-15	Fifteen Floor
1601	WARD-16	Sixteen Floor

Table 4.1- Location details of PTS

General handling guidelines as mentioned by Head of the Pharmacy

Medications must be packaged in accordance with the manufacturer's instructions and placed into the canister with adequate packing to avoid breakage.

Make sure the capsule weighs no more than 1.5 kg, with 1.2 kg allowed for medication weight to avoid tube clogs.

A carrier can be loaded without the need to wait for a previous transaction to reach its destination.

Items Not to be Sent via Pneumatic chute System as mentioned by Head of the Pharmacy

The PTS cannot be used to move the following items:

Items weighing more than one kilogram.
Glass objects that are not sufficiently padded or secured to prevent breaking.\
Radiopharmaceuticals, cytotoxic medications, and hazardous compounds.
Narcotic drugs (substances under supervision).
Substances with carbon.
Expensive products.
Virus vaccinations in live form.
Items that need to be refrigerated.
Items with a "Do Not Shake" label on the packaging.
Items that foam or froth when shaken; if shipped, they should be given time to settle before being opened.

Handling Challenges as mentioned by Head of the Pharmacy and observation

The handling challenges of PTS are as follows:

<u>Incorrect Destination</u>

The nurse needs to request a redirect if the capsule is sent to the incorrect location by contacting the BME department.

<u>Container opening</u>

Make sure the nursing and pharmaceutical divisions are correctly closing containers. But get in touch with the BME department if there's a spill or obstruction.

<u>Receiving Sensor Blocked</u>

Get in contact with BME if the receiving sensor is blocked. There's a chance that a transaction from a different department is ongoing, or some other channel is the source of the block.

<u>Maintenance</u>

The pneumatic tube system should have routine maintenance performed by BME every six months.

Decontamination as mentioned by Head of the Pharmacy

The following steps should be taken if a biological material contaminates the PTS:

<u>Immediate Response</u>

-Secure down the area to stop more contamination.

-Notify BME and Infection Control, along with all other relevant departments.

Personal Protective Equipment (PPE)

Make sure that gloves, masks, and gowns, among other required PPE, are used by all persons handling the contaminated material.

Procedure for Cleaning as mentioned by Head of the Pharmacy

Minor Contamination

Use a suitable disinfectant that has been approved by the infection control team to clean the contaminated area. Make sure the disinfectant has enough contact time according to the manufacturer's instructions.

Major Contamination

The system might need to be temporarily shut down if the contamination is severe. Use cleaning services with expertise in biohazard decontamination.

Verification

Before beginning regular activities again after cleaning, be sure the area is clear of contamination. Swab tests and visual inspections by the infection control staff could be part of this.

Documentation

Keep a record of every instance of contamination and the actions taken to address it.

Additional Points

-Before shipping off, make sure the capsule and its contents are intact.
-Ensure that every employee has received training on how to use the PTS.
-As soon as possible, report any occurrences or faults to the BME department.

CHAPTER 5

DISCUSSION

Interpretation of Result

The TAT for the PTS in the hospital setting ranged significantly from 1 minute to 56 minutes, with an average TAT of 14 minutes. This variability in performance information reflects an inconsistent performance of the system, which may impact timely delivery of medications among others. These are, for instance, the identification of major causes, such as overload of the system, operational inefficiency, shortage of staff, and technical breakdown, which gives clear direction with respect to focused improvement.

These are the problems discovered, and the SOPs resulting from this study are to solve these. Standardizing capsule loading processes may help improve the effectiveness and dependability of the PTS by planning routine maintenance, offering thorough employee training, and giving clear maps of explicit emergency protocols. Such SOPs lay down provisions for reducing the identified bottlenecks in an effort to ensure that the system runs smoothly.

Comparison with relevant studies

Previous researches underscored the importance of effective hospital logistics in maintaining operational efficiency and enhancing care for patients. Delay in the pneumatic tube system as a result of lacking frequent servicing and training of personnel was pointed out by literature from Staab et al., which this study replicated. Moreover, one of the studies conducted by Kim et al. in 2019 proved that the execution of SOPs in hospitals considerably improved the TAT and helped in reducing the occurrence of system failures.

These observations regarding TAT variability are in line with those of other medical institutions. Nguyen et al. (2018) also recorded a wide range of TAT in their PTS, attributing these delays to the many periods of high traffic and technical problems. The suggestions for implementing change made by this study, targeted at improving its findings, fall in line with those of the previous research that identified the need to address personnel matters and operational inefficiencies.

Strengths

The detailed data related to the performance and efficiency of the PTS were attained through systematic techniques of observation and analysis of 43 pneumatic tube transactions conducted in this study.

Combination of quantitative data from the TAT measurements with qualitative input from staff interviews provided a comprehensive overview of the deficiencies of the system and areas for potential development.

Detailed SOPs, based on the study's findings, give valuable recommendations which can be easily implemented in a hospital setting.

Limitations

Since the duration of the research study was small, it is expected that long-term trends and all types of fluctuation in the performance of the system were not captured.

Although 43 transactions are enough data to work with for a pilot study, it may not be big enough to extrapolate its findings on other healthcare settings.

This will carry the bias towards the overreliance on self-reported information from staff interviews, as respondents will either overreport or underreport some issues according to their experience.

CHAPTER 6

RECOMMENDATIONS

In order to enhance the efficiency of the PTS in the hospital, the following recommendations are as follows:

Maximizing Training and Staffing Levels:

-There can be enough manpower at busy times to manage large numbers of transactions and cut down on delays.
-Provide pharmacy and nursing personnel thorough instruction on how to use the PTS correctly, emphasizing best practices for loading and delivering capsules.

Regular Maintenance and Technical Support:

-To avoid technical issues the BME department should schedule periodic maintenance inspections at least every six months.

Standardize SOPs

-Formulated SOPs can be implemented to reduce mistakes and guarantee uniform capsule handling in all departments during the loading, dispatching, and receiving process.
-Review and update the SOPs on a regular basis.

CHAPTER 7

CONCLUSION

In this study, the PTS-TAT and its process flow in a hospital setup were assessed with the objective of identifying major inefficiencies in order to help in laying down standard operating procedures so that functionality can be enhanced. The present study showed a significant variation in TAT. Personnel constraint, operational inefficiency, and system overload were the three major factors that were discovered as being responsible for such delays.

The hospital can greatly enhance this in terms of effectiveness and reliability through the implementation of certain key improvements, such as staffing optimization, routine maintenance, standardization of operating procedures, real-time system monitoring, and coordination and communication among departments.

Most of these recommendations, when implemented, will improve hospital logistics and remove medicine and sample delivery delays, thus providing improved service to patients. Continuous maintenance of the system and frequent training of the employee is required for its smooth running and efficiency. Continuous communication and real-time monitoring are other means toward the solving of problems in a quick manner.

The conclusions of this study point out that the effectiveness of the PTS is an important component of the operational effectiveness of any hospital. By design and addressing inefficiencies identified, as well as the implementation of the recommended SOPs, the hospital will be better positioned to ensure timely and safe delivery of prescription drugs and other essential supplies, which will have improved operational effectiveness with better patient care outcomes.

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TITLE

Analysis and Optimization of Hospital Bell Call Response Times: A Study Across Multiple Floors in the hospital

CHAPTER 2

ABSTRACT

Title
Analysis and Optimization of Hospital Bell Call Response Times: A Study Across Multiple Floors in the hospital

Author

Shweta Prabhakar Kale

Objective
To analyse hospital bell call response times across different floors and dates, focusing on response times by nurses, healthcare assistants (HCAs), and porters.

Methodology
A maximum, average, and minimum response times have been collected for data, with varying sample sizes across different floors, and analysed using MS Excel.

Results
The findings outline variations in all response times and allow for the improving of efficiency.

Conclusion
Recommendations are made to enhance response times and improve patient care satisfaction.

Keywords
Hospital bell, Nurse call response, HCA call response, Porter call response

CHAPTER 1
INTRODUCTION

The hospital call bell systems, otherwise known as nurse call systems, are essentially electronic communication devices installed in healthcare institutions to communicate directly between patients and healthcare workers. Such devices are normally mounted beside beds and in bathrooms, thus allowing a patient to call for assistance at any time. They assist by raising an alarm to put in a call to a nurse, healthcare worker, or porter with the simple press of a button, thus their needs are promptly provided for. This is an important system in patient care because patients shall have a reliable way of summoning assistance and the hospital staff can effectively respond to them.

The importance of call bell systems in hospitals, among other things, lies in improving safety and satisfaction for patients. A quick response to the patients calls will help avoid a lot of harm which is a potential fall or any form of medical emergency and therefore put up a cleaner record of safety. Further, assistance on time for routine needs, such as medication administration or help required with personal hygiene, improves patient experiences, hence higher satisfaction rates. They also contribute to monitoring response times and managing staff workflows so that hospital management can plan staffing levels to bring overall efficiency in the delivery of patient care.

Components

The overall components for a general hospital call bell system would include the following:

Call Button

This is the button normally placed beside a patient's bed, which generates a call signal upon being pressed to seek help. State-of-the-art systems combine handheld devices or wearable technologies easily for its operation.

Figure 1.1- Call Button

Indicator Panels

These panels are mounted at nurses' stations and other locations generally within a hospital. They indicate the room number or bed number originating the call and visual indicator with an audible alert.

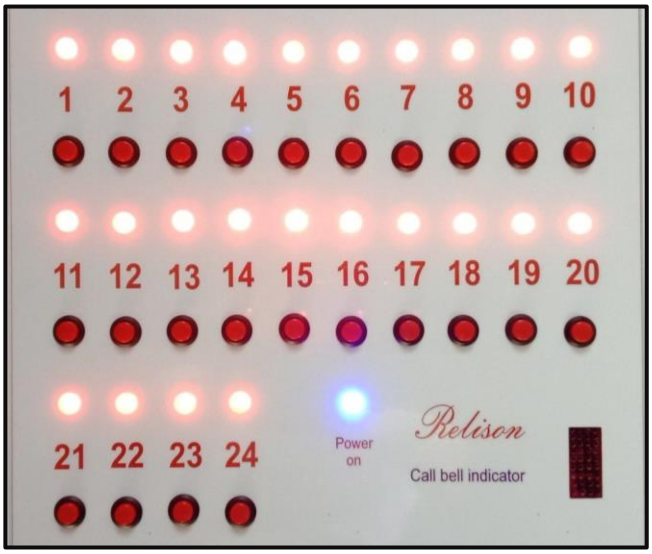


Figure 1.2- Indicator panel

Aim

The objective of this study is to evaluate and improve the response times for the hospital's bell calls.

Objectives

-Analyse response time by floor and date.

-Compare response times for nurses, HCA and porters.

CHAPTER 2

LITERATURE REVIEW

Sr. no.	Author/ Year of Publish	Study Location/ Sample Size/ Sampling Technique	Review Title	Abstract
1	Robin Digby, T. Howard, Melissa J Bloomer **(2011)**	**Location-** Mornington Centre, Peninsula Health, outer metropolitan Melbourne, Australia **Sample Size-** 41,460 call bell activations (control period); 47,478 call bell activations (post-intervention period) **Sampling Technique-** Convenience sampling	Improving call bell response time	This study set out to examine and compare the call bell response times in two wards—one intervention ward and one control ward—in a geriatric assessment and management facility, before and after interventions designed to reduce patient falls were implemented. Response times available through the institution's automated call bell system were used to evaluate intervention effectiveness. Some of the interventions included staff awareness campaigns, rescheduling nurse breaks, and hourly rounds. Though generally there was an increase in call congestion, results showed a significant improvement in response times post intervention, with a 5.21% increase in calls answered within five minutes. Even though call bell activations did not decrease and falls did not significantly decrease, it should be underlined that the findings bring out a strong message on leadership and teamwork approach in prioritizing patient safety and call bell response outcomes, at least in senior care settings.
2	Capt. Valsa Thomas, Pankaj Punjot, Binu Gigimon Varghese **(2019)**	**Location-** Dr. L.H. Hiranandani Hospital, Powai, Mumbai, Maharashtra, India **Sample Size-** 16,543 call bells	Study to assess the nurse call response monitoring - proximity contributory Factor	The literature review identifies the role of call bell systems in hospitals to be paramount, focusing on them as the primary method of patient contact in hospitals to notify staff of their needs. For both satisfaction and safety reasons, call bells require an immediate response from nurses, as delays have been shown to negatively impact patient outcome.

		Sampling Technique- Universal sampling		The Dr. L.H. Hiranandani Hospital tracked 16,543 call bells for three months and reported that its infrastructure worked very well to reduce response times—the average being 94.88% of calls answered in less than a minute. The review thus underlines the fact that an effective call bell response is of prime importance for the maintenance of good nurse-patient relationships and ensuring patient safety and general satisfaction with hospitalized treatment.
3	Nur Hidayat, Retno Lestari Ahsan Ahsan, Masruroh Rahayu **(2009)**	**Location-** Central Java, Indonesia **Sample Size-** 117 patients **Sampling Technique-** Simple random sampling	These include response time, wait time, and quality of service in the Emergency Department	Hospital preferences, patient contentment, and overall service outcomes all depend on perceived hospital service quality, defined as the gap between what patients expect and what they perceive in actuality in the context of health care received. This study of 117 emergency room patients of the public hospital of Indonesia found that the waiting time and the response time are key dimensions of the quality of the service of provision. Although 52.1% were not satisfied with the answer time, 79.4% of the patients were satisfied with the waiting time. Improving patient satisfaction, striving for excellence in hospital performance, and achieving effective communication require improving staff capability, sufficient hospital resources, and delivery.
4	Nancy Martin, Gloria Cardosa **(2003)**	**Location-** Cambridge Memorial Hospital **Sample size-** 140 **Sampling technique-** NA	The Patient Connection: Improving Call Bell Response at Cambridge Memorial Hospital	In a technologically advancing environment, the need is directly related to enhancing the amount of satisfaction among patients in healthcare settings; this can be accomplished through at least one key avenue: rapid call bell response. The status regarding patient satisfaction, as noted by the Standardized Hospital Patient Satisfaction Survey and the Ontario Hospital Report Card, is often rooted in direct care contacts. Decreasing the call-bell response time at Cambridge Memorial Hospital is a

				shining example of how dedicated improvement methodologies can be initiated through many years of patient feedback. A corporate project team was established, and interventions were introduced across various clinical programs with great success. Although the introduction of portable phones presented the potential for quicker responses, staff preference for face-to-face communication undermined just how hard it is to balance effectiveness with patient pleasure. More research is needed into this complex relationship between perceived and actual response times. This will emphasize the necessity of continuing to achieve improvements in care that is centered on the patient.

CHAPTER 3

METHODOLOGY

Study Design:

The present study is a cross-sectional and analytical study.

Study Setting:

The study was conducted in a hospital setting, on different floors which are 9^{th}, 11^{th}, 12^{th}, 13^{th}, 14^{th}, 15^{th}

Study Population

Patients using the bell call system, nurses, HCAs, and porters.

Study Tools

Bell call system records, hospital records

Duration Of Study

2 months 18 days

Sample Size

Varying sample sizes based on different dates and floors visited.

Sampling Technique

Convenient sampling was used to conduct the study.

Data Collection Procedure

Secondary data was used for this study. As mentioned earlier, bell call system records and written records by nurses were used.

Data Analysis

Data was analysed using Microsoft Excel.

CHAPTER 4

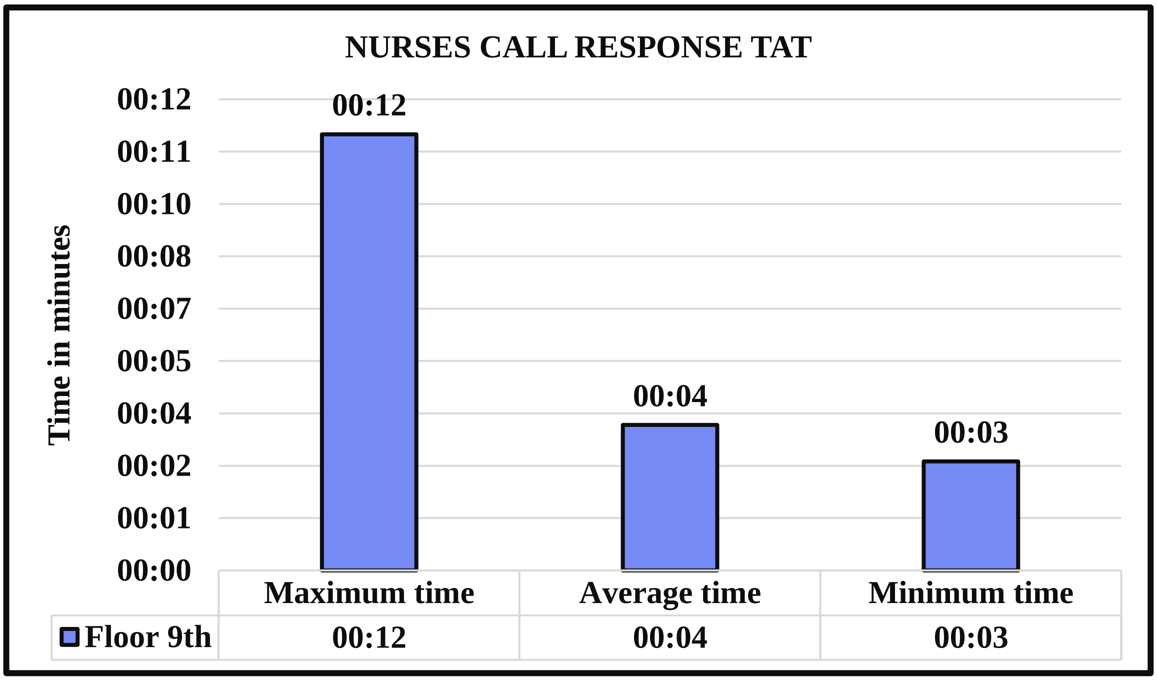
RESULTS

Floor Number	Floor Specialization	Total Number of Beds
9th	IPD- Twin Share, BMT Unit	40
11th	General Ward+ BPL Ward	145
12th	IPD- Twin Share	59
13th	IPD- Twin Share	74
14th	IPD- Single Share	37
15th	IPD- Single Share	37

Table 4.1- Floor Details

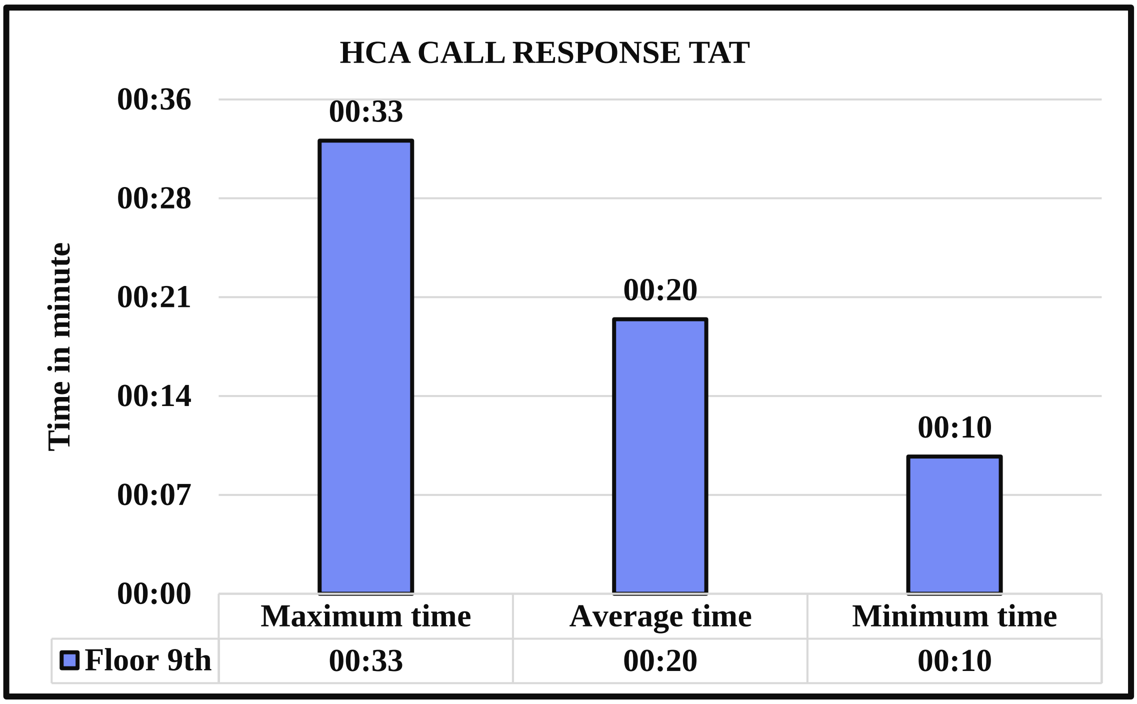
9th Floor Data

Date- 14th & 15th May 2024



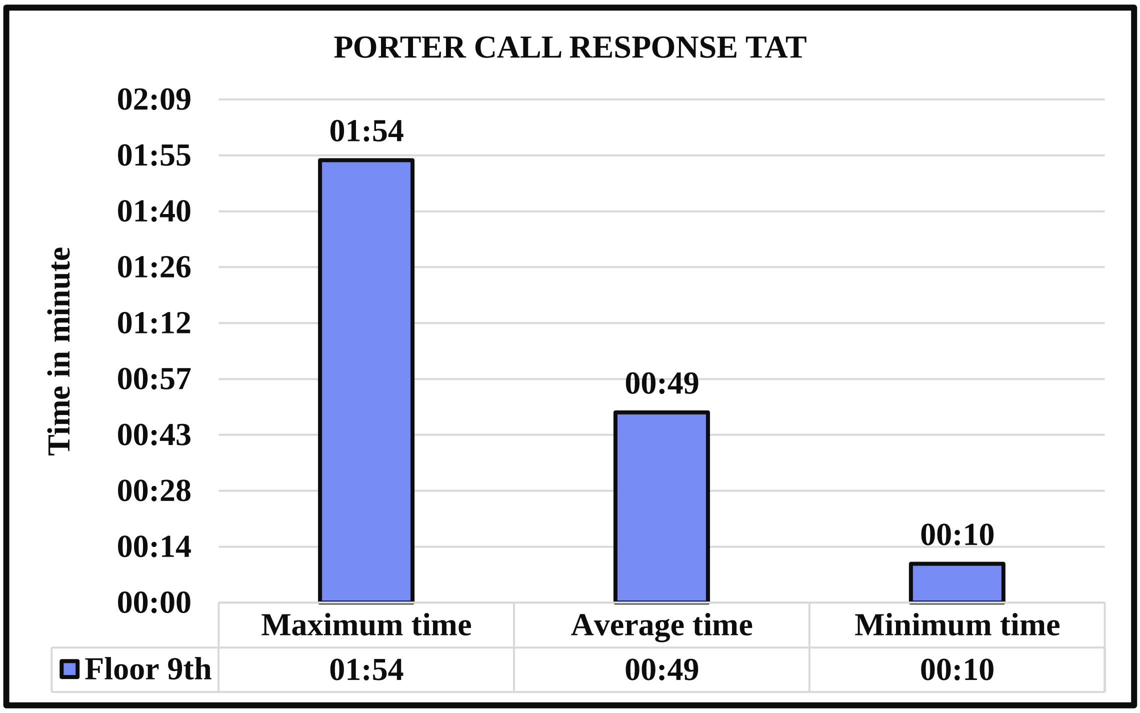
Sample size- 39

Figure 4.1- 9th floor Nurse call response TAT



Sample size- 14

Figure 4.2- 9th floor HCA call response TAT

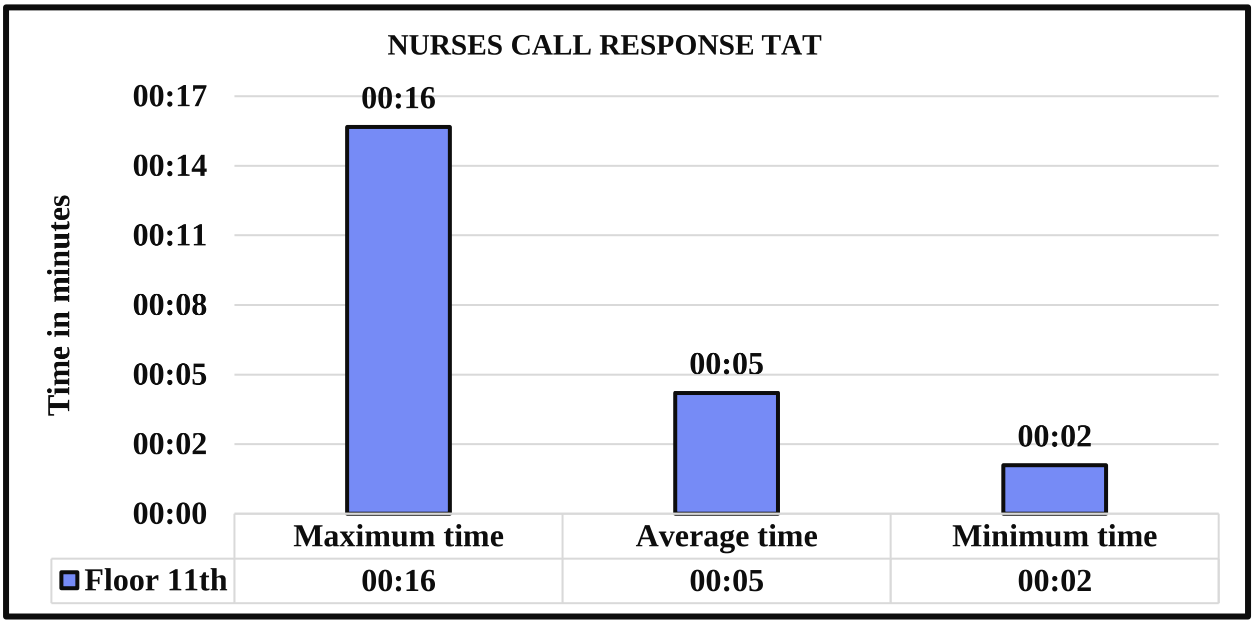


Sample size- 19

Figure 4.3- 9th floor Porter call response TAT

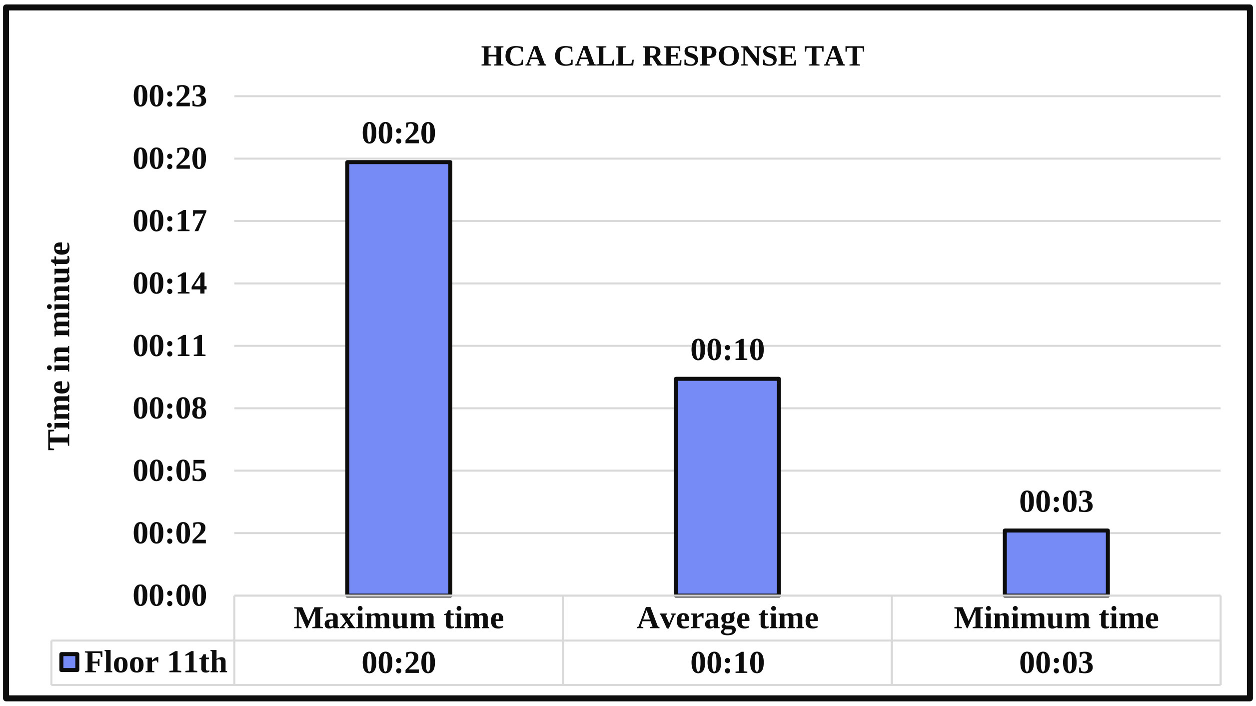
11th Floor Data

Date - 13th & 16th May 2024



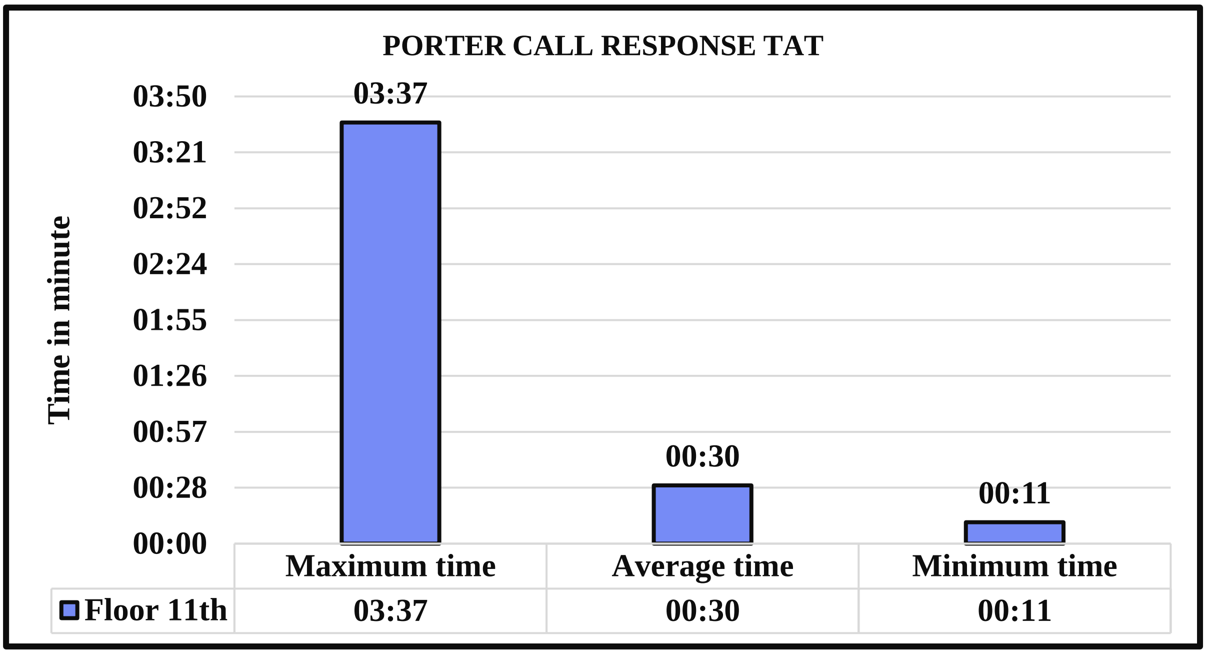
Sample size- 28

Figure 4.4- 11th Nurse Porter call response TAT



Sample size- 19

Figure 4.5- 11th floor HCA call response TAT

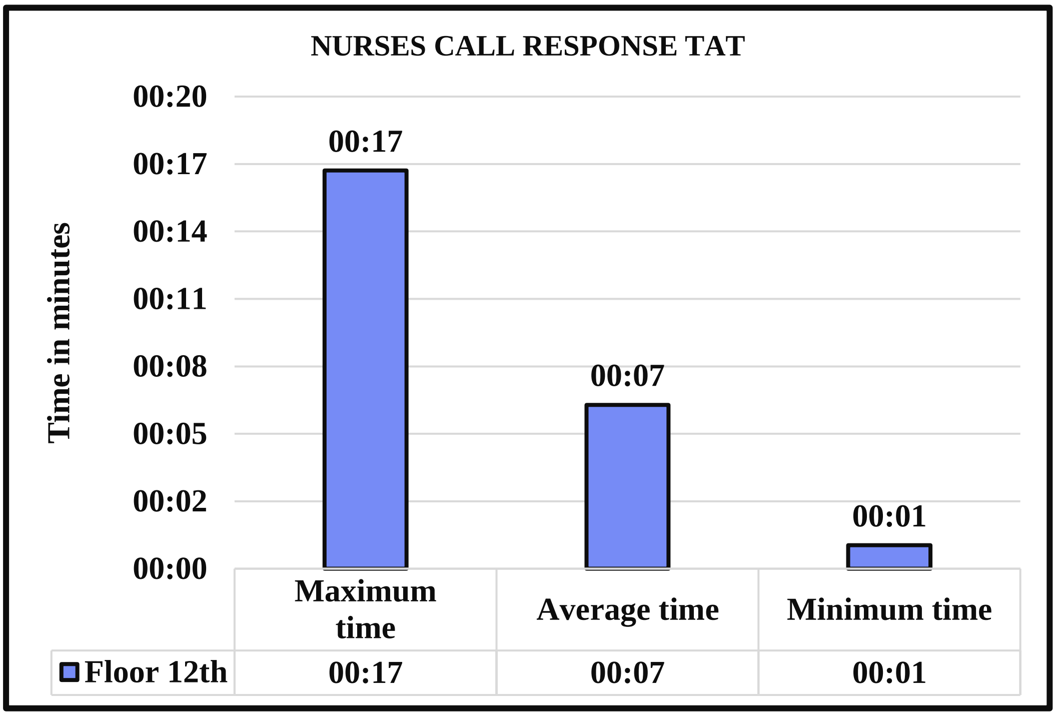


Sample size- 21

Figure 4.6- 11th floor Porter call response TAT

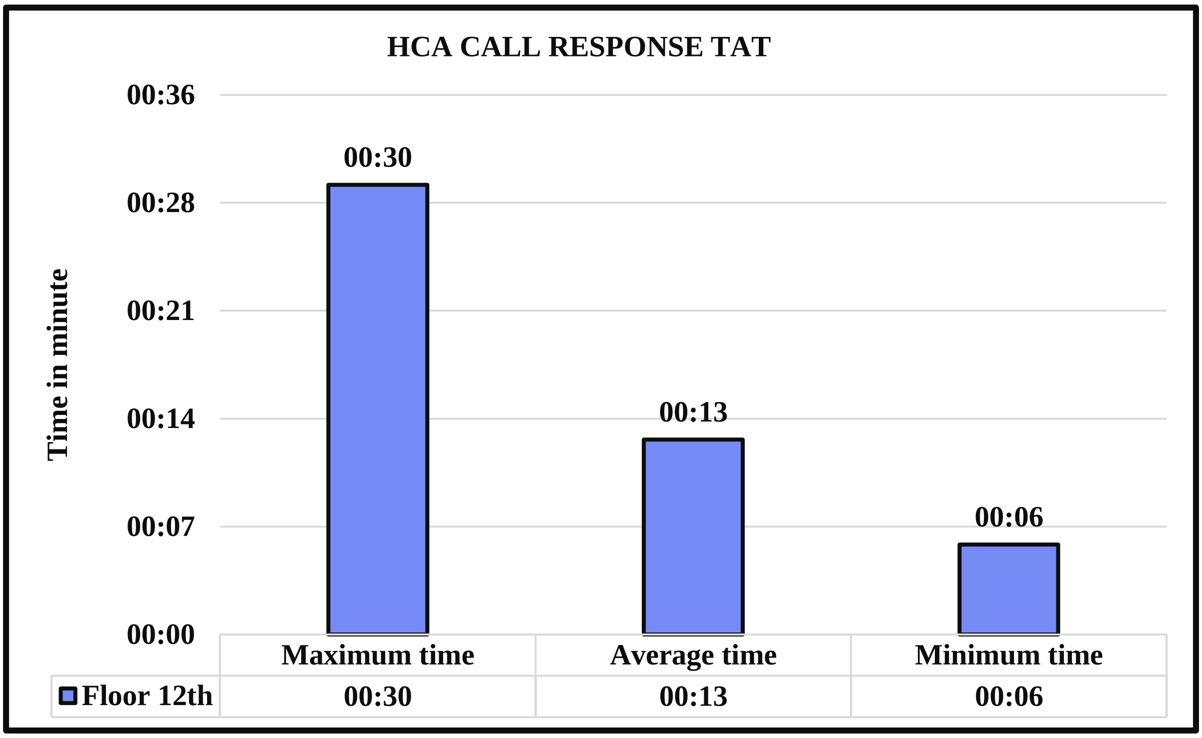
12th Floor Data

Date - 14th & 15th May 2024



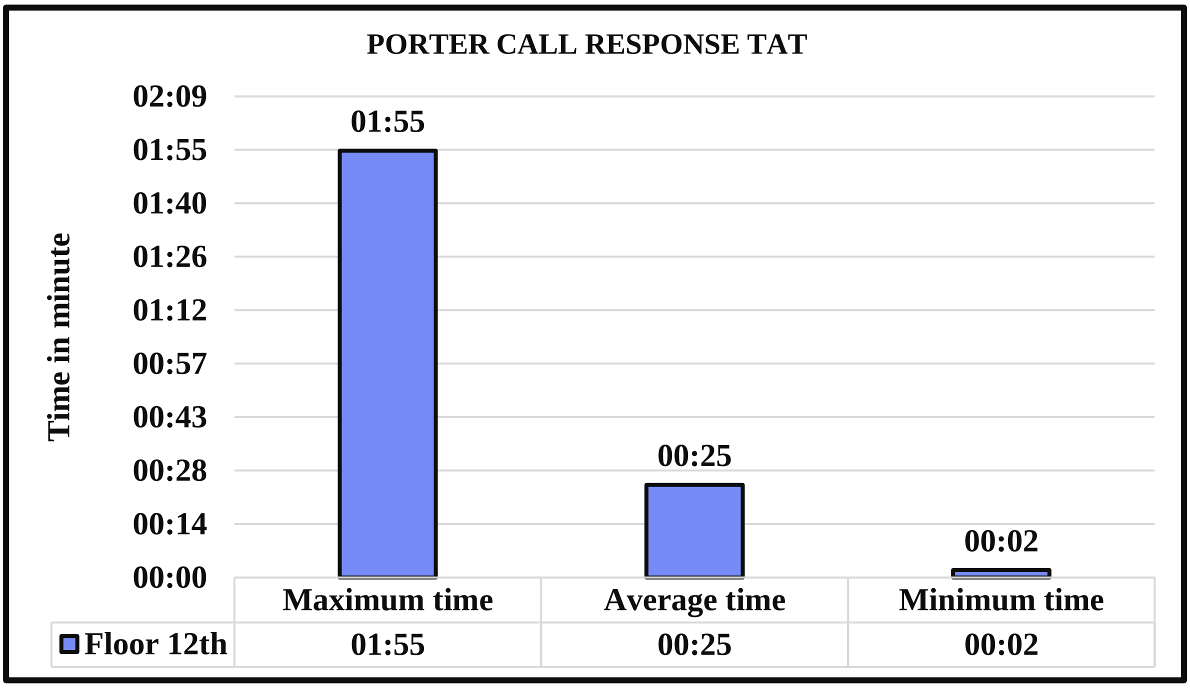
Sample size- 39

Figure 4.7- 12th floor Nurse call response TAT



Sample size- 10

Figure 4.8- 12th floor HCA call response TAT

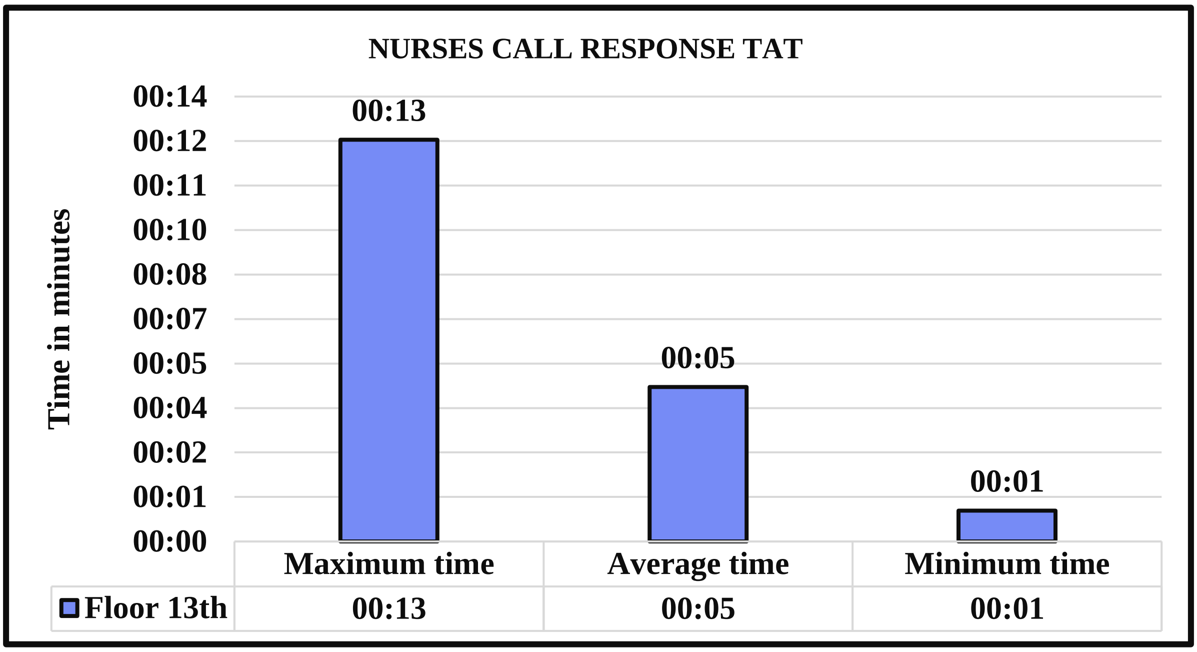


Sample size- 10

Figure 4.9- 12th floor Porter call response TAT

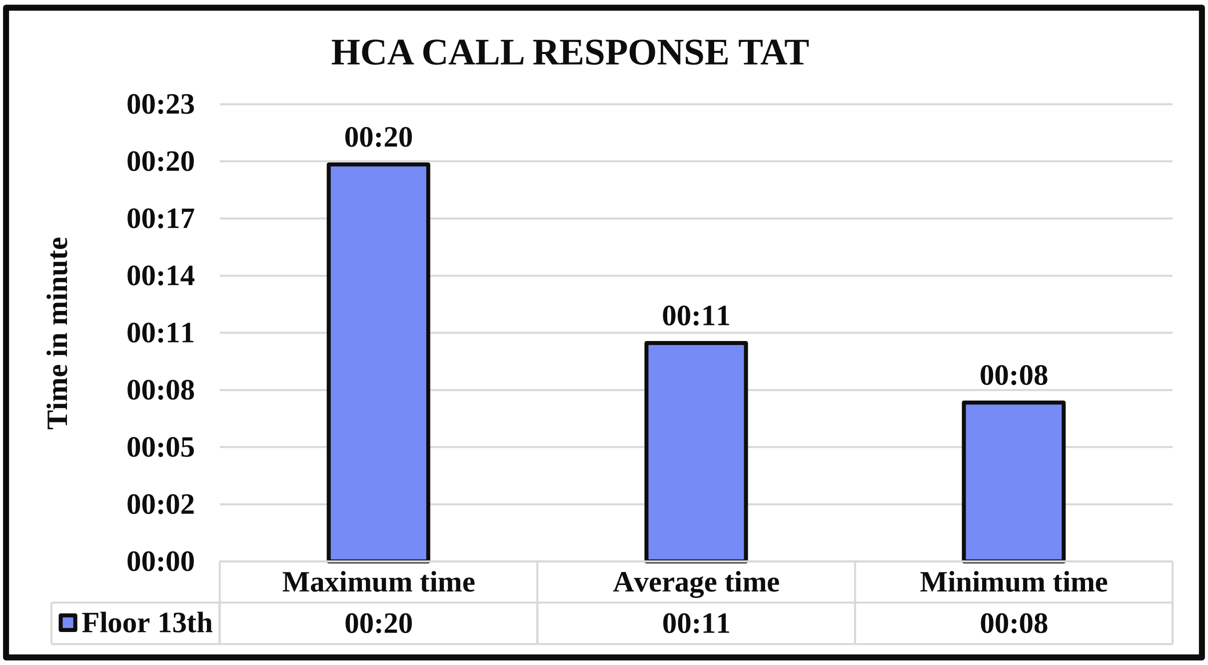
13th Floor Data

Date - 13th & 16th May 2024



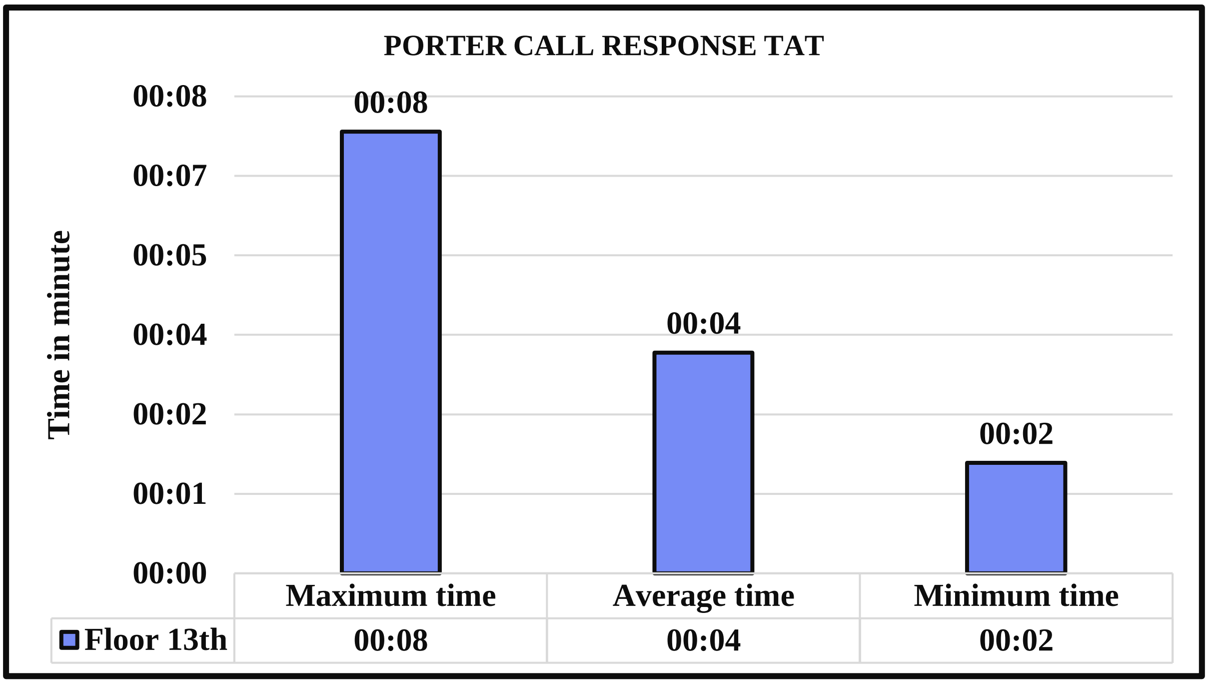
Sample size- 40

Figure 4.10- 13th floor Nurse call response TAT



Sample size- 11

Figure 4.11- 13th floor HCA call response TAT

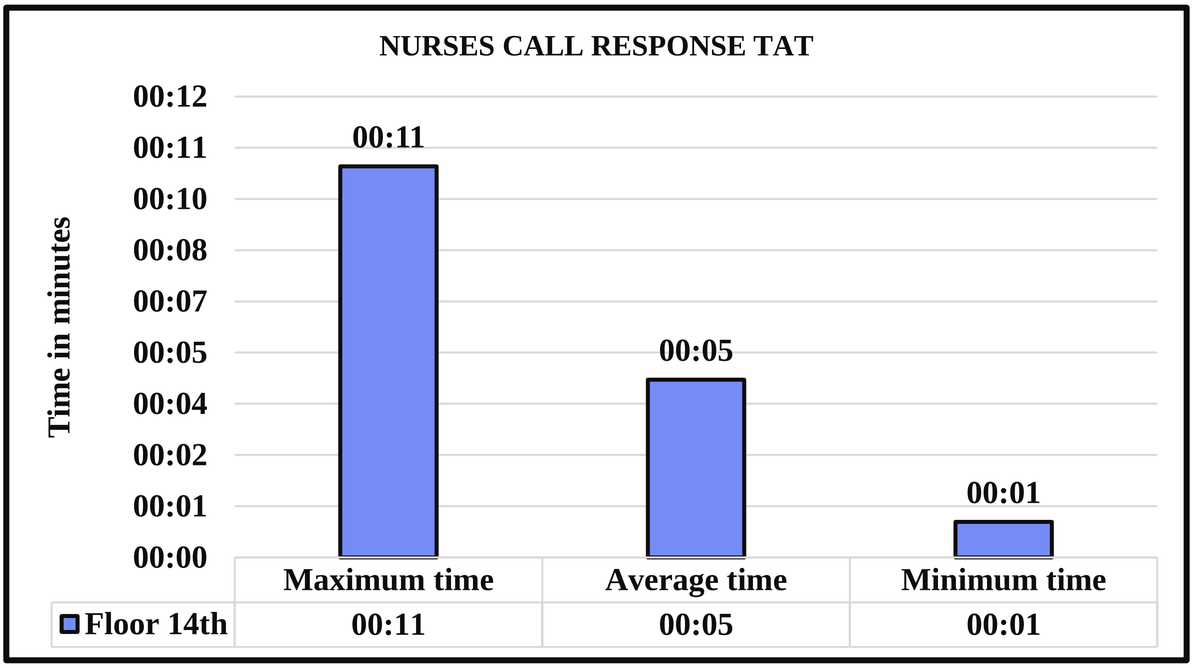


Sample size- 5

Figure 4.12- 13th floor Porter call response TAT

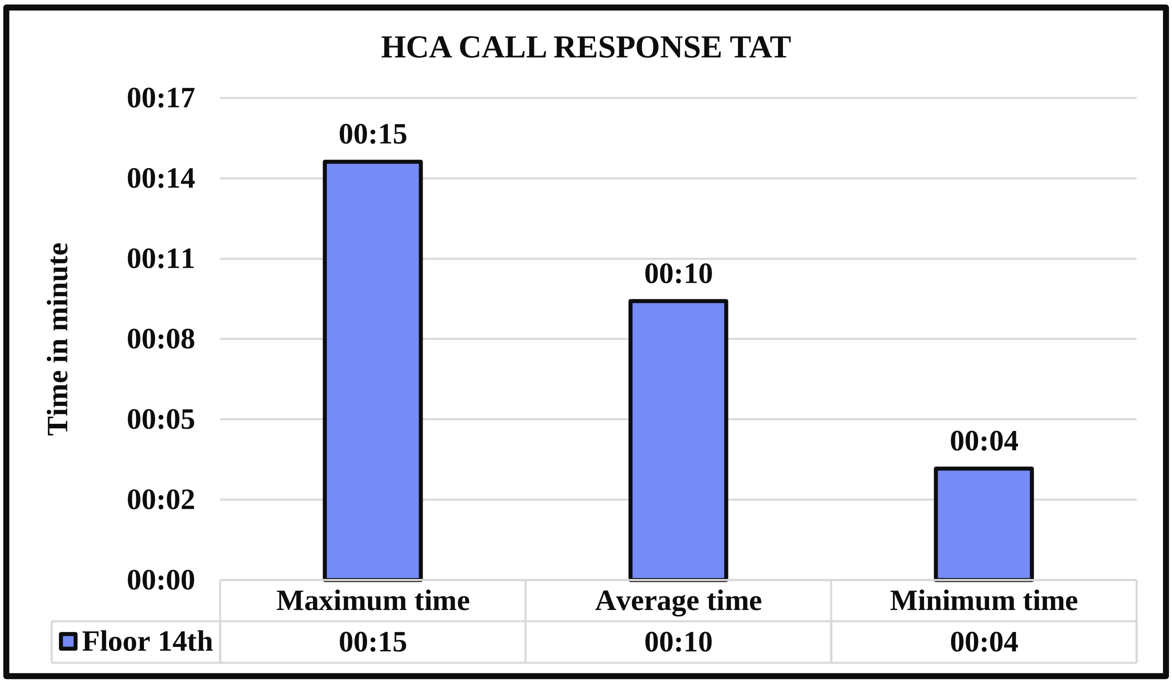
14th Floor Data

Date - 13th & 14th May 2024



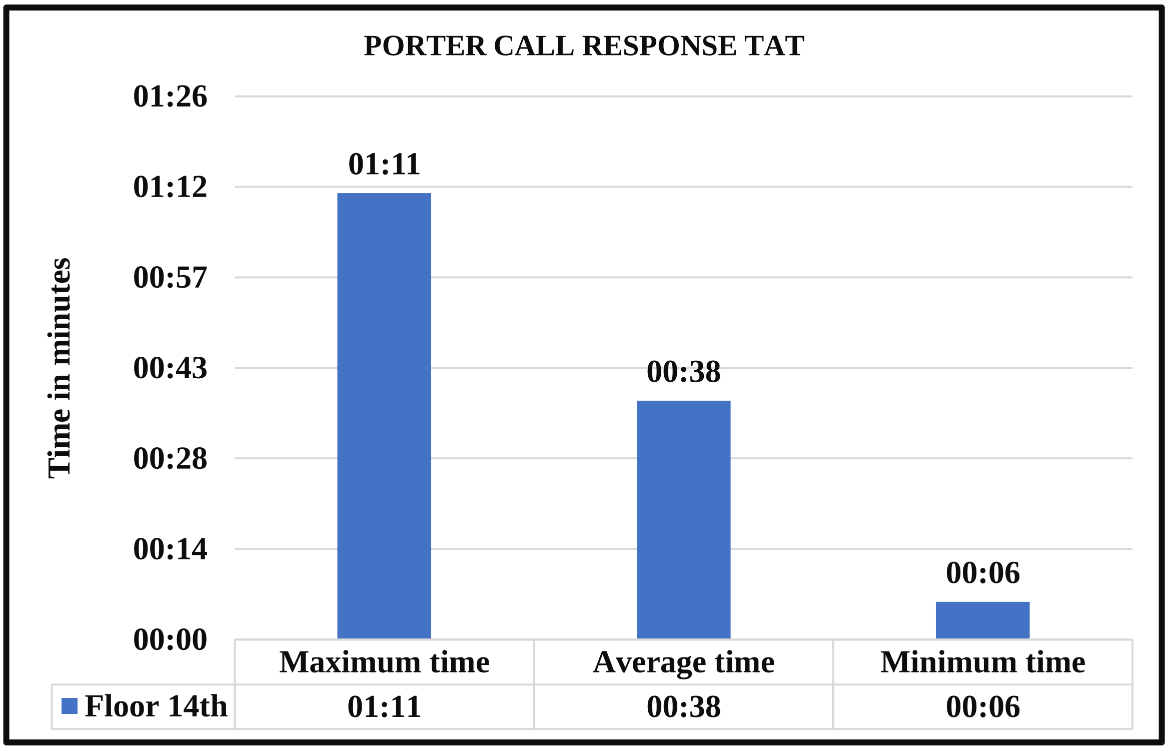
Sample size- 33

Figure 4.13- 14th floor Nurse call response TAT



Sample size- 12

Figure 4.14- 14th floor HCA call response TAT

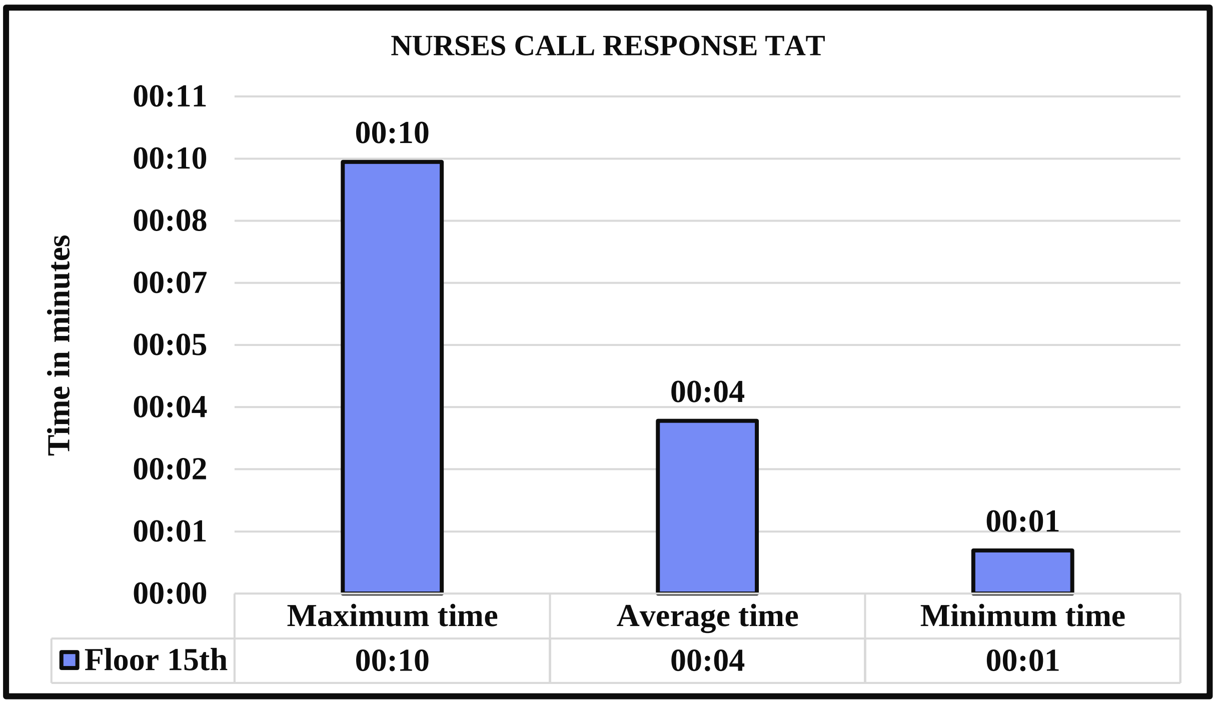


Sample size- 6

Figure 4.15- 14th floor Porter call response TAT

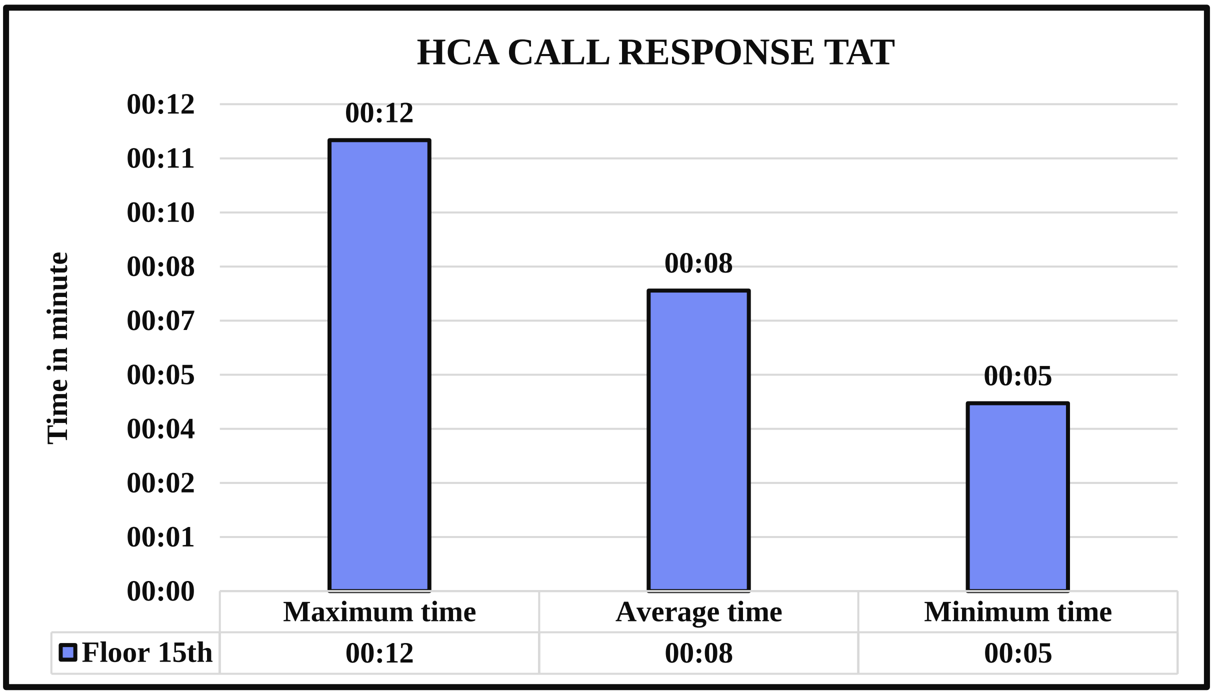
15th Floor Data

Date - 13th & 14th May 2024



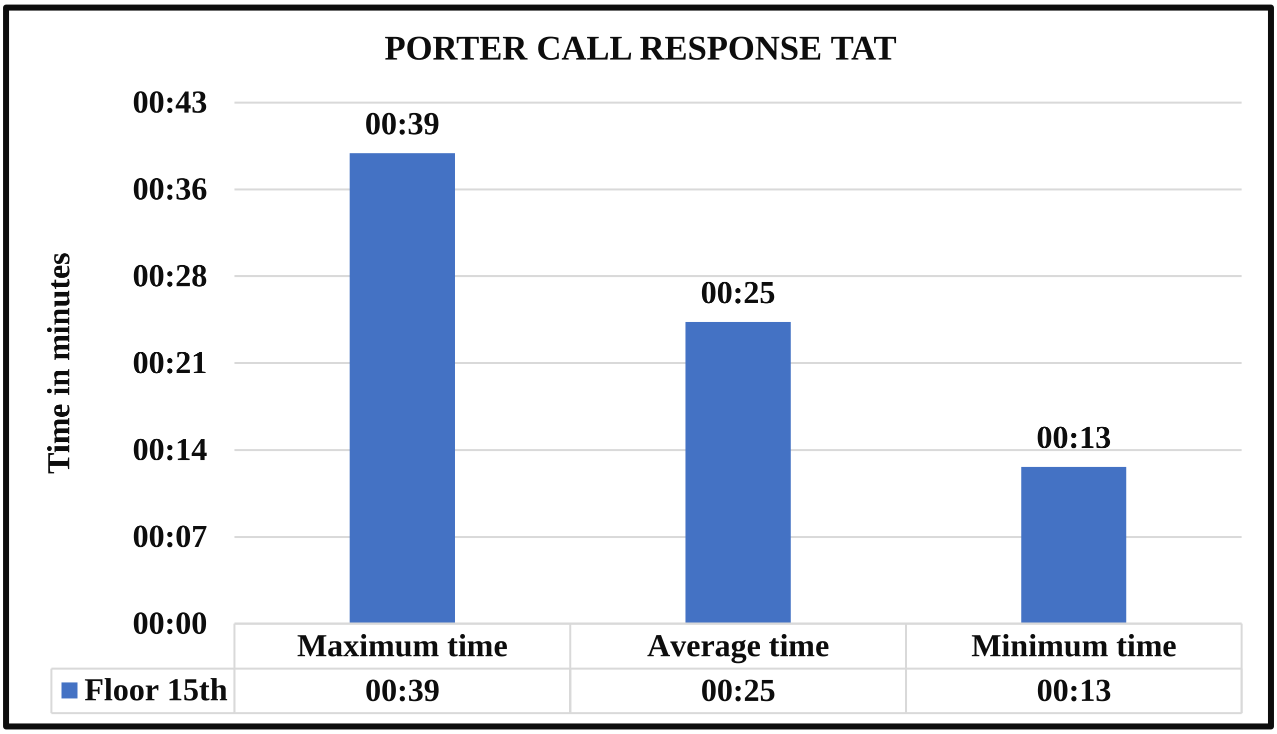
Sample size- 42

Figure 4.16- 15th floor Nurse call response TAT



Sample size- 11

Figure 4.17- 15th floor HCA call response TAT

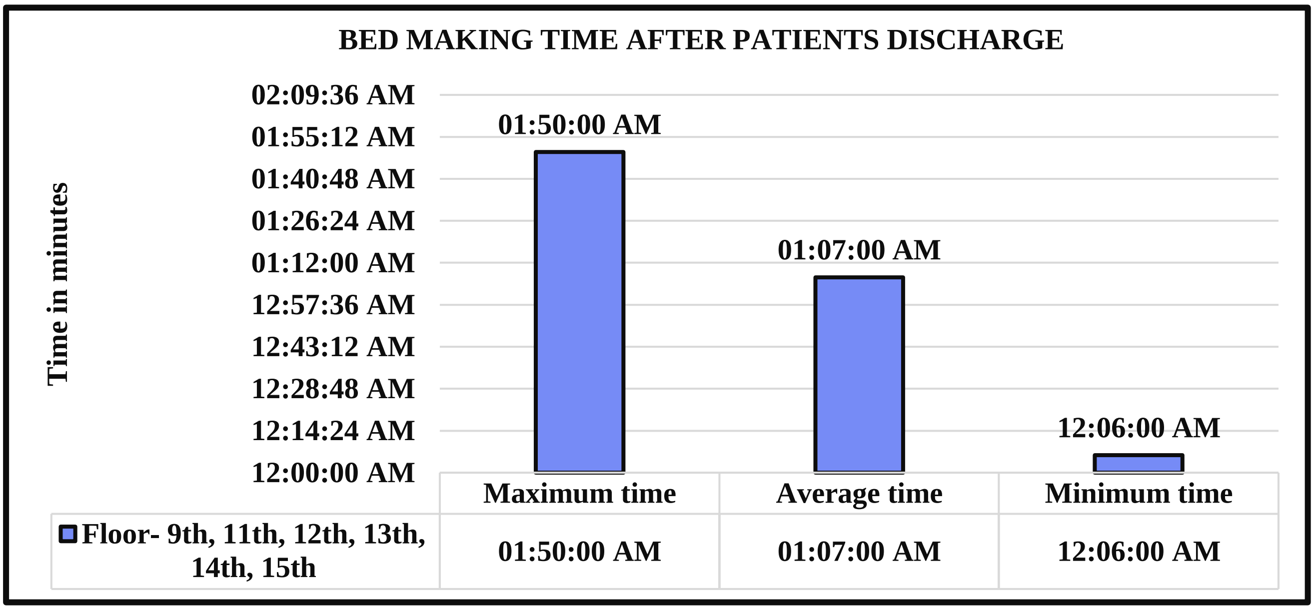


Sample size- 7

Figure 4.18- 15th floor Porter call response TAT

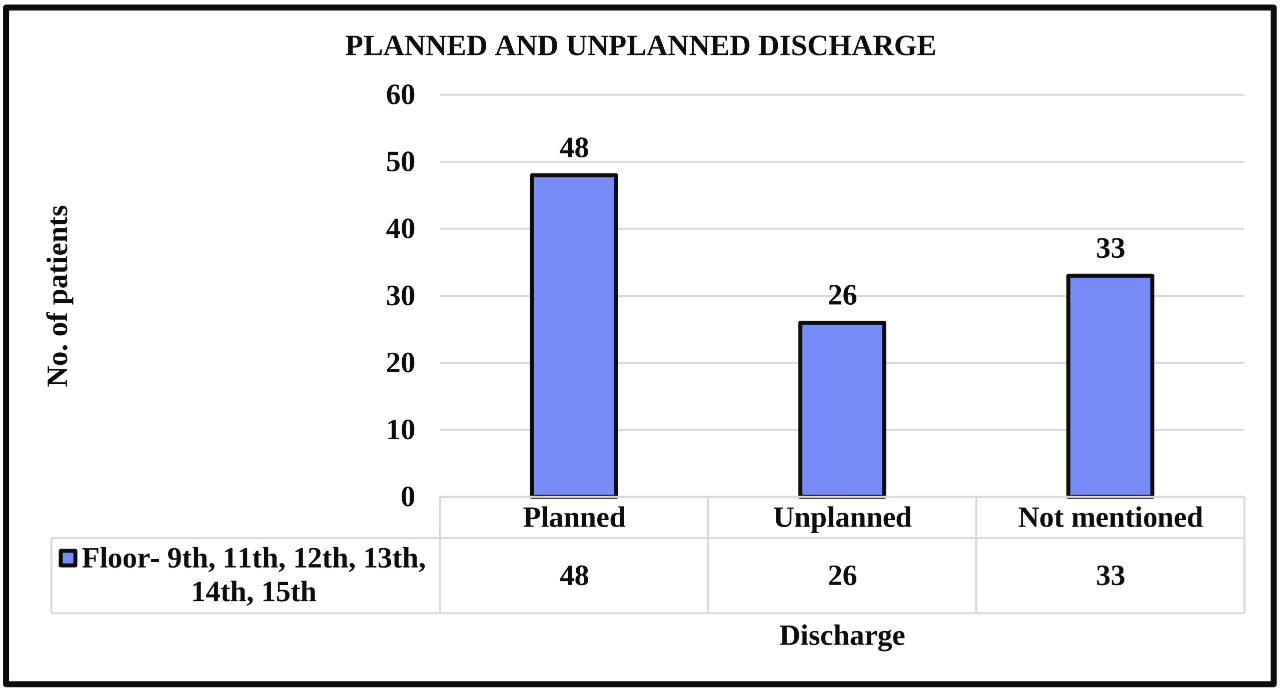
Time taken to make the bed TAT

Date- 13th- 16th May 2024



Sample size- 14

Figure 4.19- Bed making time



Sample size- 107

Figure 4.20- Planned and Unplanned Discharge

The times for bell call in this hospital varied greatly from floor to floor and within staff roles. On the 12th floor, the maximum response time by a nurse was 17 minutes, with the quickest response time at 1 minute. HCA followed a pattern with the 9th floor having the maximum response time, and their minimum response time was 3 minutes. For the 11th floor, the porters had the longest response time of over 3 hours and the shortest time was 2 minutes. These results manifest that there are inconsistencies in the response time depending on the floors, number of beds, and patient-to-nurse ratio, HCA ratio and the porter staff that may affect patient care and satisfaction; highlighting areas for potential improvement in staffing, training, and workflow management.

CHAPTER 5

DISCUSSION

Interpretation

The analysis of hospital bell call response times across different floors provided significant insights into the operational efficiency and patient care standards of the hospital. The findings revealed notable variations in response times by nurses, healthcare assistants (HCAs), and porters, indicating areas for potential improvement.

Comparison with Relevant Studies

Comparatively, our findings align with previous research by Digby et al. (2011), which highlighted the impact of specific interventions on response times, though our study indicates greater variability across different floors. Similarly, Thomas et al. (2019) emphasized the importance of prompt responses to call bells for patient satisfaction and safety, supporting our observation of the need for standardized response protocols. The differences observed in our study might be due to varying staffing levels, training, and workflow management practices across floors.

Limitations of the Study

Limitations of the study include the research period was conducted on a relatively short period, which might not fully represent long-term trend and variations of the response times. It also did not take into account external circumstances, such as peak admission times or any emergency situation, that would affect response times.

Strengths of the Study

This study has some remarkable strengths. The response time from multiple floors was examined in detail and the current study provided a detailed analysis on the discrepancies pertaining to performance in those. Quantitative data were used and, hence, provide for objective measurement and comparison. The multi-floor approach followed by this present study provides the overall picture dealing with the operational efficiency of the hospital.

CHAPTER 6

RECOMMENDATIONS

Based on the findings, recommend strategies to optimize hospital bell call response times, which may include:

-Adjust staffing during peak hours.

-Conduct training on the strategies for effective reaction of health professionals and the -timely care of patients.

-Implement cross-training opportunities so that staff can perform job duties outside their normal skill areas, lessening the reliance on specific roles during times of critical response.

-Reduce time required in making a bed to improve the efficiency of the flow of patients.

-Ensure that nurses are keeping records for both planned and unplanned discharge patients for better management.

CHAPTER 7

CONCLUSION

It produced the fact that the response time depends, varying from floor to floor, and hence requires some targeted improvements. The findings suggested that optimized staffing levels, regular trainings conducted, and better workflow management will result in satisfied response times. Improvements made have implications for better patient care, improved patient satisfaction, and reduced risk of adverse events. It means patients' requests are attended to in time, thus reducing the potential dangers of falling or experiencing a medical emergency, which again increases satisfaction rates and promotes better patient outcomes. Response times by nurses from 1 minutes to 17 minutes from one floor to another are therefore examples of variability that point out operational inefficiencies to tackle so as to create a safer, more reliable care environment.

The hospital has to decide on the following strategies to address these issues: manage the number of staff during peak hours, conduct efficient response protocol training regularly, and enhance workflow management by implementing streamlined processes and cross-training opportunities. Continuous monitoring and evaluation of the response times will help in regular improvement to be complemented by the enhancement in communication systems. The limitations of the study—relying on secondary data and the somewhat short study period—are balanced by one major strength: it provides an in-depth understanding of the discrepancies in response times between the floors. Future research is needed to examine long-term effects of these interventions along with further factors impacting response times, in order to develop more effective strategies that ensure enhanced care and increase patient satisfaction.

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