QUALITY IMPROVEMENT IN CRITICAL CARE AREAS USING THE LEAN SIX SIGMA APPROACH – A STUDY ON COMPLIANCE TO QUALITY INDICATORS, AT A TERTIARY CARE HOSPITAL IN DURGAPUR

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

Dr. Nabanita Mukherjee

Under the Supervision and Guidance of

Dr. J.P. Singh

2021

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STUDENT DECLARATION

DECLARATION BY STUDENT

I hereby declare that this dissertation titled **"Quality Improvement in Critical Care Areas using the Lean Six Sigma Approach – A study on compliance to quality indicators, at a tertiary care hospital in Durgapur"** 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 Information derived from the published or unpublished work of others has been duly acknowledged in the text.

Nabanita Mukherjee
(Signature)

Dr. Nabanita Mukherjee

Date: 19.06.2021

CERTIFICATE FROM THE ORGANIZATION

THE MISSION HOSPITAL DURGAPUR | FUTURISTIC TECHNOLOGY. BRILLIANT MINDS.

Ref: TMH/HRD/OG/June -21/ 19

Date: 21.06.2021

To Whom It May Concern

This is to certify that **Dr. Nabanita Mukherjee** has done her three months dissertation on "Quality Improvement in Critical Care Areas using the Lean Six Sigma Approach – A Study on compliance to Quality Indicators at The Mission Hospital, Durgapur" from 22.03.2021 to 21.06.2021.

During the period of dissertation she has been found sincere.

We wish her a successful future and career ahead.

Ramesh Lall
VP – HR

Dr. Partha Pal
Chief Medical Superintendent

Dr. Partha Pal
Chief Medical Superintendent
The Mission Hospital

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ABSTRACT

Background: An intensive care unit provides critical lifesaving care to patients who are severely sick or in a life-threatening situation. Because the ICUs provide sophisticated monitoring technology, a high level of medical competence, and continual access to highly trained nurses, ICU beds are an extremely expensive and rare resource. Quality control is crucial here, and quality indicators are used to track performance. Understanding these variables can aid in the improvement of patient care.

Rationale: To improve outcomes for patients and the health system as a whole, a method for monitoring and comparing the quality of services in different intensive care units is needed. As such, this study is done to understand the compliance of the nursing staffs working in the ICUs of The Mission Hospital, Durgapur, towards the quality indicators functional in its critical area areas using the Lean Six Sigma approach and studying the deviation between the knowledge and practice regarding the same among the nursing staffs working in different ICUs.

Materials and Methods: An observational cross-sectional study was done among the nursing staffs of different ICU wards, using google form questionnaire and checklists. Lean Six Sigma was used as a study tool. Situational Analysis was done through one-to-one survey and Retrospective data collection from Hospital Records. A sample size of 164 was considered using Convenience Sampling. And data analysis was done using Descriptive statistical tools like chi square analysis, using the SPSS version 28.0.0.0.

Results: An increase in the bed occupancy and average length of stay among the ICU patients was markedly observed. There was also an increase in the numbers of Hospital Acquired Infection Rates. The chi-square analysis revealed highly significant difference x^2 (3) = 18.0231, $p < 0.05$) and (x^2 (3) = 11.48, $p < 0.05$) in practice, among the nursing staffs with respect to the quality indicators based on their seniority level and number of trainings attended by them, respectively.

Conclusion: Infection management is crucial in determining the success of any ICU. Better infection prevention techniques are needed in the ICU, so as to lower the morbidity and mortality for the admitted patients Hospital quality indicators and the correct way to follow them, is necessary to deliver a quality healthcare service experience to the patients admitted in the critical care areas of the hospital.

Keywords: Critical care, infection control, quality indicators, Lean Six Sigma, Fish bone analysis, Pareto chart

ACKNOWLEDGEMENTS

The opportunity provided to do dissertation at The Mission Hospital, Durgapur was an enriching and valuable experience. I am highly obliged to have met so many experienced professionals who led me throughout my study period. I am sincerely grateful to all of them for sharing their honest and illuminating views on several aspects related to the project.

First and foremost, I would like to acknowledge **Dr. Partha Pal** (Chief Medical Superintendent) and **Dr. Tarakanath Taraphdar** (Assistant Medical superintendent) who inspired, guided and helped me to complete my project at their respected organization. I take this moment to recognize their contribution gratefully.
Secondly, I would like to thank my seniors in the Quality Department, who helped me have a clear approach regarding my project.

I would also like to thank the nursing staffs of all the ICUs in the hospital and the entire Infection Control team, whose support and participation was extremely crucial for the fulfilment of my project.

I am extremely thankful to my Guide and support **Dr. J.P. Singh** (Professor) for his constant guidance and support throughout the project duration. His valuable insights and suggestions helped me a lot in successful completion of my project.

I recognize this opportunity as a big milestone in the development of my career will strive to use the knowledge and skills gained in the best possible way

Lastly, I want to express my respects and love to my parents, for their constant encouragement and motivation in my higher studies.

Sincerely,
Dr. Nabanita Mukherjee

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ABBREVIATIONS

ALOS	Average Length of Stay	**IV**	Intra Venous
CAPA	Corrective Action and Preventive Action	**KPI**	Key Performance Indicators
CAUTI	Catheter Associated Urinary Tract Infection	**MICU**	Medical ICU
CCU	Critical Care Unit	**MO**	Medical Officers
CDC	Centre For Communicable Diseases	**NABH**	National Accreditation Board for Hospitals
CLABSI	Central Line Associated Blood Stream Infections	**NICU**	Neonatal ICU
COVID-19	Coronavirus Disease Of 2019	**OT**	Operation Theatre
DMAIC	Define, Measure, Analyse, Improve, Control	**PICU**	Paediatric ICU
EOL	End of Life	**PPE**	Personal Protective Equipment
HAI	Hospital Acquired Infection	**RTI**	Respiratory Tract Infection
HDU	High Dependency Unit	**SICU**	Surgical ICU
HMIS	Hospital Management Information System	**SIPOC**	Suppliers, Inputs, Process, Outputs, Consumers
ICU	Intensive Care Unit	**SSI**	Surgical Site Infection
IEC	Information Education Communication	**VAP**	Ventilator Associated Pneumonia
ITU	Intensive Thoracic Unit	**WHO**	World Health Organization

Quality Improvement in Critical Care Areas using the Lean Six Sigma approach – A study on compliance to quality indicators, at a tertiary care hospital in Durgapur

CHAPTER 1 - INTRODUCTION

An intensive care unit is a type of ward that can be found in most hospitals. It provides critical lifesaving care to patients who are severely sick or in a life-threatening situation[1]. Patients in critical care units require 24 hours medical care and attention, in order to sustain their body functions in normal condition. They may not be able to breathe on their own and may be suffering from multiple organ failure, so medical technology takes over these duties until they are able to recover. Because the ICUs provide sophisticated monitoring technology, a high level of medical competence, and continual access to highly trained nurses, ICU beds are an extremely expensive and rare resource[1]. For both the patient and his or her family, being in an intensive Care Unit can be a tough experience. The medical staffs in the ICUs are aware of this and are available to assist and support patients and their attendants during their treatment and stay in the unit.

Quality control is crucial in critical care units, and quality indicators are used to track performance. The differences in ICU outcomes between hospitals are likely related to differences in ICU design and treatment routes. Understanding these variables can aid in the reduction of variability and the improvement of patient care[1]. It takes a long time and money to care for critically ill patients[1]. To improve outcomes for patients and the health system as a whole, a method for monitoring and comparing the quality of services in different intensive care units is needed.

When we want to compare the quality aspect in any healthcare set up, NABH sets the benchmark. As such, this study is done to understand the compliance of the nursing staffs working in the ICUs of The Mission Hospital, Durgapur, towards the quality indicators functional in its critical area areas. Lean Six Sigma has become a widely implemented management tool and process improvement technique within the healthcare sector[1]. Lean Six Sigma uses lean methodologies to identify and remove waste, and then uses Six Sigma tools to reduce process variation. The Lean and Six Sigma (DMAIC) concepts combine to increase a process' overall efficiency by the detection of causes of deviations from the

optimal process, their removal, and, as a result, providing a complete process performance improvement[2].

In the one-to-one interviews with the staffs of critical care areas of The Mission Hospital, Durgapur, patients with increased length of stay and many cases of Hospital Acquired Infections, surfaced up as key issues. The Infection control team reported reduced compliance towards hygienic practices, among the staffs in the ICUs.

The quality of service in any ward in the hospital including the CCUs, largely depend upon the nursing staffs working there. Hence, the aim of this study is to study the compliance of the nursing staffs to quality indicators (NABH 5th edition) in the critical care areas of the hospital using the Lean Six Sigma approach. The study also aims to studying the deviation between the knowledge and the practice of different quality indicators in the ICUs, among the nursing staffs working there, using a survey-based approach.

1.1. Research Question –

1.1.1. What is the compliance of various quality indicators being measured for the quality assessment in the critical care areas of The Mission Hospital, Durgapur, and the main reasons for the outliers?

1.1.2. What is the difference in knowledge and practice towards various quality indicators in the critical care areas of the hospital, among the nursing staffs, according to various background characteristics?

1.2. Objectives:

1. To determine the compliance level to different quality indicators of the ICUs in the hospital. – *General Objective*
2. To study the gap between knowledge and practice among the nursing staffs of ICUs regarding compliance to the quality indicators. – *General Objective*
3. To study the secondary data obtained from the HMIS and analyse the trend shown for various quality indicators for the last 6 months. – *Specific Objective*
4. To identify reasons for non-compliance to quality indicators in the ICUs of the hospital. – *Specific Objective*
5. To identify key improvement areas for increasing the compliance level towards quality indicators in the ICUs of the hospital. – *Specific Objective*

➢ **Research Hypotheses**

- Null Hypotheses (H0): There is no difference in knowledge and practice towards various quality indicators in the critical care areas of the hospital, among the nursing staffs, according to various background characteristics.
- Alternate Hypotheses (H1): There is a difference in knowledge and practice towards various quality indicators in the critical care areas of the hospital, among the nursing staffs, according to various background characteristics

Quality indicators are measures of the healthcare quality in order to raise the standard of practice and provide a quality health service to the patient. The approach for a continuous quality improvement goes along with setting targets and benchmarks and comparing the quality indicators under each one of them. The various indicators of the critical care areas, considered for assessment against the set benchmark for this study are as follows:

1.3. Key Performance Indicators (KPIs)

1.3.1. Infection control Indicators:

- ICU specific Hospital Acquired Infection rate
- Compliance to hand hygiene practices among the medical staffs in various ICUs
- Compliance to biomedical waste management practices by the medical staffs among the ICUs

1.3.2. Human Resource Indicators:

- Nurse to patient ratio for ventilated and non-ventilated patients in the ICUs (per shift)

1.3.3. Quality and Policy indicators:

- ICU bed occupancy
- Average length of stay
- Number of adverse incidents in the ICUs
- Compliance to quality and policy standards

After assessing each of these quality indicators, a comparative trend analysis would help differentiate in the quality of service provided by each of these ICUs and identify the gaps and reasons for the possible non-compliance in various areas. Six sigma tools such as Cause-effect analysis and Pareto analysis would lead us to the specific causes of roadblocks in the quality assurance in the ICUs.

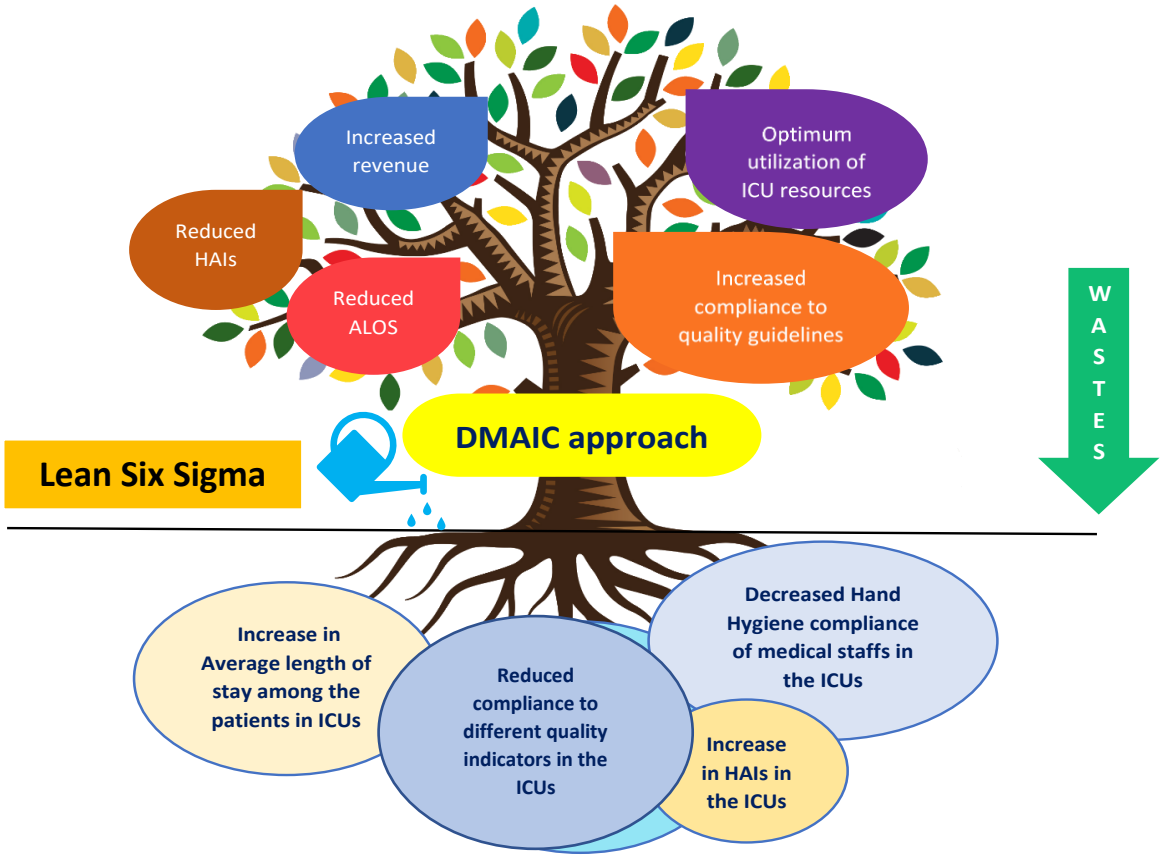


Figure 1 Problem Tree with Lean Six Sigma and DMAIC approach. Source and Credit: Self.

CHAPTER 2 - REVIEW OF LITERATURE

1. An Intervention to Decrease Catheter-Related Bloodstream Infections in the ICU[3]

Study Year: 2006	**Authors:** Peter Pronovost, Dale Needham, Sean Berenholtz, et. al.	
Sample Size: 103	**Location:** Michigan	

Salient Features: In Michigan, a collaborative cohort research was conducted in 103 ICUs. The incidence of catheter-related bloodstream infections was reduced using an evidence-based intervention. Infection rates were compared up to 18 months after the research intervention was implemented using multilevel Poisson regression modelling. At 3-month intervals, infection rates per 1000 catheter-days were measured. The mean rate per 1000 catheter-days reduced from 7.7 to 1.4 at 16 to 18 months of follow-up ($P<0.002$). The median rate of catheter-related bloodstream infection per 1000 catheter-days reduced from 2.7 to 0 at 3 months following implementation of the study intervention ($P<0.002$). This resulted in a large and sustained reduction (up to 66%) in rates of catheter-related bloodstream infection.

2. The Effect of Multidisciplinary Care Teams on Intensive Care Unit Mortality[4]

Study Year: 2010	**Authors:** Michelle M. Kim, Amber E. Barnato, Derek Angus, et. al.	
Sample Size: 169	**Location:** Pennsylvania	

Salient Features: A statewide hospital organizational survey was linked to hospital discharge data to undertake a population-based retrospective cohort analysis of medical patients admitted to Pennsylvania acute care hospitals (N=169) from July 1, 2004, to June 30, 2006. The significant link between daily multidisciplinary rounds and 30-day mortality was established using multivariate regression model. The final analysis covered 112 hospitals and 107324 patients in total. The overall 30-day mortality rate was seen to be 18.3%. Multidisciplinary treatment was related with significant decreases in the risk of death after adjusting for patient and hospital variables (odds ratio, 0.84; 95 percent confidence interval [CI], 0.76-0.93 [P=.001]).

3. Hospital mortality rate i.r.t. staff workload: a four-year study in an adult ICU[5]

Study Year: 2000	**Authors:** A J Shearer, C Hau, Tarnow-Mordi,	
Sample Size: 1050	**Location:** United Kingdom	

Salient Features: For patient admissions during the year 1992-1995, those who complied with the mortality risk adjustment by the APACHE II equation, they were evaluated on the basis of shifts as per their workload in the ICU. One observer validated the APACHE II results. During each patient's stay, the workload was measured by the ratio of occupied to suitably staffed beds, as well as the total ICU nursing requirements. The APACHE II equation predicted 337 deaths, but there were 49 more. The median occupancy of beds was 5.8, and the median nursing hours per patient was 1.6. Adjusted mortality rate was observed to have increased with the ratio of occupied beds to beds with more number of staffs throughout the stay for every patient, after nurse necessity measures were removed.

4. Effectiveness of a hospital-wide programme to improve compliance with hand hygiene[6]

Study Year: 2000	**Authors:** Didier Pittet, Stéphane Hugonnet, Stephan Harbarth	
Sample Size: 20000	**Location:** Switzerland	

Salient Features: Before and after the implementation of a hand-hygiene programme, the average compliance with hand hygiene during regular patient care in a teaching hospital in Geneva, Switzerland was observed. From December 1994 to December 1997, seven hospital-wide observational surveys were conducted twice a year. More than 20000 opportunities for hand hygiene were considered in the study. From 48 percent in 1994 to 66 percent in 1997, compliance improved steadily. Between 1993 and 1998, overall nosocomial infection reduced, MRSA transmission rates fell, while alcohol-based hand rub solution usage grew every 1000 patient-days. The campaign resulted in a sustained increase in hand hygiene compliance, as well as a decrease in nosocomial infections and MRSA transmission.

5. Improving Communication in the ICU Using Daily Goals[7]

Study Year: 2003	**Authors:** Peter Pronovost, Sean Berenholtz, Todd Dorman	
Sample Size: 50 ICU	**Location:** U.S.A.	

Salient Features: In a 16-bed surgical oncology ICU, a prospective cohort research was conducted in which all patients admitted to the intensive care unit (ICU) were eligible. ICU length of stay (LOS) and the percentage of ICU residents and nurses who understood the ICU's goals of care were the main outcome variables. At the start of the study, only around 10% of residents and nurses knew what the day's goals of care were. More than 95 percent

of nurses and residents understood the day's goals of care after using the daily goals form. The average length of stay in the intensive care unit (ICU) reduced from 2.2 to 1.1 days.

6. The WHO Clean Care is Safer Care programme: Field-testing to enhance sustainability and spread of hand hygiene improvements[8]

Study Year: 2008	**Authors:** Didier Pittet, B. Allegranzi, Julie Storr	
Sample Size: NA	**Location:** Switzerland	

Salient Features: In its three years of existence, the First Global Patient Safety Challenge has gained great traction, partly due to the mobilization of countries, healthcare executives, patients and patient organizations, and technical specialists to support the initiative through effective action. There is a widespread growth of the use of system change to improve hand hygiene. As research into the worldwide burden of disease caused by HAI advances, it will be possible to track the impact of programs like Clean Care is Safer Care on HAI more precisely.

7. The present use of quality indicators in the intensive care unit[9]

Study Year: 2012	**Authors:** H. Flaatten	
Sample Size: 26 QIs	**Location:** Netherlands, India, Germany	

Salient Features: There were 63 different QIs in use, and no single indication was used by all countries. The standardised mortality rate was the most commonly used indicator in 6 out of 8 countries. Using national QIs to assess the quality of intensive care between nations is currently problematic due to a range of 47 percent to 86 percent. The findings clearly revealed that the concept of quality in the ICU is seen differently in different countries. The profile of QIs chosen differs as well.

8. ICU Nurse to Patient Ratio is associated with complication and resource use after esophagectomy[10]

Study Year: 2000	**Authors:** R K Amaravadi, J B Dimick, P J Pronovost, et. al.	
Sample Size: 366	**Location:** Maryland	

Salient Features: The relation of NNPR with patient mortality, ALOS, hospital expenditure, and specific surgical problems was determined using a multivariate type analysis adjusted for case mix, hospital, and surgeon volume. A NNPR of 1:2 was related with a 39 percent increase in the median ALOS and a 32 percent rise in expenditures. In patients following oesophageal resection, a nurse caring for more than two ICU patients at

night increases the likelihood of various postoperative respiratory and infectious problems, as well as higher resource consumption.

9. Quality Indicators Compliance Survey in Indian Intensive Care Units[11]

Study Year: 2017	**Authors:** Munta Kartik, Palepu B. N. Gopal, Rahul Amte	
Sample Size: 400	**Location:** India	

Salient Features: In this study, the percentage of compliance to several quality indicators in ICU were studied. 400 responses were collected through questionnaires and were analysed accordingly. Infection control measures, ICU-acquired infections, and quality and policy measures all showed promising results. EOL care pathways and ICU nurse staffing both required some improvement. In ICUs, there are a few areas were identified that needed improvement like, ICU discharge timings, standardized mortality ratio monitoring, and multidisciplinary rounds.

10. Physician Staffing Patterns and Clinical Outcomes in Critically Ill Patients[12]

Study Year: 2002	**Authors:** Peter J. Pronovost, Derek Angus, Todd Dorman, et. al.	
Sample Size: 1050	**Location:** Worldwide	

Salient Features: Critically ill adults and children were chosen for randomized and observational controlled studies. ICU attending physician staffing techniques were studied, as well as the outcomes of hospital and ICU mortality and length of stay (LOS). In 16 of 17 trials (94 percent), high-intensity staffing was linked to lower hospital mortality, with a pooled estimate of the relative risk for hospital mortality of 0.71. It also resulted in a significant decrease in the length of stay. As a result, high-intensity vs. low-intensity ICU physician staffing is linked to lower hospital and ICU mortality, as well as shorter hospital and ICU lengths of stay.

CHAPTER 3 - METHODOLOGY

3.1. Material and Methods –

***Study design*:** Observational Cross-Sectional Study

***Study population*:** Patients and Nursing staffs in the critical care areas of The Mission Hospital, Durgapur

***Study period*:** April 2021 – June 2021

***Period of data analysed*:** December 2020 – May 2021 (6 months)

***Study tools*:** Structured Closed-ended Questionnaires and Checklists

***Six Sigma tools*:** Lean Six Sigma tools – Chi square test

DMAIC tools (Define, Measure, Analyse, Improve and Control)

Project Charter, SIPOC diagram, Fish bone diagram, Pareto chart, Kaizen 5S tools

Research Approach – Quantitative

***Data Collection Methods*:**

- Situational Analysis through one-to-one survey.
- Retrospective data collection from Hospital Records.

Primary data

- Direct Questionnaires to nursing staffs in the ICUs using google forms.
- Collection of data from quality indicators checklists

Secondary Data

- ICU Records - Patient files and registers
- HMIS data (6 months)

Sampling Method: Convenience Sampling

Sample Size: 164 (out of total 225 nursing staffs in the critical care units)

- Inclusion criteria: Nursing Staffs working and patients admitted in the critical care areas i.e., MICU, CCU, ITU, SICU, HDU, NICU and PICU.
- Exclusion criteria:

- Staffs who were not available or not willing to participate in the survey.
- All other nursing staffs and patients except mentioned in the inclusion criteria.

*Limitation – Due to the ongoing COVID surge in the Hospital during the study period, many of the nursing staffs working in the ICUs could not participate in the survey because of being on leave or in isolation for covid infection. As such, a sum total of 164 staffs out of 225 could be interviewed for the study.

***Ethical Considerations*:**

- Data confidentiality has been maintained throughout the study.
- The staff details and their respective departments have been kept confidential.
- The information collected would be shared for dissertation purpose only.
- No one was forced to participate in the study.
- Consent was taken from every respondent.

***Data Analysis*:** Descriptive statistical tools like chi square analysis, using the SPSS version 28.0.0.0.

***Data Representation*:** Charts and graphs using MS Excel.

Once the data was collected and compiled, a trend analysis was done for each of the quality indicators to taking internal targets as benchmarks for standardising the results. The areas of deviation were analysed and outliers were identified to understand the cause for their specific occurrence. Hypotheses testing was done using the chi square analysis to understand the gap in compliance to different quality indicators. The survey answers were grouped into good and poor based on the marks distribution, with respect to both knowledge and practice.

Category of response	Percentage of Marks obtained
Good	60% and above
Poor	Below 60%

Interaction with the different ICU heads and coordinators was done to identify the reason behind the non-compliance and occurrence of the outliers. The reasons were then analysed using Fish bone diagram and Pareto chart to understand the root cause and the ICU presenting with maximum outliers, in order to recommend key improvement strategies.

CHAPTER 4 - RESULTS

4.1. Define Phase

Table 1 Project Charter for the Proposed Research Project in the ICUs of The Mission Hospital, Durgapur

<table>
<tr><td colspan="2">Problem Statement
There is a decreased compliance to quality indicators among the medical staffs of the critical care areas in The Mission Hospital, Durgapur.</td><td>Stakeholder Needs
Increase in the hospital revenue.
Availability of hospital resources and its optimum utilization.</td></tr>
<tr><td colspan="2">Project Title
Analysing the compliance to quality indicators among the medical staffs of the critical care areas in a tertiary care hospital in Durgapur - a DMAIC approach</td><td>Project Goals
Increased Revenue and availability of hospital resources.
Decreased incidences of HAIs
Decreased Average length of stay for the patients admitted in ICUs
Increased compliance to NABH quality guidelines.</td></tr>
<tr><td>Estimated Cost Saving
To increase the bed availability by 20% and increase hospital revenue by 35%.
To increase patient footfalls by increasing the patient satisfaction by reducing their average length of stay.</td><td>Key Actions
Develop a fish bone (Ishikawa) diagram
Develop data collection plan
Do pareto analysis
Identify KPIs
Define standards and indicators (NABH)</td><td>Barriers
Non-compliance by the medical staffs in ICUs.
Improper record keeping.
Inadequate knowledge about NABH quality guidelines.</td></tr>
<tr><td colspan="3">Scope of the project
Identifying the key improvement areas for increasing the compliance level of the medical staffs towards quality indicators in the ICUs of the hospital, in order to increase the quality of services being delivered to the patients.</td></tr>
<tr><td colspan="3">Project Timeline</td></tr>
<tr><td>Define</td><td>Identification of the problem area in the ICUs
Developing tools for data collection</td><td>1 week</td></tr>
<tr><td>Measure</td><td>Collection of data through patient checklist
Conducting ICU staff questionnaire
Conducting Document Audit
Collection of data from registers and patient files
Collection of data in the ICU matrix
Collection of data from Infection Control Department</td><td>8 weeks</td></tr>
<tr><td>Analyse</td><td>Analysis of data from all the ICUs of the hospital
Analysis of data from patient files and registers of the ICUs for the past 6 months</td><td>2 weeks</td></tr>
<tr><td>Improve</td><td>Data Interpretation and Representation
Designing solutions and proposals</td><td>1 week</td></tr>
<tr><td>Control</td><td>Approval of Proposed Solutions</td><td>1 week</td></tr>
</table>

In this phase, the six ICUs of the hospital i.e., 2 MICUs, 2 CCUs, 1 ITU, 1 HDU, 1 PICU and 1 NICU, were closely monitored and problems were identified meeting with the important stakeholders. The problem statements were defined and a project charter was made.

Following this, the study tools were developed. A questionnaire was prepared to understand the compliance level of the medical staffs to the quality indicators in the ICU and checklists were formed for doing the trend analysis for different quality parameters over the past 6 months from the study. The survey was conducted through google forms that were circulated among the 225 nursing staffs of the critical care areas. An e-consent form was also used for ethical considerations. The form collected responses over the period of April and May 2021. The questionnaire was divided into 2 sections, namely the infection control indicators and the quality and policy indicators. The questions were based on both the knowledge and practice of the medical staffs during their shifts in the ICUs. Secondly, the checklists were filled by each ICU ward on daily basis for six months i.e., from December 2020 to May 2021, for the purpose of the trend analysis.

Furthermore, a SIPOC diagram was developed to understand the patient handling process in the critical care areas, to identify areas of gaps and non-compliance to various quality indicators.

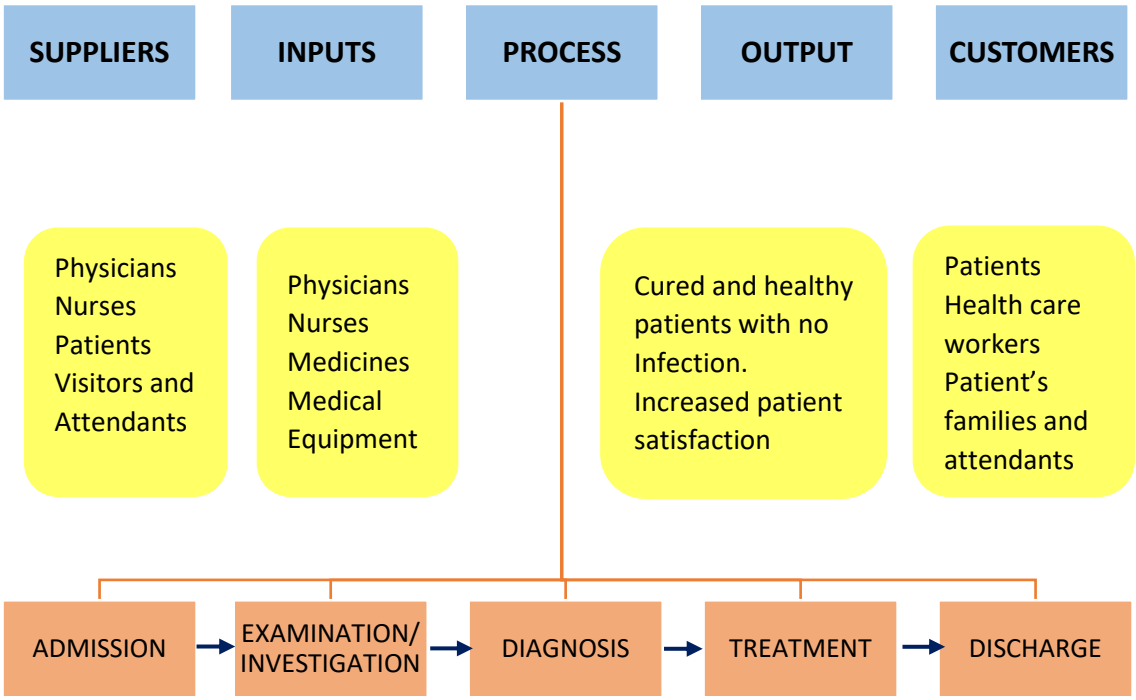


Figure 2 SIPOC Diagram – Patient Handling Process in the Critical Care Areas. Source and Credit. Self

From the above SIPOC diagram, the areas where the issues originate are mainly in the Input sector and between the duration of treatment and discharge. The elements of issues were strictly analysed with reference to non-compliance to the quality indicators considered for the study.

4.2. Measure Phase:

4.2.1. Trend Analysis of Bed Occupancy in the critical care areas for last 6 months

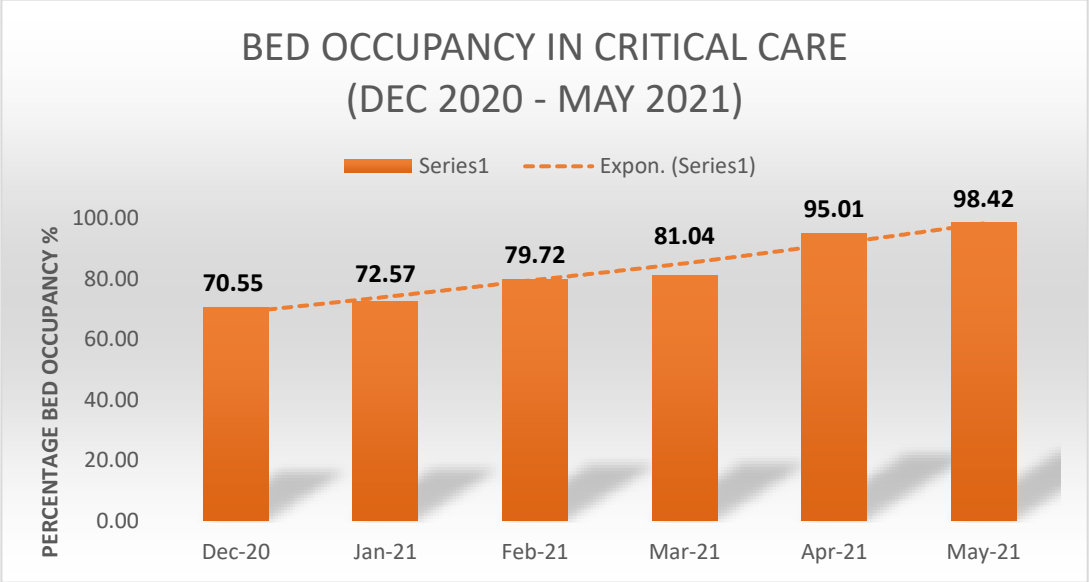


Figure 3 Bed Occupancy Rate in the Critical Care Areas from December 2020 to May 2021. Source. The Mission Hospital. Credit. Self

The day-to-day performance data on the patients admitted in the different critical care areas of the hospital for a retrospective period of 6 months, revealed a steady increase in the bed occupancy from December 2020 to May 2021, and there is a marked increase from February 2021 to April 2021. The reason attributed to this increase is the surge of covid positive patients in the hospital and increased admission of patients in the critical care areas seeking prolonged medical care. The highest bed occupancy rate was seen in the month of May 2021, since the COVID-19 critical cases were at its peak during this period.

Decreased ICU bed availability might have a negative impact on hospital-wide patient turnover, particularly in the Emergency department and postsurgical care departments, as well as increased critical-care patient deaths due to long wait periods for ICU bed allocation. Unit extension, adjustment of triage procedures, and targeted attempts to reduce throughput delays are all strategies for managing capacity strain.

4.2.2. Trend Analysis for the Average Length of Stay for patients in the critical care areas for the last 6 months.

The Average Length of stay was observed to be about 6 days in December 2020, which deceased to 3 days in February 2021, that steadily increased to five and a half days in May 2021. A marked increase in the ALOS was seen during the month of

April and May 2021. The reason to this increased ALOS could be attributed to the fact that, few of the ICUs were converted into COVID isolation wards and the increased demand for critical care for moderate to severe cases of COVID pneumonia. Extended hospital stays in intensive care units are expensive and have a negative impact on patients, their families, and the economy of the hospital. In addition, the amount of time spent in the ICU has an impact on mortality. The fundamental goal in intensive care is to reduce length of stay and expense in order to improve the quality of healthcare services.

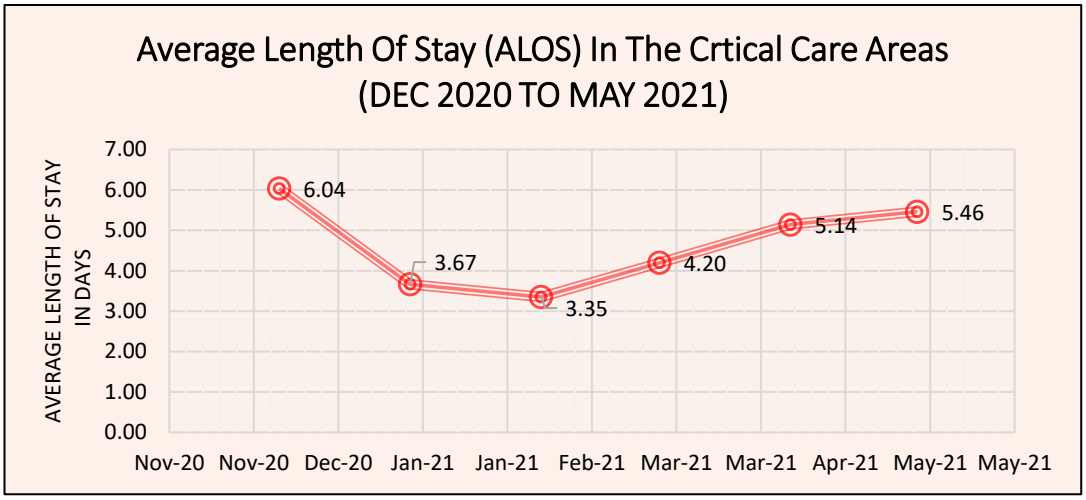


Figure 4 Average Length of Stay (ALOS) in the critical care areas from December 2020 to May 2021. Source. The Mission Hospital. Credit. Self.

4.2.3. Trend Analysis for the Hospital Acquired Infection Rates in the Critical care areas for the last 6 months

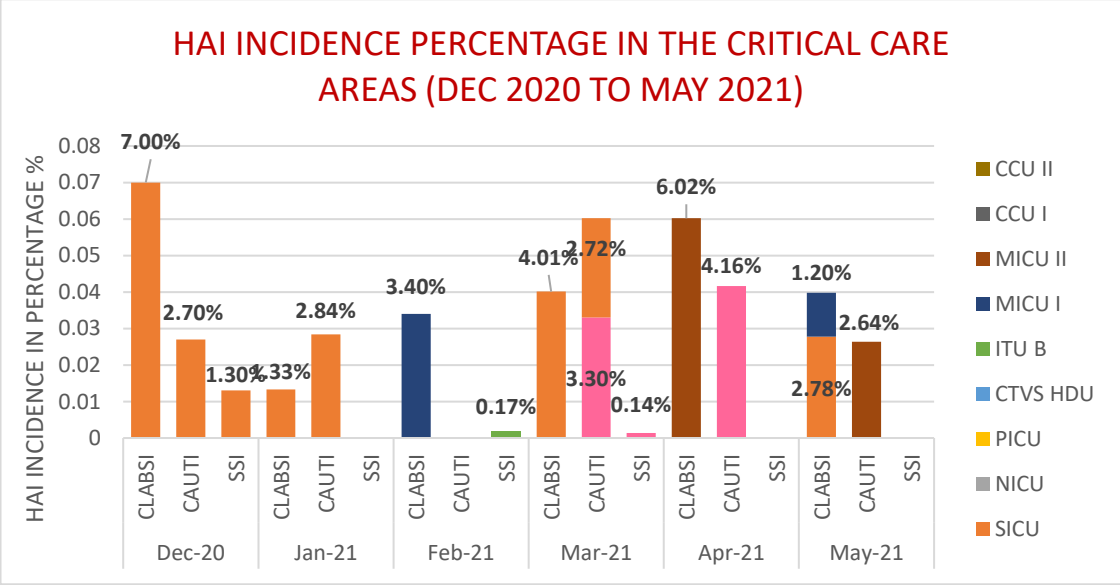


Figure 5 Hospital Acquired Infection Rates in the Critical Care areas from December 2020 to May 2021. Source. The Mission Hospital. Credit. Self

The Hospital Acquired infections that were most commonly seen in the ICUs of the Mission Hospital, Durgapur were, Central Line Associated Blood Stream Infections (CLABSI), Catheter Associated Urinary Tract Infections (CAUTI) and Surgical Site Infection (SSI). The Surgical ICU attributed to most of the HAI incidences in the Hospital, followed by MICU – 1, MICU – 2 and HDU.

The table below compares the Frequency of the HAI occurring in the critical care areas versus the set NABH benchmark.

Table 2 Frequency of different Hospital Acquired Infections in the ICUs of the hospital against the NABH benchmark

Hospital Acquired Infection	Actual Frequency	Benchmark
Central Line Associated Blood Stream Infections (CLABSI)	4.5%	1%
Catheter Associated Urinary Tract Infections (CAUTI)	5.5%	3%
Surgical Site Infection (SSI)	0.9%	0%
Respiratory Tract Infection	0%	2%
Ventilator Associated Pneumonia (VAP)	0%	0%
Skin Infections	0%	0%

HAI could be caused by a number of potential factors:

- Basic infection control practices are not well followed.
- Excess crowding of patients at the hospital.
- The implementation of hospital policies and the procedures followed are not well regulated.
- Lack of awareness about safety practices during blood transfusion procedures.
- Blood and fluid exposure, and Needle stick injuries.
- Improper sanitation in the hospital environment and waste disposal system.
- Hospital staffs exhibiting poor compliance towards hand hygiene.

Factors that contribute to healthcare staffs' low compliance to hand hygiene practices:

- Lack of awareness about hospital quality and policy standards
- Busy schedule of the nursing staffs or patient overload.

- Improper positioning or inadequate quantity of the sinks in the working areas.
- Scarcity or unavailability of hand washing soaps and/or towels.
- Understaffing or overstaffing of nurses in the wards.
- There is a lack of direct evidence-based study on the influence of better hand hygiene on the rate of hospital acquired infections.
- Gloves are often misunderstood that they decrease the need for hand washing.

4.2.4. Trend Analysis for the Incidence of Adverse events occurring in the Critical Care Areas for the last 6 months

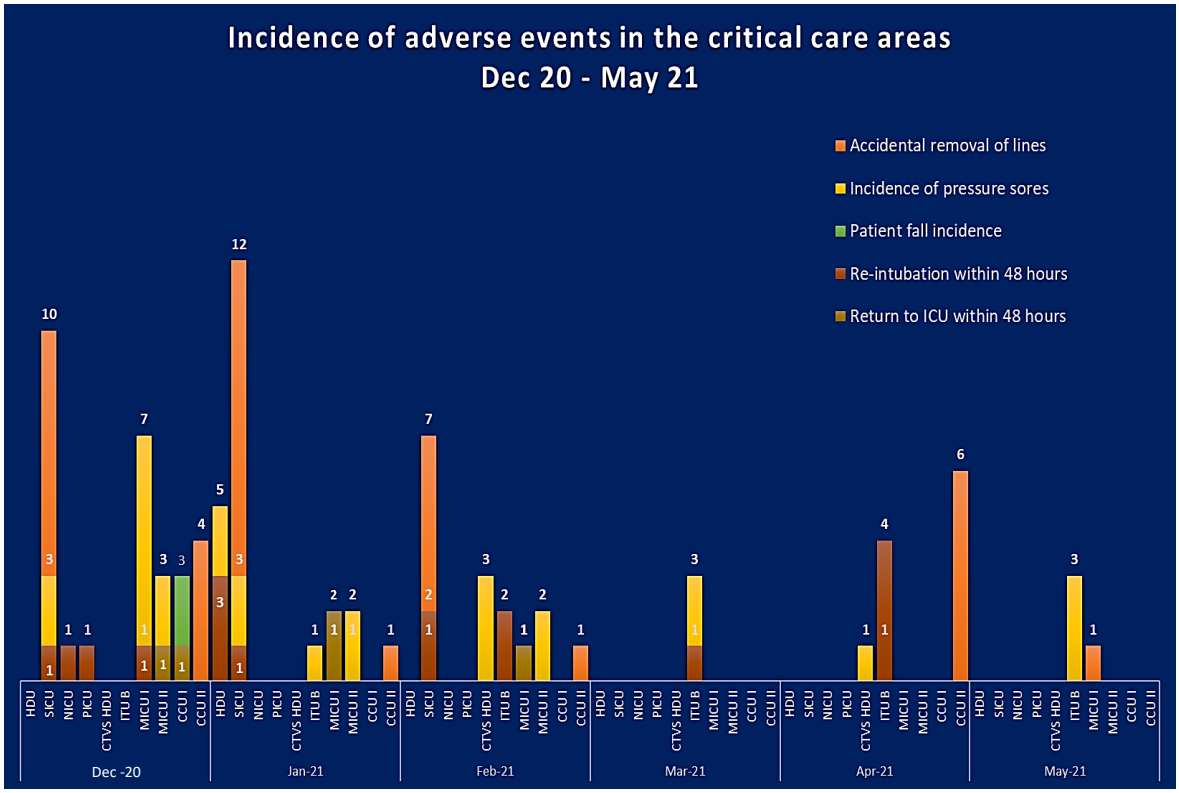


Figure 6 Incidence of adverse events in the critical care areas of the hospital from December 2020 to May 2021. Source. The Mission Hospital. Credit. Self

Treatment, procedure, ordering or carrying out pharmaceutical orders, reporting or communication, and failures to take precautions or follow protocols are all common ICU errors. Because of the severity of their medical problems, the complexity of their therapies, polypharmacy, and technology-based interventions, critically ill patients are at a significant risk of complications. Almost all ICU patients experience potentially hazardous events, and nearly half (45%) of these occurrences are avoidable.

The highest incidence of an adverse event is reported in the month of December 2020 and January 2021 from the Surgical ICU. There were as many as 10 incidents of Accidental removal of lines in the SICU in the month of December last year, followed by 12 incidents of the same in the month of January this year. Incidence of Pressure sores are high in the MICU – 1 during the month of December 2020. There were only 3 incidences of patient fall in the month of December reported in the CCU – 1, and no further incidents till date. The cases of Re-intubation within 48 hours were seen in HDU (3) January 2021 and ITU-B (4) in April 2021. Incidences of Return to ICU within 48 hours were seen in a less number in CCU -1 (1) and MICU – 1 (1) during the month of January 2021 and February 2021 respectively.

4.2.5. Nurse to Patient Ratio in the critical care areas for the last six months

The nurses in the critical care areas are posted in a rotational basis, with respect to a duty roaster assigned by the nursing in charge, and the extra nursing staffs are called on need basis.

The nurse-to-patient ratios maintained in the critical care areas is as per NABH standards, i.e., 1:1 for ventilated patients and 1:2 or 1:3 for non-ventilated patients.

A typical shift wise nursing staff distribution in the ICUs of the hospital:

Table 3 Distribution of Nurses according to their shifts in the critical care areas of the Hospital

WARDS	MORNING SHIFT			EVENING SHIFT					NIGHT SHIFT			STAFF ABSENT	DAY OFF	LEAVE	TOTAL STAFF
	T PT		TOTAL STAFF	T PT		ACTUAL STAFF	EXTRA SHIFT	TOTAL STAFF	T PT		TOTAL STAFF				
	VENT+ BIPAP	NON-VENT		VENT+ BIPAP	NON-VENT				VENT+ BIPAP	NON-VENT					
MICU-I			12			8	4	12			12				49
MICU-2			6			5	1	6			6				25
CCU-I			6			4	1	5			5				23
CCU-II			6			3	3	6			5				23
C/S HDU			4			2	1	3			5				15
CTVS ITU-B			6			5	2	7			6				22
NICU			2			2	2	4			2				22
PICU			3			3	0	3			3				11
HDU			5			3	2	5			4				20
SICU			7			3	3	6			6				23
TOTAL			57			38	19	57			54				225

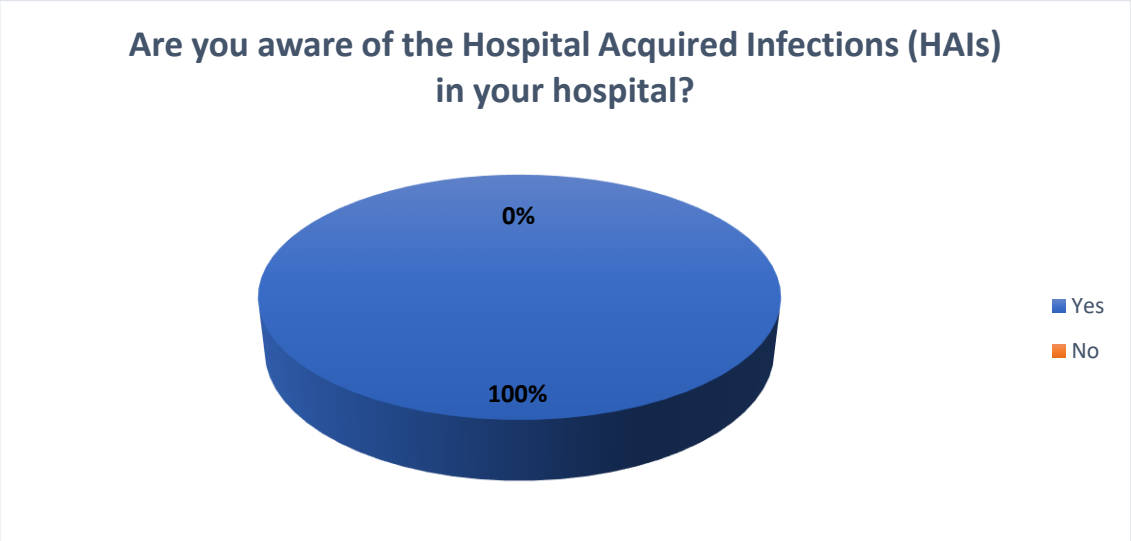
4.2.6. Results from survey

A sum total of 164 responses (73% of total staffs) were collected from the different critical areas of the hospital. The distribution of the sample from various ICUs are as follows:

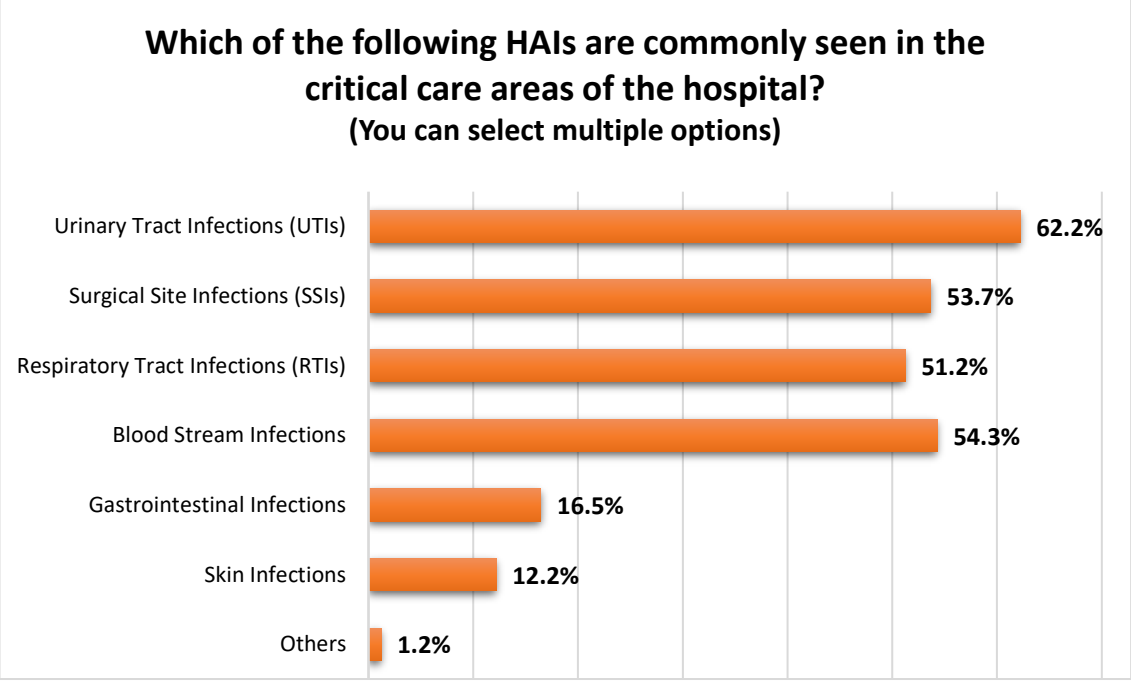
Table 4 Distribution of responses collected in the survey from each ICU ward

DEPT.	HDU	SICU	NICU	PICU	C/S HDU	ITU B	MICU I	MICU II	CCU I	CCU II	TOTAL
No. of Responses	18	16	12	7	11	15	34	18	17	16	164

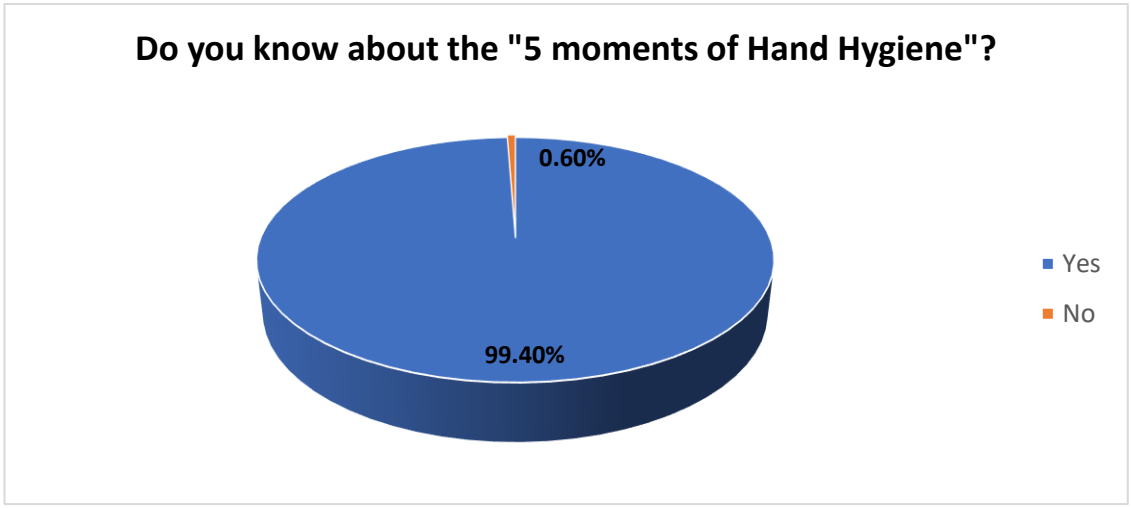
Questions on Infection Control



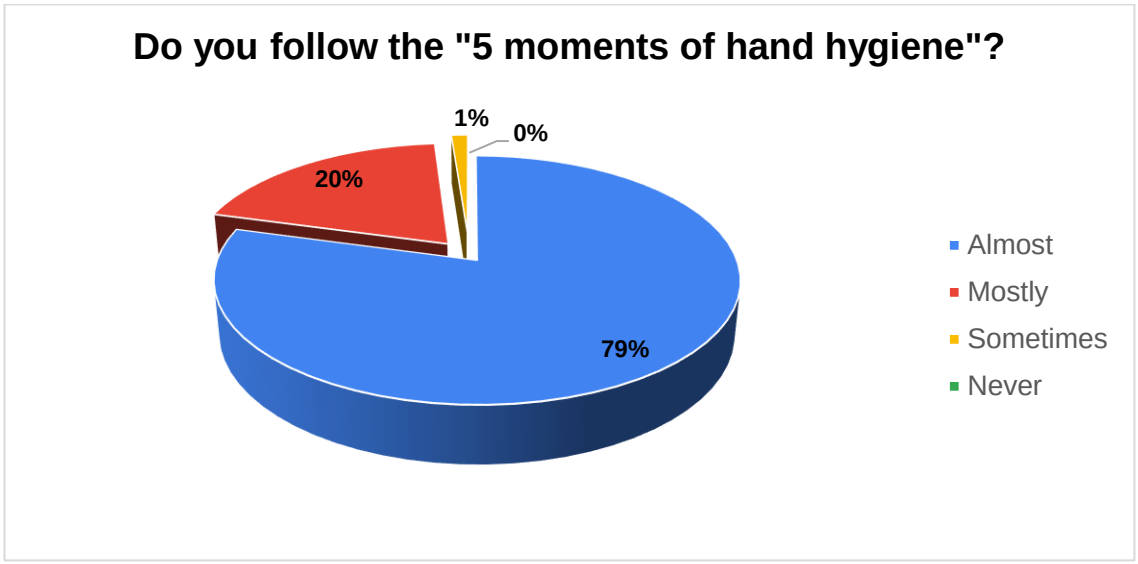
Out of the 164 respondents, everyone i.e., almost 100% of the respondents were aware of the Hospital Acquired Infections (HAIs) occurring in the different ICUs of the hospital.



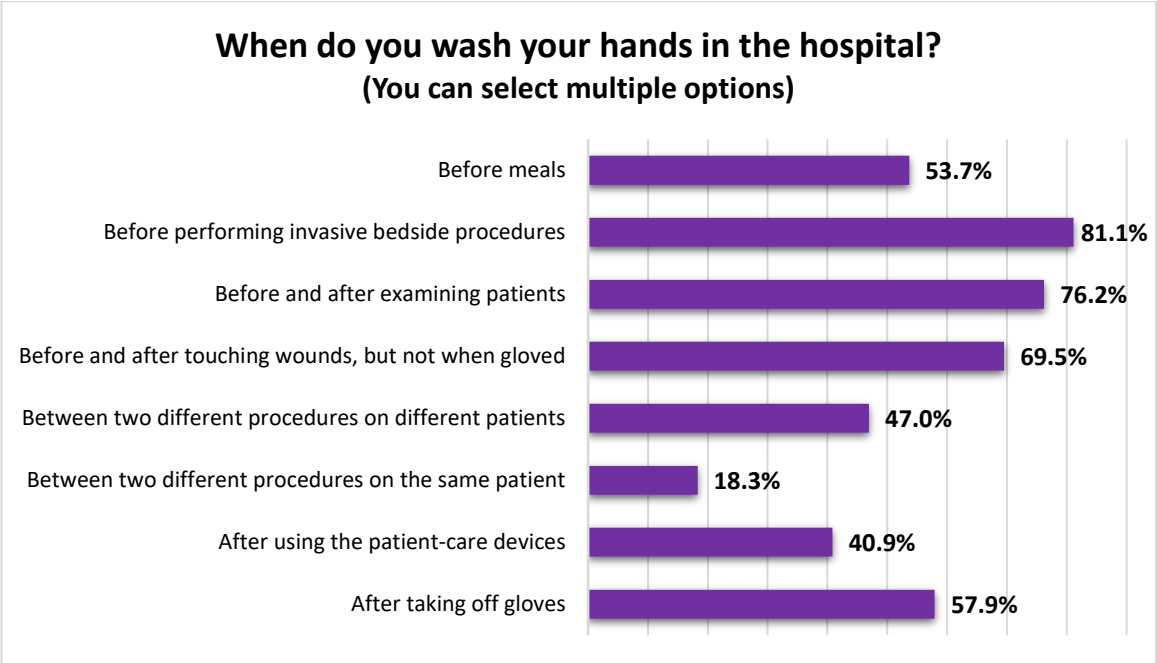
The graph above shows the response of the nursing staffs on prevalence of the different HAIs in the ICUs. Almost 62% of the respondents selected UTI as the most prevalent HAI, around 53% selected SSI, and as much as 89% of them selected Blood stream infections, followed by 84% selecting RTIs as the most prevalent one. Rest of them i.e., around 20% respondents, selected Gastrointestinal and Skin infections to be a commonly seen HAI.



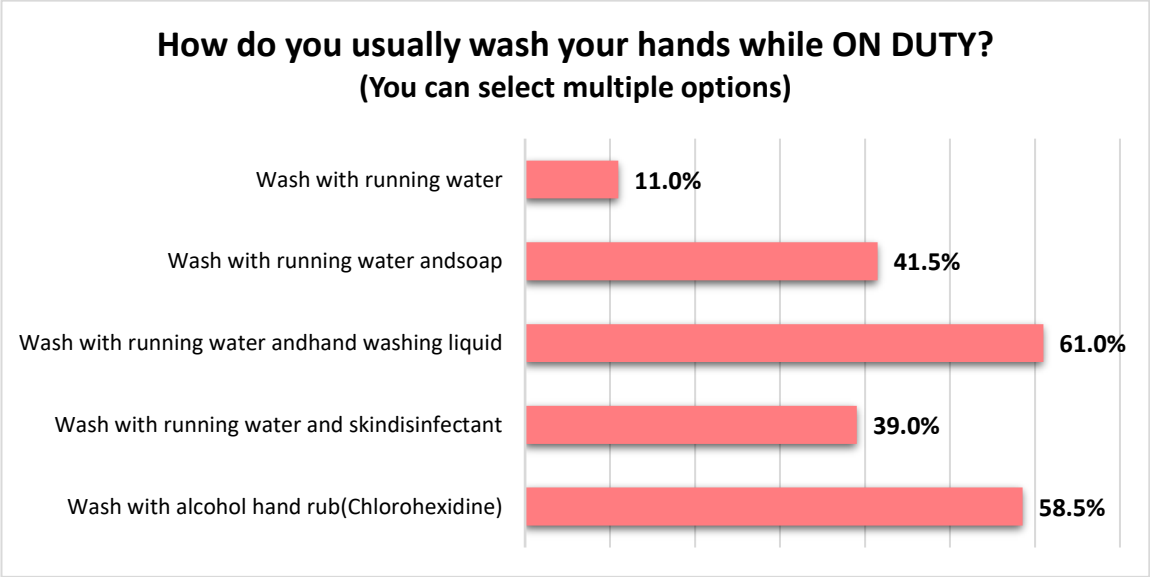
As many as 99% of the respondents were aware of the 5 moments of hand hygiene that should be followed in the critical care areas of the hospital, whereas only 1% were not aware of the same.



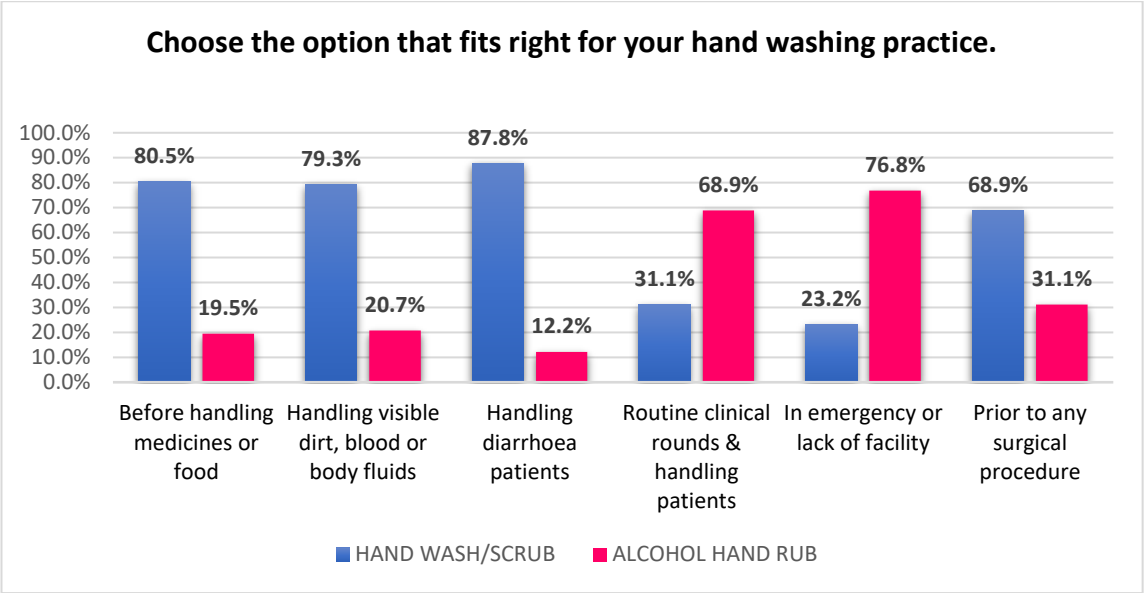
As many as 79% of the respondents accepted to be following the 5 moments of hand hygiene during their daily duty hours in the critical care areas of the hospital. 20% of them followed it mostly and only 1 % accepted to be practicing the same sometimes.



In the graph shown above, as many as 53% respondents accepted to wash their hands before meals, 81% did hand washing before performing invasive bedside procedures, and 76% washed their hands before examining the patients. Additionally, 47% respondents washed their hands between two different procedures on different patients, whereas 18% practiced the same in between procedures on the same patient. Lastly, around 41% washed their hands after using patient care devices, and 59% practiced hand washing after taking off their gloves.

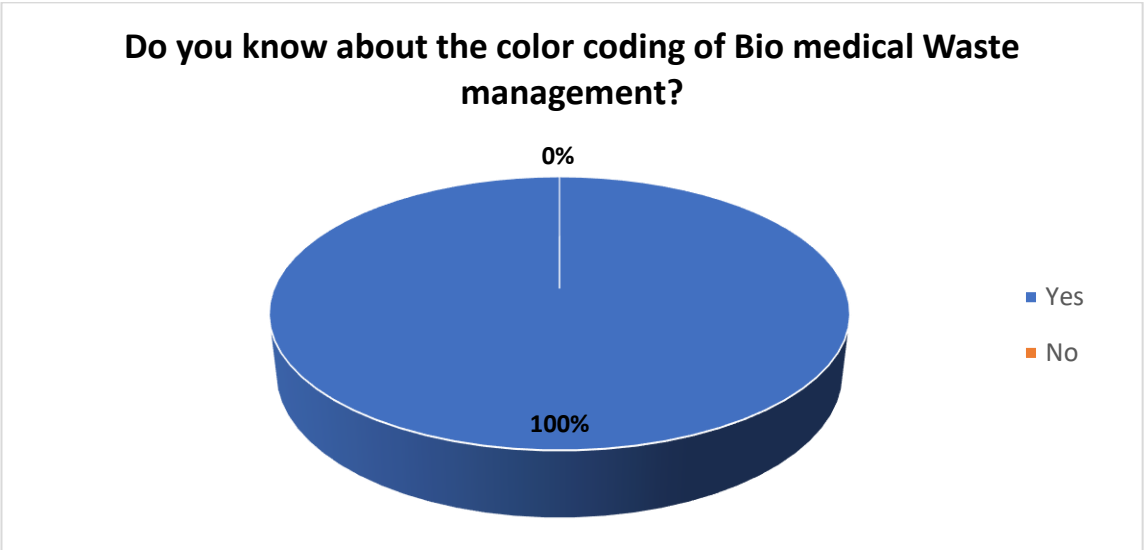


As per the graph shown above, only 11% of the respondents washed their hands with just running water. 42% used soap with running water to wash their hands. 61% of them used hand washing liquid instead of soap, whereas 39% used skin disinfectant. Lastly, as many as 59% used alcohol rubs like chlorohexidine to wash their hands.

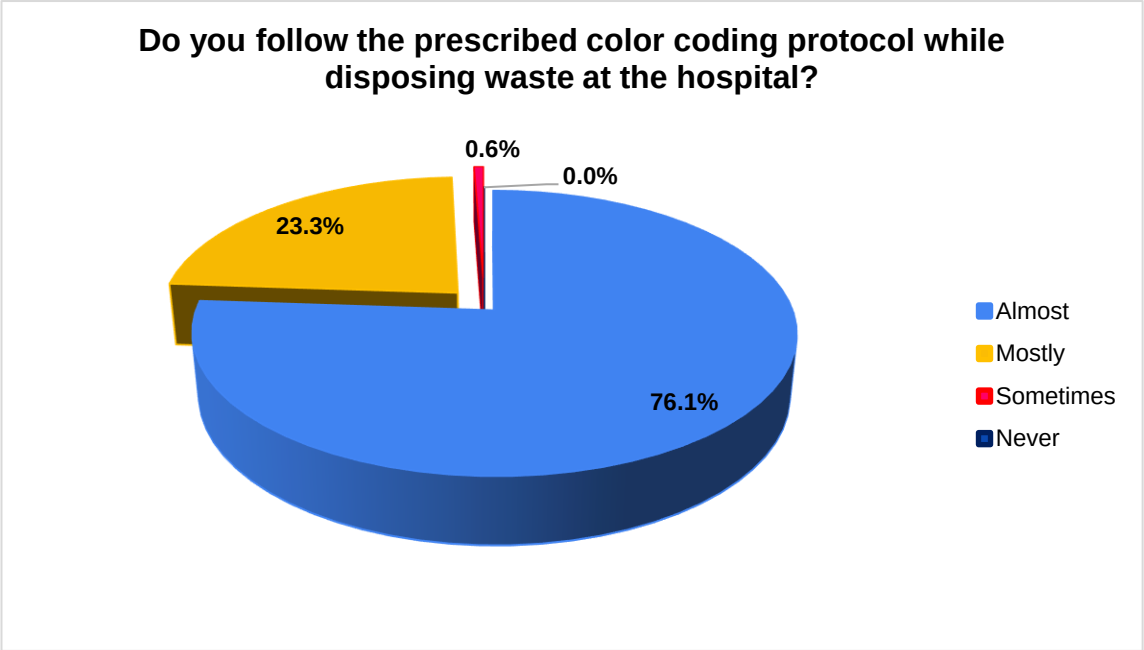


As per the graph above, 81% of the respondents did hand wash before handling medicines or food, and rest 19% used alcohol hand rub for the same. Furthermore, 79% of the respondents did hand wash after handling visible dirt, blood or body fluids, while 21% of them used alcohol hand rub in such scenario. Moving ahead, 88% of the respondents washed their hands after handling diarrhoea patients and rest 12% used alcohol hand rub for the same. In the next question, 31% of the respondents did hand washing practice during routine clinical rounds, while 69% cleaned their hands with alcohol hand rub for the same. Then, 23% used hand wash in case of emergency or lack of facility whereas, as many as 77% used alcohol hand rub in such case. Lastly, 69% used hand washing practice prior to any surgical procedure and rest 31% preferred using alcohol hand rub.

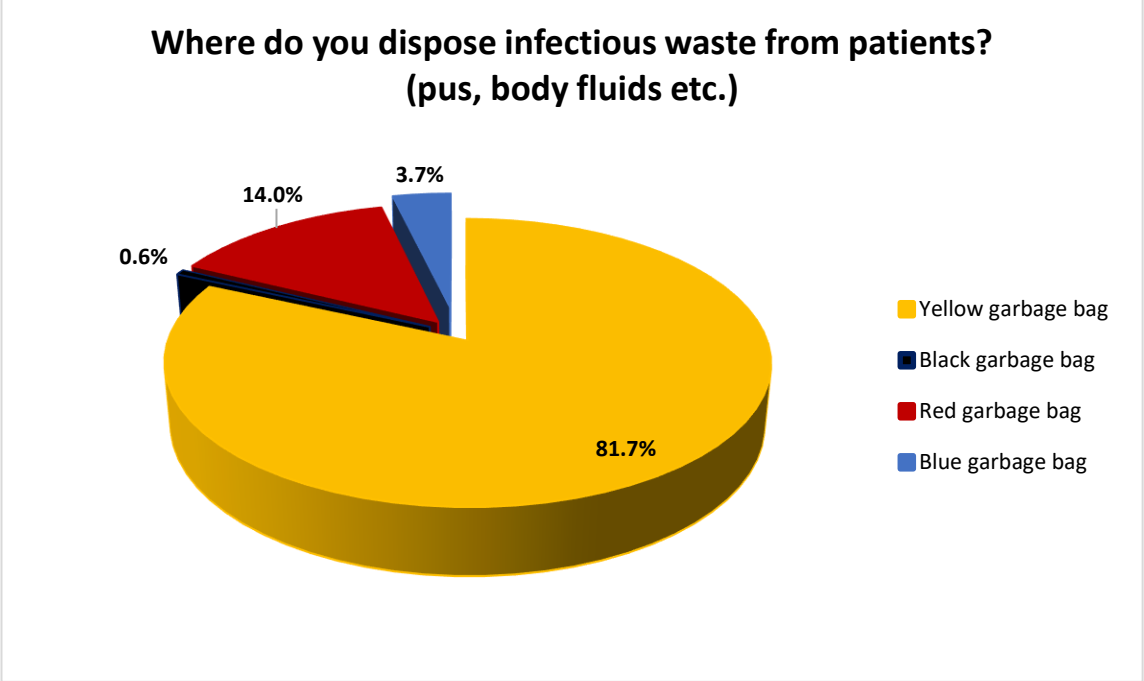
Questions On Bio-Medical Waste Management



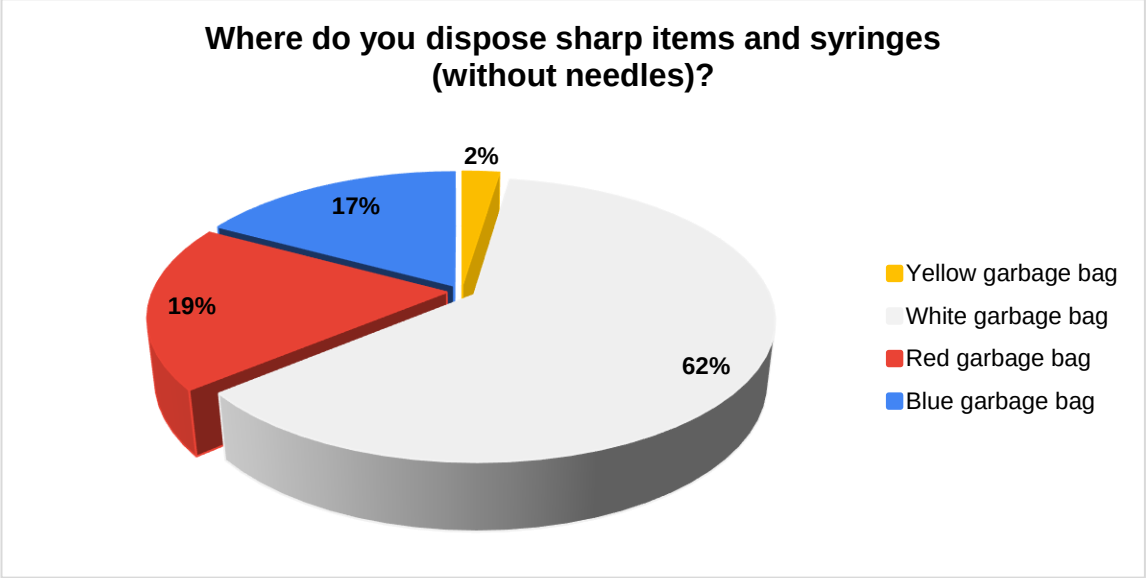
As seen in the graph above, out of the 164 respondents, everyone i.e., almost 100% of the respondents were aware of the colour coding of Bio medical waste management.



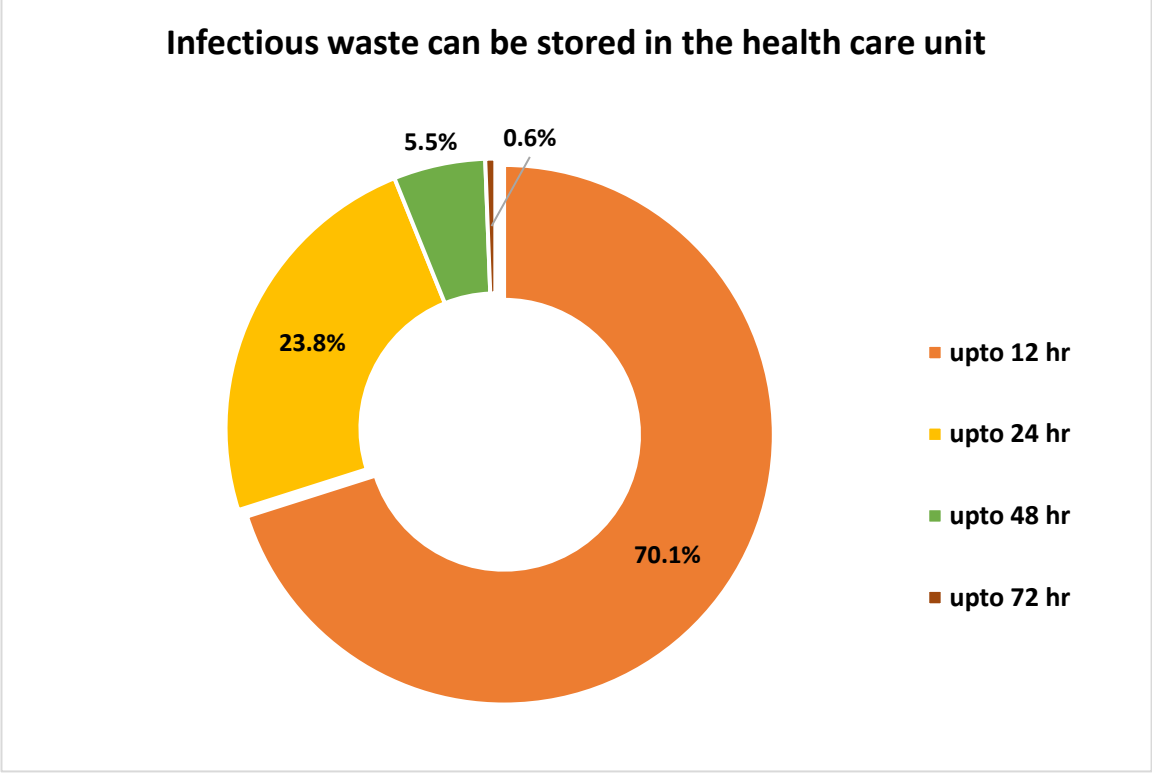
As many as 76% of the respondents accepted to be following the prescribed colour coding protocol while disposing waste in the critical care areas of the hospital. 23.3% of them followed it mostly and only 0.6 % accepted to be practicing the same sometimes.



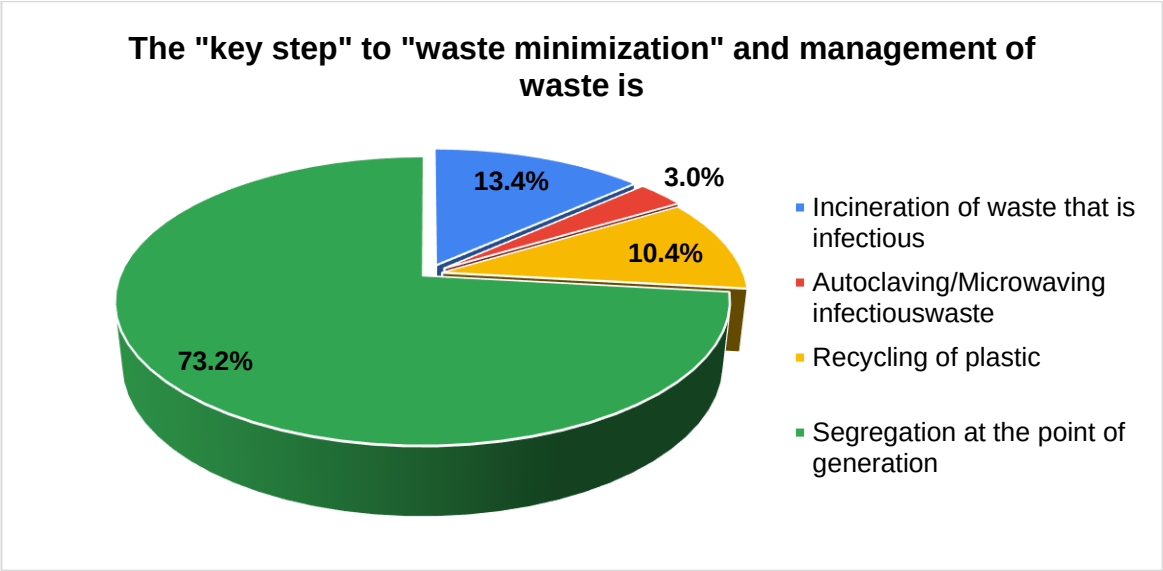
From the above graph, it is seen that only 81.7% answered the question correctly, i.e., disposing the infectious waste from patients in the yellow garbage bag, and rest all selected the other options in the question.



From the above graph, it is seen that only 62% answered the question correctly, i.e., disposing the sharp items and syringes (without needles) in the White garbage bag, and rest all selected the other options in the question.



From the above graph, it is seen that only 70% answered the question correctly, i.e., infectious waste can be stored in the health care unit for a maximum period of 12 hours, and rest all selected the other options in the question, i.e., 23% opted for 24 hours, 5.5% for 48 hours and around 1 % opted for 72 hours.



From the above graph, it is seen that only 73.2% answered the question correctly, i.e., the key step to waste minimization and management of waste is segregation at the point of generation, and rest all selected the other options in the question.

Question on Policy Indicators

Choose the options that describe the policy protocols you follow in the Critical Care areas.				
	Always	Sometimes	Rarely	Never
Daily assessment of patient condition	77.4%	18.3%	4.3%	0%
Follow end of life care guidelines	65.9%	24.4%	9.1%	0%
Report needle stick injuries	65.9%	27.4%	6.7%	0%
Report any adverse events	57.9%	33.5%	7.9%	0%
Regular fall monitoring	74.4%	18.9%	6.7%	0%
Regular pressure ulcer monitoring	68.3%	25.6%	6.1%	0%
Isolation of Infected Patients	54.3%	26.2%	11.6%	0%
Following a daily structured handover	70.7%	25.0%	4.3%	0%
Reporting medication errors	65.9%	28.7%	5.5%	0%

The above table shows the percentage of respondents who comply to the quality and policy guidelines in the critical care areas, Always, Mostly or sometimes. This included daily patient assessment, following EOL guidelines, reporting the adverse events, isolation of infected patients, following structured handover practices and reporting medication errors.

4.3. Analyse Phase:

Measuring the difference between Knowledge and Practice about quality indicators among the nursing staffs of various background characteristics in the critical care areas - Chi square analysis

The responses recorded were grouped into four types of variables, i.e., based on the type of ICU ward, experience in the healthcare sector, number of nursing trainings attended and according to the seniority of post held in the hospital. These numbers were then divided into two groups based on their scores in the survey in the knowledge and practice section, and categorised further as, good or poor. Responses that scored more than 60% were considered as good and the rest were grouped as poor. Furthermore, the chi square analysis was done to understand the significant difference in the knowledge and practice among different groups of nursing staffs working in the critical care areas.

Variables		Knowledge				Practice			
	Total	Good	Poor	Pearson's Chi Square	Asymp. Sig. (2 sided)	Good	Poor	Pearson's Chi Square	Asymp. Sig. (2 sided)
Wards	**164**				**p-value**				**p-value**
HDU	**29**	21	8	**2.762**	**0.838**	12	17	**8.514**	**0.203**
SICU	**16**	12	4			10	6		
NICU	**12**	7	5			3	9		
PICU	**7**	6	1			4	3		
ITU	**15**	12	3			9	6		
MICU	**52**	39	13			19	32		
CCU	**33**	26	7			18	15		
Experience									
0-1 years	**71**	51	20	**0.053**	**0.997**	31	40	**5.409**	**0.144**
1-3 years	**54**	42	12			25	29		
3-5 years	**29**	22	7			16	13		
> 5 years	**10**	8	2			7	1		
Trainings attended									
1	**63**	47	16	**3.082**	**0.214**	26	37	**18.023**	**0.00012**
2-3	**86**	62	24			61	25		
4 or more	**15**	14	1			12	2		
Position held									
Senior Level	**39**	33	6	**5.937**	**0.0514**	31	8	**11.48**	**0.00322**
Assistant	**107**	83	24			69	38		
Trainee/Intern	**18**	10	8			6	12		

Table 5 Chi square analysis and p-value for the distribution of nursing staffs with respect to their knowledge and practice. The score above 60% in both knowledge and practice were grouped as Good and rest were grouped as Poor. A P-value < 0.05 was considered to indicate asymptomatic significance. The p-values marked yellow show a significant difference.

Chi square for wards and knowledge:

Table 6 Crosstabulation of nursing staffs of different ICU wards with respect to their knowledge.

Wards * Knowledge group Crosstabulation

Count

		Knowledge group		
		Good	Poor	Total
Wards	HDU	21	8	29
	SICU	12	4	16
	NICU	7	5	12
	PICU	6	1	7
	ITU	12	3	15
	MICU	39	13	52
	CCU	26	7	33
Total		123	41	164

Chi-Square Analysis

	Value of statistic	Degrees of freedom	Asymptomatic Significance (2-sided)
Pearson Chi-Square	2.762[a]	6	.838
Likelihood Ratio	2.646	6	.852
Linear-by-Linear Association	.501	1	.479
N of Valid Cases	164		

a. 4 cells (28.6%) have expected count less than 5. The minimum expected count is 1.75.

The value of chi-square statistic is 2.762. The *p*-value is .838.

The result was found non-significant at $p < .05$.

A chi-square analysis has been performed in order to study the relation between the nursing staffs in different types of ICU wards and their knowledge about the quality indicators in the critical care areas. The relationship identified between the above variables was found to be non - significant, x^2 (6, N = 164) = 2.762, p = 0.838.

Therefore, the result showed no significant difference between the knowledge level of the nursing staffs about the quality indicators in different types of ICU wards.

Chi square for wards and practice:

Table 7 Crosstabulation of nursing staffs of different ICU wards with respect to their practice.

Wards * Practice group Crosstabulation

Count

		Practice group		
		Good	Poor	Total
Wards	HDU	12	17	29
	SICU	10	6	16
	NICU	3	9	12
	PICU	4	3	7
	ITU	9	6	15
	MICU	19	33	52
	CCU	18	15	33
Total		75	89	164

Chi-Square Analysis

	Value of statistic	Degrees of freedom	Asymtomatic Significance (2-sided)
Pearson Chi-Square	8.514[a]	6	.203
Likelihood Ratio	8.657	6	.194
Linear-by-Linear Association	.024	1	.876
N of Valid Cases	164		

a. 2 cells (14.3%) have expected count less than 5. The minimum expected count is 3.20.

The value of chi-square statistic is 8.514. The *p*-value is 0.203.

The result was found non-significant at $p < .05$.

A chi-square analysis has been performed in order to study the relation between the nursing staffs in different types of ICU wards and their practice regarding the quality indicators in the critical care areas. The relationship identified between the above variables was found to be non - significant, x^2 (6, N = 164) = 8.514, p = 0.203.

Therefore, the result showed no significant difference between the practice level of the nursing staffs about the quality indicators in different types of ICU wards.

Chi square for experience and knowledge:

Table 8 Crosstabulation of the work experience of the nursing staffs in the ICUs with respect to their knowledge.

Experience * Knowledge Crosstabulation

Count

		Knowledge		
		Good	Poor	Total
Experience	<1 year	46	16	62
	1 - 2 years	33	11	44
	3 - 4 years	32	10	42
	5 years and above	12	4	16
Total		123	41	164

Chi-Square Analysis

	Value of statistic	Degrees of freedom	Asymtomatic Significance (2-sided)
Pearson Chi-Square	.053[a]	3	.997
Likelihood Ratio	.053	3	.997
Linear-by-Linear Association	.032	1	.859
N of Valid Cases	164		

a. 1 cells (12.5%) have expected count less than 5. The minimum expected count is 4.00.

The value of chi-square statistic is 0.053. The *p*-value is 0.997.

The result was found non-significant at $p < .05$.

A chi-square analysis has been performed in order to study the relation between the experience of the nursing staffs in different types of ICU wards and their knowledge about the quality indicators in the critical care areas. The relationship identified between the above variables was found to be non - significant, x^2 (3, N = 164) = 8.514, p = 0.997.

Therefore, the result showed no significant difference between the experience and the knowledge level of the nursing staffs about the quality indicators in different types of ICU wards.

Chi square for experience and practice:

Table 9 Crosstabulation of the work experience of the nursing staffs in the ICUs with respect to their practice.

Experience * Practice Crosstabulation				
Count				
		Practice		
		Good	Poor	Total
Experience	<1 year	23	39	62
	1 - 2 years	21	23	44
	3 - 4 years	20	22	42
	5 years and above	11	5	16
Total		75	89	164

Chi-Square Analysis

	Value of statistic	Degrees of freedom	Asymtomatic Significance (2-sided)
Pearson Chi-Square	5.409[a]	3	.144
Likelihood Ratio	5.472	3	.140
Linear-by-Linear Association	4.375	1	.036
N of Valid Cases	164		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 7.32.

The value of chi-square statistic is 5.409. The *p*-value is 0.144.

The result was found non-significant at $p < .05$.

A chi-square analysis has been performed in order to study the relation between the experience of the nursing staffs in different types of ICU wards and their practice regarding the quality indicators in the critical care areas. The relationship identified between the above variables was found to be non - significant, x^2 (3, N = 164) = 5.409, p = 0.144.

Therefore, the result showed no significant difference between the experience and the practice level of the nursing staffs about the quality indicators in different types of ICU wards.

Chi square for training attended and knowledge:

Table 10 Crosstabulation of number of trainings attended by the nursing staffs in the ICUs with respect to their knowledge.

Training attended * Knowledge Crosstabulation				
Count				
		Knowledge		
		Good	Poor	Total
Training attended	1	47	16	63
	2 - 3	62	24	86
	4 or more	14	1	15
Total		123	41	164

The value of chi-square statistic is 3.0818. The *p*-value is .214191.

The result was found non-significant at $p < .05$.

A chi-square analysis has been performed in order to study the relation between the experience of the nursing staffs in different types of ICU wards and their practice regarding the quality indicators in the critical care areas. The relationship identified between the above variables was found to be non - significant, x^2 (3, N = 164) = 5.409, p = 0.144.

Therefore, the result showed no significant difference between the experience and the practice level of the nursing staffs about the quality indicators in different types of ICU wards**.**

Chi square for training attended and practice:

Table 11 Crosstabulation of the number of trainings attended by the nursing staffs in the ICUs with respect to their practice.

Training attended * Practice Crosstabulation				
Count				
		Practice		
		Good	Poor	Total
Training attended	1	26	37	63
	2 - 3	61	25	86
	4 or more	13	2	15
Total		100	64	164

The value of chi-square statistic is 18.0231. The *p*-value is .000122.

The result was found significant at $p < .05$.

A chi-square analysis has been performed in order to study the relation between the number of Trainings attended by the nursing staffs in the ICU wards and their practice regarding the quality indicators in the critical care areas. The relationship identified between the above variables was found to be highly - significant, x^2 (3, N = 164) = 18.0231, p = 0.000122.

Therefore, the result showed a highly significant difference between the number of trainings attended and the practice level of the nursing staffs about the quality indicators in different types of ICU wards**.**

Chi square for position held and knowledge:

Table 12 Crosstabulation of position held by the nursing staffs in the ICUs with respect to their knowledge.

Position held * Knowledge Crosstabulation

Count

		Knowledge		
		Good	Poor	Total
Position held	Senior Level	33	6	39
	Assistant	83	24	107
	Trainee/Intern	10	8	18
Total		126	38	164

The value of chi-square statistic is 5.9372. The *p*-value is .051376.

The result was found non-significant at $p < .05$.

A chi-square analysis has been performed in order to study the relation between the number of Trainings attended by the nursing staffs in the ICU wards and their knowledge about the quality indicators in the critical care areas. The relationship identified between the above variables was found to be non - significant, x^2 (3, N = 164) = 5.9372, p = 0.051376.

Therefore, the result showed no significant difference between the position held and the knowledge level of the nursing staffs about the quality indicators in different types of ICU wards.

Chi square for position held and practice:

Table 13 Crosstabulation of position held by the nursing staffs in the ICUs with respect to their practice.

Position held * Practice Crosstabulation

Count

		Practice		
		Good	Poor	Total
Position held	Senior Level	31	8	39
	Assistant	69	38	107
	Trainee/Intern	6	12	18
Total		106	58	164

The value of chi-square statistic is 11.48. The *p*-value is .003215.

The result was found significant at $p < .05$.

A chi-square analysis has been performed in order to study the relation between the position held by the nursing staffs in the ICU wards and their practice regarding the quality indicators in the critical care areas. The relationship identified between the above variables was found to be highly - significant, x^2 (3, N = 164) = 11.48, p = 0.003215.

Therefore, the result showed a highly significant difference between the number of trainings attended and the practice level of the nursing staffs about the quality indicators in the critical care areas.

4.3.1. Root Cause Analysis

In light of the trend analysis and the survey done so far, the problems identified in the Critical Care areas are as follows:

1. High rate of CLABSI and CAUTI in few of the ICUs of the hospital
2. High incidence of Accidental Removal of lines and pressure sores
3. Low Hand hygiene compliance among the ICU nursing staffs
4. Low compliance to Bio-medical waste management practices among these staffs

Problem 1.: Cause and Effect Analysis – High incidence of CLABSI

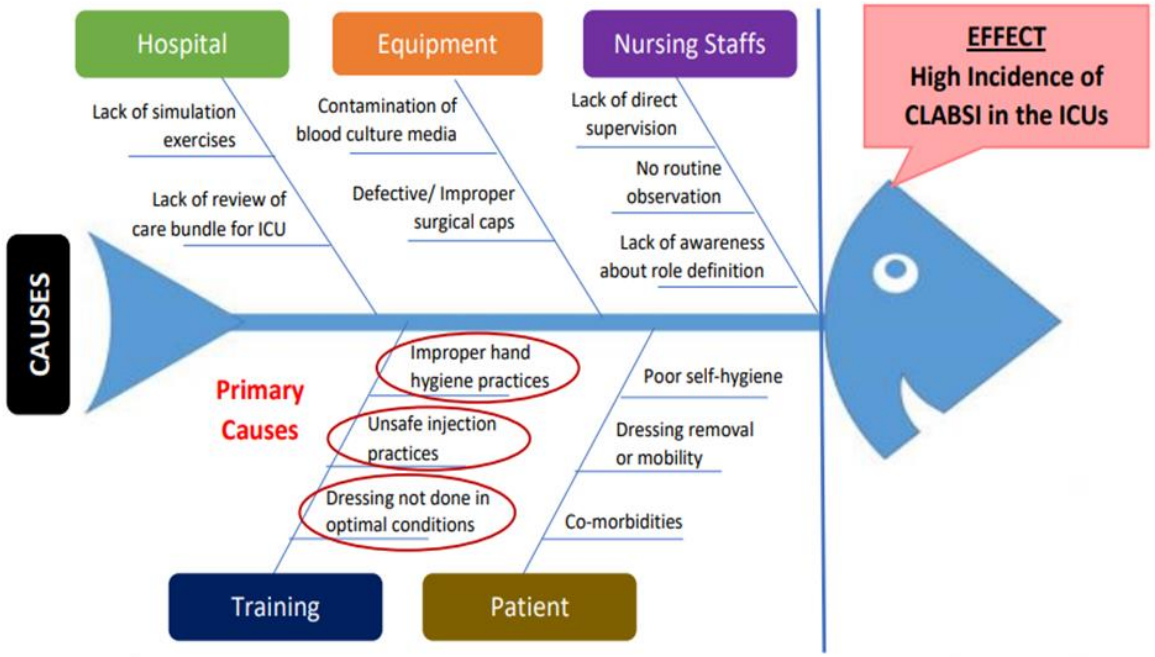


Figure 7 Fish bone diagram for the Root Cause Analysis of the increased incidence of Central Line Associated Blood Stream Infection (CLABSI) in different Critical Care areas of The Mission Hospital, Durgapur. Source. The Mission Hospital. Credit. Self

Interpretation:

An increased incidence of CLABSI in the ICUs of the hospital is mainly attributed to lack of training of the nursing staffs. The primary causes of the infection identified through the Fish bone diagram are; Improper hand hygiene practices, unsafe mode of injection to patients and dressing of surgical site being done at a low optimal condition. Other reasons identified include patient factors, Lack of supervision on the part of nursing staffs, defective surgical equipment and/or lack of regular monitoring and review of the CARE Bundle for the ICUs.

Problem 2.: Cause and Effect Analysis – High incidence of CAUTI

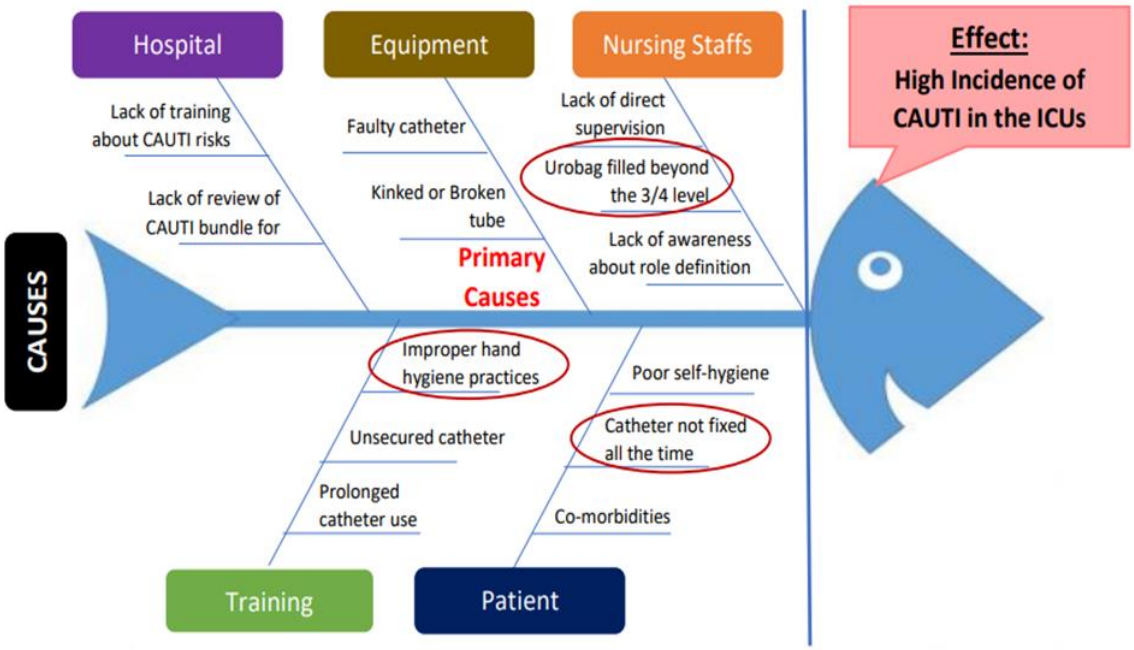


Figure 8 Fish bone diagram for the Root Cause Analysis of the increased incidence of Catheter Associated Urinary Tract Infection (CAUTI) in different Critical Care areas of The Mission Hospital, Durgapur. Source. The Mission Hospital. Credit. Self

Interpretation:

In addition to CLABSI, there is an added increase in the incidence of CAUTI in the critical care areas of the hospital. The primary reasons identified for the same were gaps in hand hygiene practices while handling the catheter of the patient, patient negligence in wearing the catheter all the time and lack of monitoring of the level of urine filled in the urobag by the nursing staff. Other common reasons included, lack of training of the hospital nursing staffs about the risks of CAUTI and the possible complications to the patients, patient factors including improper self-hygiene and/or use of a faulty or broken equipment.

Problem 3: Primary Reasons for Increased Incidence of Pressure Sores:

As per the hospital incidents' record, the main reasons documented for the increased occurrence of Pressure Sores in patients are –

- Prolonged bed ridden patients having a longer length of stay
- Patients having increased albumin in their blood due to any disease condition.
- Under supervision of patient positioning – 2 hourly position change not done.
- Inadequate monitoring of HAPUs - Irregular monitoring in Braden pressure ulcer scale.

- Prolonged wearing of diapers by patients or non-supervision by the GDA while cleaning excreta.

Patients who acquired Pressure Ulcers were bedridden in the hospital for a longer period and had a worse skin barrier function than those who did not. With a longer ALOS in the ICU, the need of skin barrier testing may become even more important. When patients with Pressure Ulcers were compared to those without them, the stratum corneum's moisture content was found substantially lower and the pH of skin surface was observed to be considerably more at the areas of lower sacrum and hip. As a result, enhanced attention to these areas may enhance nursing practices targeted at reducing the development of Pressure Ulcers.

Problem 4: Primary Reasons for Increased Incidence of Accidental removal of lines:

Accidental removal of Catheter Line is linked to issues from both the removal and the reinsertion of the catheter. As a result, determining the incidence is critical in order to put preventative measures in place.

As per the hospital incidents record, the main reasons documented for the increased occurrence of Accidental Removal of Lines in patients are –

- In case of a restless or irritable patient
- Lack of awareness during shifting of patients
- Self-removal by patients

The results from removal of catheter lines, if not done properly, are considerably serious. The problem occurs from the air embolism since the line tract might be left uncovered for a long period of time.

Potential Complications are listed below:

  - Embolism of the Airway
  - Fracture of the catheter and embolism
  - Thrombus or fibrin sheath dislodgement
  - Bleeding or haemorrhage
  - Complications of the arteries - compression of the brachial plexus

A continuous monitoring of patients with attached central line should be done by the attending nursing staff. Physical restraint might be used in cases where patient attempts self-removal of central line. Care should be taken while shifting patients out of the ICU wards.

Pareto Analysis

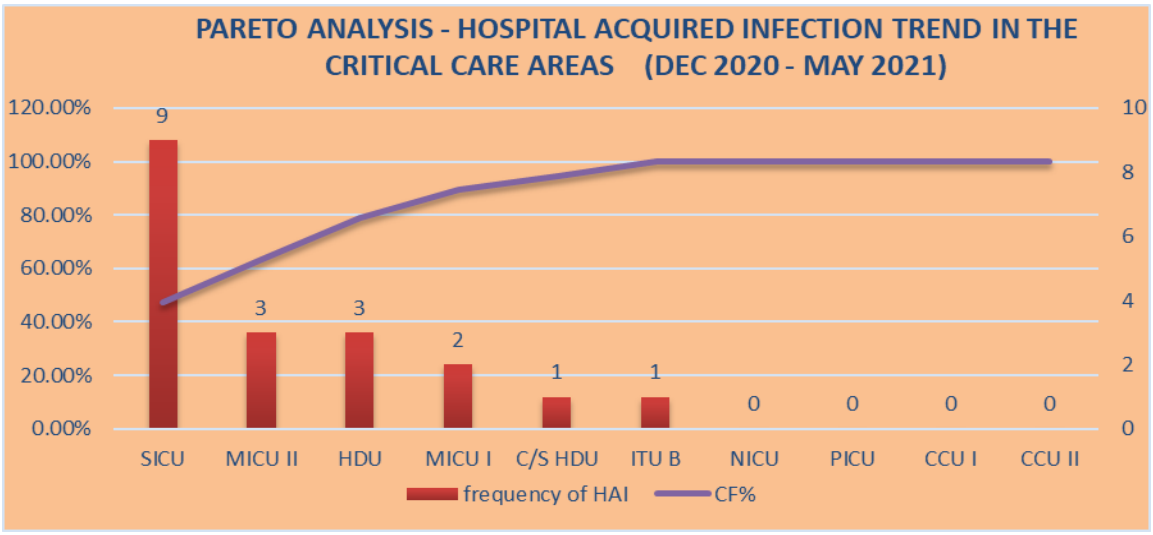


Figure 9 Pareto Chart for the Hospital Acquired Infections in the different ICU wards. Source. The Mission Hospital. Credit. Self

Interpretation: After doing the pareto analysis of the HAI incidents obtained from various wards, it was seen that 70-80% of the Hospital Acquired Infections are reported from the three ICUs i.e., SICU, MICU II and HDU. So, focussing on reducing the HAI rates in these 3 ICUs can significantly reduce the majority of HAI rates in the critical care areas of the hospital.

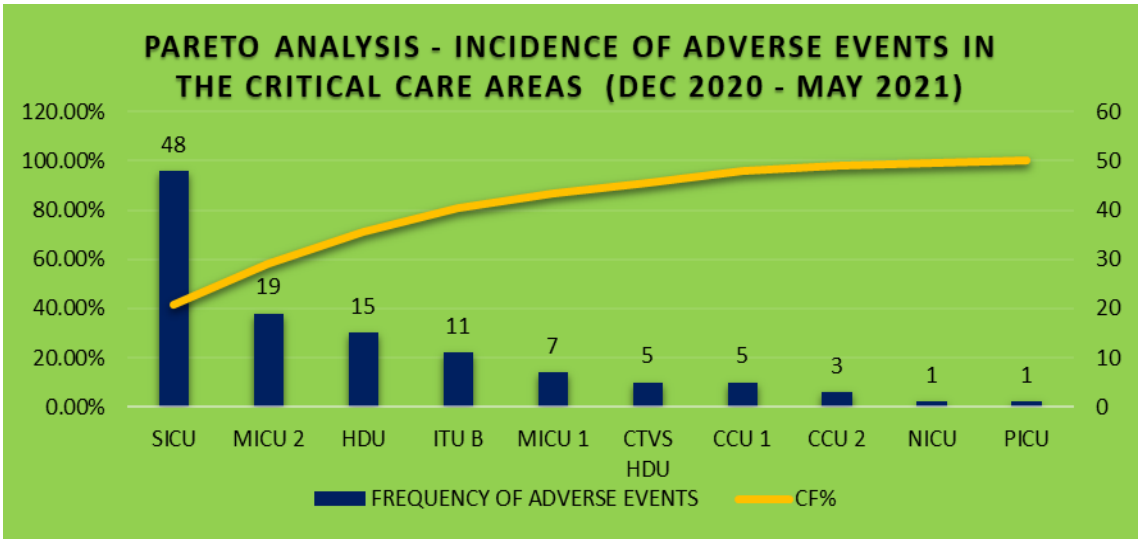


Figure 10 Pareto chart for the Incidence of Adverse events in different ICU wards of the hospital. Source. The Mission Hospital. Credit. Self

Interpretation: The above pareto analysis of the adverse events reported from the critical care areas reveals that 70-80% of the incidents are reported from the SICU, MICU II and HDU. So, careful monitoring strategies in these 3 ICUs can significantly reduce the rate of adverse events in the critical care areas of the hospital.

CHAPTER 5 – DISCUSSION

All the issues mentioned in the previous chapter are inter-related and contribute significantly to the occurrence of one another. Low compliance to hand hygiene and bio-medical waste management practices has a direct influence on the HAI rate in the Hospital. An increase in the Hospital Acquired Infection directly increases the Average Length of stay for the patient by a minimum of 7-8 days. Given below are the component wise summary of the ICU bed charges in The Mission Hospital, Durgapur:

Table 14 Break-up of ICU bed charges at The Mission Hospital, Durgapur

Component	**Charges in Rupees (Rs.)**
Bed Charges + ICU charge	13% of total bill amount
Investigations	20% vary
Pharmacy	50% vary (Estimated Rs. 10000)
Doctor's Consultation	8% vary (Estimated Rs. 700)
O.T.	Vary
Blood Bank	5% vary
Bedside Procedures	4% vary
Total	**Estimated approx. Rs. 25,000 – 30,000 per patient per day.**

As such, for an exceed in the Length of Stay for the patient for a period of 7-8 days, would amount to Rs. 1,75,000 – 2,00,000 per patient. There also an extra burden on Hospital resources and services that in turn leads to decrease in the Total Hospital Revenue. Patient satisfaction and high recovery rate are the important factors that are responsible for the increased patient turnover in any hospital.

Hence, in the last part of the DMAIC process i.e., the Improve and Control Phase, key improvement areas are identified and suggestions are made.

5.1. Improve Phase:

Problem Identified	Corrective Action/Preventive Action (CA/PA)
1. Increase in the nosocomial infection rate	• Nursing staffs need to be trained about appropriate hand hygiene measures. • In the ICUs, strict adherence to the CARE package for CLABSI, CAUTI, and SSI to be followed. • The Infection Control Team should provide on-the-spot training. • When handling the central line, gloves should be worn. • Patients admitted to be monitored on a daily basis, and dressings to be changed as needed. • In order to avoid surgical-site infections and lower mortality rates, use a surgical safety checklist.
2. Increase in incidence of few adverse events in the ICU	• Identification of patients who are at high risk to be made simpler. As a result, clinicians and staff may quickly apply the necessary measures to reduce the risk of falling by identifying patients at high-risk. • Setting up bed alarms for patients who are required to be handled with extra care. • Performing safety checks on a regular and recurring basis. All high-risk patients should be subjected to twice-daily safety rounds in addition to the hourly rounds. • Patient in catheters must be closely monitored to avoid potential self-removal of the catheter line. • The nursing staff in the ICU should monitor bedridden patients using the Braden pressure ulcer scale on a regular basis.

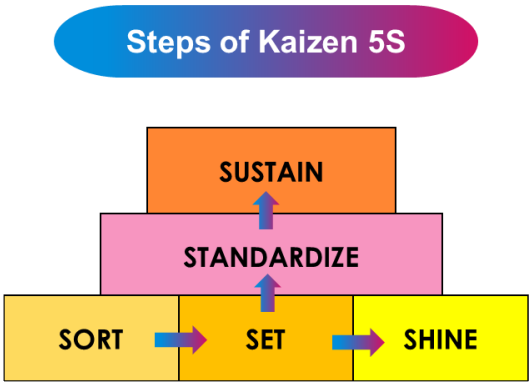
3. Decreased compliance with infection control guidelines	• The use of PPE as and when required by the care provider. • Safety, hygiene, and infection control procedures to be strictly followed. • Medical waste must be handled and disposed of properly. • Disinfectant wipes must be used to remove any blood, fluids, or excretions from the body surface. Soiled wipes must be thrown away in the room's yellow trash can. • In critical care areas, a proper temperature of up to 60 degrees Celsius should be maintained. • Hand washing should be emphasized following any contact with the patient. • During hospital visiting hours, no more than two adult visitors should be allowed 'at a time,' and the length of stay should be determined by the patient's needs.
4. Gaps in the knowledge and practice regarding quality and policy guidelines in the ICU	• Training of the medical staffs in the critical care areas, regarding the NABH guidelines and benchmarks, to achieve quality-based patient care. • Regular monitoring with open and closed file audits in the ICUs to check the compliance. • Continuous surveillance of the nursing staff's activities in the critical care wards, for spot identification of gaps and training. • Multidisciplinary rounds to enhance patient care. • Implementation of daily maintenance sheets can lead to effective handovers among team members leading to reduction in average length of stay in the ICUs.

The Chi-square analysis done regarding the Knowledge and Practice of the nursing staffs about Infection Control Measures, Biomedical waste management and several quality and policy indicators, pointed out that there was a significant difference among the Position held by the nursing staffs and the number of trainings they have attended, with the Practice behaviour among them. As such, the practice behaviour was seen to be better with increasing seniority and with increased number of trainings attended by the nursing staffs.

Hence, the following Corrective Actions can be suggested for the above-mentioned scenario:

- Conducting training for the nursing staffs to orient them regarding the correct and acceptable practice towards the quality indicators in the critical care areas.
- Nurse Trainees, Interns and Nursing assistants should be kept in focus for the training programmes.
- Spot training and corrective strategies can be adopted by surveillance and monitoring of nursing activities inside the critical care wards.
- Training programs should be conducted at least once a month, to orient the nurses about the correct quality protocol, they need to adhere to in the ICUs.

Kaizen 5S Technique



Kaizen 5S could be put in use to improve the work environment for the nursing staffs in the critical care areas. This could be done under 5 steps:

Sort, Set, Shine, Standardize and Sustain

Sort: Waste management is crucial in the Hospital ICUs to maintain a cleaner environment for both the staffs and the patients. The "Reduce, Reuse, Recycle Concept" could be included with the sorting activities. This may include:

- Segregation and separation of medical waste
- Disposal of waste items in the specific color coded bins.
- Separation of items that can be reused by the hospital, at the point of generation.

Set (Set in order): This step promotes orderliness, thus helping in achieving better work efficiency by the nursing staffs in the ICUs. The tools that could be used for the "set" activity are; Red Tag, Numbering, Alphabetical order, colour coding, zones, safety signs, checklists etc. The ICU could be divided into zones for isolation of patients with communicable disease (like COVID-19). Colour coding of patient bands who have a high score in the Morse Fall Scale can help identifying the vulnerable patients, and could be kept on close monitoring. Safety signs could be marked outside the isolation areas to avoid accidental exposure of the nursing staffs.

Shine: This is an activity that needs participation of everyone irrespective of their working areas. "Shine" Activity is done to maintain cleanliness in the work area especially in the critical care areas. Each staff should be allocated a specific territory in their wards, and they are expected to maintain cleanliness of that area dedicated to them.

Standardize: This activity is a continuous process that involves:

- Making Kaizen 5S a part of daily activity for the nursing and other healthcare staffs.
- Displaying and Pasting IEC material with slogans/pictures of "Sort", "Set" and "Shine" in the working area of the ICU wards.
- Standardisation of colour coding to be followed in the hospital for waste management.

Sustain: After application of the above 4S activities, it is important to maintain the clean environment in the day-to-day activities in the critical care areas. For this, regular audits and inspection with close monitoring to be done, to impart 5S in the habit of the nursing staffs and healthcare workers, working in the critical care units.

5.2. Control Phase:

Table 15 Tentative Timeline for execution of proposed solutions

Activities	Tentative duration
Meeting with the operation and quality heads of the critical care areas	1 week
Meeting with the Infection Control Team	1 week
Making a training plan for the ICU nurses	1 week
Deciding training goals and objectives	2 days
Approval of the training plan by the Hospital authorities	3 days
Continuous surveillance monitoring of the nursing activities in the ICUs	4 weeks
Listing out gaps and spot training	1 week
Conducting weekly once training program	12 weeks
Assessing pre and post training knowledge and Practice of the nurses	1 week
Focussing on areas that needs re-evaluation	Continuous

Recommendations and Suggestions

- **Precautions and Recommendations for Infection Control in ICU:**
  - Careful handling of Blood, body fluids and tissue samples to be done in order to prevent any contamination outside the container and the laboratory forms.
  - Gloves should be used while drawing blood, giving IV/IM injections.
  - Wash gloves with soap and water after every procedure.
  - Follow the 5 moments of hand hygiene following all the steps of handwashing.
  - Use fresh/ autoclaved pair of gloves every day.
  - Destroy needle and syringe hub in needle and syringe destroyer.
  - Place non sharps e.g., gauze, cotton, clothing, contaminated with blood/ body fluids in polythene bags (Marked yellow).
  - Any form of accidental spills and/or any exposures to the infectious materials should be reported on immediate basis.

Figure 11 The 5 Moments of Hand Hygiene. Source and Credit: WHO (World Health Organization)

Figure 12 Steps of Hand washing. Source and Credit. WHO and CDC

➢ Waste Management in the ICUs

Care should be taken to drop the waste in the specified coloured bags:

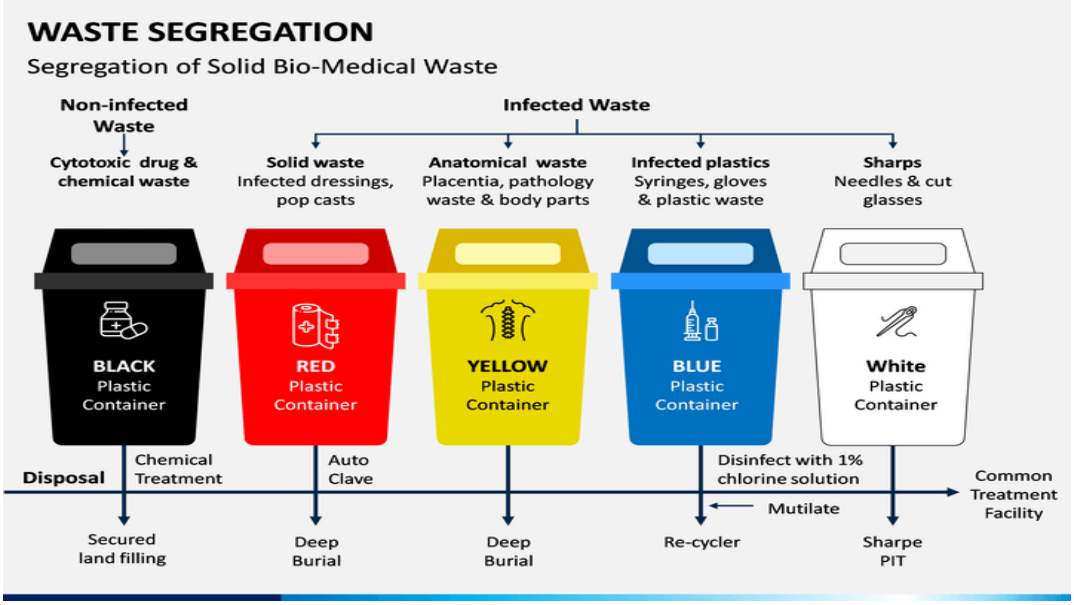


Figure 13 The colour coding for Biomedical waste segregation. Source: WHO. Credit: Juniordentist.com

YELLOW BAGS: For infectious waste

- Solid dressing
- Plasters/ caste
- Human and Animal organ/ tissue/ parts
- Discarded medicine cytotoxic drugs without breaking ampoules/ vials/ bottles

BLACK BAGS: For non-infectious waste

- Paper cardboard
- Plastic Glass/ cups
- Bottles
- Metal cans

RED BAGS: Wastes generated from disposable items such as tubing, plastic bottles, intravenous tubes and sets, catheters, urine bags, syringes (without needles) and vacutainers with their needles cut and gloves.

BLUE BOX: Broken or discarded and contaminated glass including medicine vials and ampoules except those contaminated with cytotoxic wastes

WHITE BAGS: Waste sharps including Metals, Needles, scalpels, blades, or any other contaminated sharp objects. This includes both used, discarded and contaminated metal sharps.

- **Recommendations for adherence to Quality and Policy protocols in the ICUs**
  - Adequate supervision of critically ill patients;
  - Prevent incidences of pressure sores by regular patient monitoring and evaluation with Braden Pressure Ulcer score;
  - Enforce infection control protocols, including sterilization of equipment and machines;
  - Follow proper admission and discharge criteria as framed according to the Hospital policies.
  - Follow the EOL care pathways as and when needed.
  - Report incidences of adverse events like needle stick injuries, patient falls etc to the nursing in charge.
  - Participate in the trainings and mock drills conducted in the critical care areas.

CHAPTER 6 – CONCLUSION

Most of the ICUs in India are facing the shortage of skilled workers like trained intensivists and critical care nurses, that is leading to a shortage of ICU beds across the country, especially during the pandemic and increased incidence of COVID pneumonia. In patients admitted to ICUs, a 24-hour trained intensivist presence has been found to improve outcomes[11]. It has been well established that ICUs with a high nurse-to-patient ratio offer better outcomes. Budget constraints and a staffing shortfall seemed to have influenced the research's nursing care for patients admitted in ICU. The prevention approach for reducing disease spread within ICUs has been identified by isolation of infected patients[13]. Isolation of infected cases was followed by 54 percent of respondents in our survey. Infection management is crucial in determining the success of any ICU. Hand hygiene plays a key role in hospitals nowadays, due to the development of antibiotic-resistant pathogens. One of the most essential techniques for preventing nosocomial infections is hand cleanliness. Most of the ICUs have guidelines for hand washing before and after patient examination, as well as before and after entering any critical care unit. In our survey, around 61% of the respondents seemed to be following proper hand hygiene protocols during their duty hours in the ICU. Furthermore, VAP, SSI, CAUTI, and CLABSI rates have been used by hospitals to track the HAI rates in more than 75 percent of critical care units. HAIs have resulted in longer stays and a lack of available beds for ICU patients. Our survey witnesses an increased percentage of CLABSI and CAUTI rates and a net increase in the ALOS by 7 - 8 days. As a result, better infection prevention techniques are needed in the ICU, so as to lower the morbidity and mortality for the admitted patients.

This study found gaps in specific aspects of knowledge and practice among the nursing staffs working in the ICUs regarding their compliance towards different quality and policy indicators. There were marked differences between the knowledge and awareness about the 5 moments of hand hygiene and biomedical waste management, and the positive attitude towards the same was seen in a lesser number of staffs. The attitude was seen to be better in senior level staffs and/or staffs with more training regarding the same. Hence, this gap should be focused on in future awareness and training programs conducted for the nursing staffs in the hospital. Strict, regular and authoritative training sessions on Hospital quality indicators and the correct way to follow them, is necessary to deliver a quality healthcare service experience to the patients admitted in the critical care areas of the hospital.

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ANNEXURE 1 – THE QUESTIONNAIRE

COMPLIANCE TO QUALITY INDICATORS SURVEY

Dear Participant,

This survey is conducted solely for research purpose, to understand the knowledge and attitude of the medical staffs towards the quality aspect in the ICUs. You are invited to participate in the research project for understanding your compliance towards the quality standards in the ICUs of the Hospital. The results of this survey would be used for scholarly purposes.

Your responses shall be handled with utmost confidentiality and none of your personal information shall be asked except your email address.

Your participation is voluntary. You may proceed further if you are willing to take the survey.

* Required

1. Electronic Consent: Kindly mark your choice below. *

Mark only one oval.

- ◯ Yes, I would like to take the survey.

2. Name of the clinical work area

Mark only one oval.

- ◯ MICU
- ◯ CCU
- ◯ ITU
- ◯ SICU
- ◯ HDU
- ◯ NICU
- ◯ PICU

3. Are you aware of the Hospital Acquired Infections (HAIs) in your hospital? *

Mark only one oval.

- ◯ Yes
- ◯ No

4. Which of the following HAIs are commonly seen in the critical care areas of the hospital? (You can select multiple options) *

Check all that apply.

- ☐ Urinary Tract Infections (UTIs)
- ☐ Surgical Wound Infections
- ☐ Respiratory Tract Infections (RTIs)
- ☐ Blood Stream Infections (i.e., bacteremia/septicemia)
- ☐ Gastrointestinal tract Infections (GITIs)
- ☐ Skin Infections
- ☐ Others

5. Do you know the "5 Moments of hand Hygiene"? *

Mark only one oval.

- ◯ Yes
- ◯ No

6. Do you follow the "5 moments of hand hygiene"? *

Mark only one oval.

- ◯ Always
- ◯ Mostly
- ◯ Sometimes
- ◯ Never

7. When do you wash your hands in the hospital? (You can select multiple options) *

Check all that apply.

- [ ] Before meals
- [ ] Before performing invasive bedside procedures
- [ ] Before and after examining patients
- [ ] Before and after touching wounds, but not when gloved
- [ ] Between two different procedures on different patients
- [ ] Between two different procedures on the same patient
- [ ] After using the patient-care devices
- [ ] After taking off gloves

8. How do you usually wash your hands while ON DUTY? (You can select multiple options) *

Check all that apply.

- [ ] Wash with running water
- [ ] Wash with running water and soap
- [ ] Wash with running water and hand washing liquid
- [ ] Wash with running water and skin disinfectant
- [ ] Wash with alcohol hand rub (Chlorohexidine)

9. Choose the option that fits right for your hand washing practice. *

Mark only one oval per row.

	Hand wash/scrub	Alcohol hand Rub
Before handling medicines medicines or food	◯	◯
Handling visible dirt, blood or body fluids	◯	◯
Handling diarrhoea patients	◯	◯
Routine clinical rounds & handling patients	◯	◯
In emergency or lack of facility	◯	◯
Prior to any surgical procedure	◯	◯

10. Do you know about the color coding of Bio medical Waste management? *

Mark only one oval.

- ◯ Yes
- ◯ No

11. Do you follow the prescribed color coding protocol while disposing waste at the hospital?

Mark only one oval.

- ◯ Always
- ◯ Mostly
- ◯ Sometimes
- ◯ Never

12. Where do you dispose infectious waste from patients? (pus, body fluids etc.) *

Mark only one oval.

- ◯ Yellow garbage bag
- ◯ Black garbage bag
- ◯ Red garbage bag
- ◯ Blue garbage bag

13. Where do you dispose sharp items and syringes (without needles)? *

Mark only one oval.

- ◯ Yellow garbage bag
- ◯ White garbage bag
- ◯ Red garbage bag
- ◯ Blue garbage bag

14. Infectious waste can be stored in the health care unit: *

Mark only one oval.

- ◯ Upto 12 hr
- ◯ Upto 24 hr
- ◯ Upto 48 hr
- ◯ Upto 72 hr

15. The "key step" to "waste minimization" and management of waste is *

Mark only one oval.

- ◯ Incineration of waste that is infectious
- ◯ Autoclaving/Microwaving infectious waste
- ◯ Recycling of plastic
- ◯ Segregation at the point of generation

16. Choose the options that describe the policy protocols you follow in the Critical Care areas. *

Mark only one oval per row.

	Always	Mostly	Sometimes	Never
Daily assessment of patient condition	◯	◯	◯	◯
Follow end of life care guidelines	◯	◯	◯	◯
Report needle stick injuries	◯	◯	◯	◯
Report any adverse events	◯	◯	◯	◯
Regular fall monitoring	◯	◯	◯	◯
Regular pressure ulcer monitoring	◯	◯	◯	◯
Isolation of Infected Patients	◯	◯	◯	◯
Following a daily structured handover	◯	◯	◯	◯
Reporting medication errors	◯	◯	◯	◯

ANNEXURE 2 – CHECKLISTS

ICU MATRICES - MONTHLY INDICES		
SRL NO.	**ICU MATRICES**	**NO.**
1	ICU TOTAL LENGTH OF STAY (DISCHARGED PATIENTS)	
2	TOTAL NUMBER OF ICU ADMISSIONS	
3	TOTAL NUMBER OF ICU DISCHARGES	
4	NO. OF ICU BEDS OCCUPIED BY PATIENTS	
5	TOTAL NUMBER OF PATIENT FALLS	
6	TOTAL NUMBER OF PRESSURE SORES REPORTED	
7	TOTAL CASES OF ACCIDENTAL REMOVAL OF LINES	
8	TOTAL NUMBER OF CASES OF REINTUBATION WITHIN 48 HOURS	
9	TOTAL PATIENTS WHO RETURNED TO ICU WITHIN 48 HOURS	

ICU MATRICES - DAILY INDICES		
SRL NO.	**ICU MATRICES**	**NO.**
1	TOTAL NUMBER OF PATIENTS ON VENTILATOR	
2	TOTAL NUMBER OF NON-VENTILATED PATIENTS	
3	TOTAL NUMBER OF NURSES IN THE ICU (ALL SHIFTS)	
4	HOURS OF TRAINED INTENSIVIST PRESENCE IN MICU	

ICU MATRICES – MONTHLY HAI RATE		
SRL NO.	**ICU HAI Matrices**	**NO.**
1	NUMBER OF CLABSI/CAUTI/SSI REPORTED	
2	TOTAL NUMBER OF CATHETER DAYS/TOTAL NUMBER OF CENTRAL LINE DAYS/TOTAL NUMBER OF CARDIAC SURGERIES (PER MONTH)	