IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 2, September 2023

Fast in Action to Reduce Rejection (FARR): Pre-Analytical Errors in Blood Sampling Procedures by the Nurses

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Abstract: *The pre-analytical errors are the major source of mistakes in laboratory diagnostics referring to all of the inappropriate performances before the specimens are measured by the analyzers2,such as improper sample collection, transport delays, illegible handwriting on requisition, wrong or missing identification, haemolysed, clotted 14 and quantity not sufficient (QNS) samples, wrong vacutainer selection, inappropriate blood to anticoagulant ratio and so on. However, it has been reported that the pre-analytical phase is error-prone which may lead to repeated sampling, inaccurate test results, delay in diagnosis, and may jeopardize patient safety which may potentially compromise patient care and clinical outcomes 7.*

This review examines pre-analytical errors, their causes, their impact on lab results, and strategies for creating clear classification systems to reduce these errors among nurses. Errors, often by trained staff nurses, highlight the need for regular competency tests and an active detection system to enhance lab testing reliability and quality.

The study focused on identifying and categorizing errors 8 during phlebotomy collection. It aimed to mitigate these errors, which though not catastrophic, signalled system failures. The campaign successfully reduced errors from 368 to 287 after starting in response to a high error count in July 2022. The campaign also led to a shift from open to closed blood collection methods, including improved aseptic techniques. More than 1,000 nurses adopted this change, demonstrating a positive impact on maintaining sample quality and reducing errors. Overall, the campaign achieved remarkable success in addressing pre-analytical blood sample errors.

Keywords: Pre-analytical errors, Blood Collection, Phlebotomy, Blood sample collection, Laboratory Testing

I. INTRODUCTION

The complexity of the current healthcare environment has increased the potential for medical errors which represents a disturbing trend. **Hospital-based errors stand as the eighth most common cause of death in the United States.** For the clinical laboratory, errors that occur in the **pre-analytical phase** of testing may account for up to 75% of total laboratory errors; 25% of these may have detrimental effects on patient care, which contribute to unnecessary investigations or inappropriate treatment, increase in lengths of hospital stay, as well as dissatisfaction with healthcare services [5&11].

Eliminating or reducing these errors requires a concerted effort by healthcare organizations, product manufacturers, and policymakers [6].

Accurate and reliable laboratory test results are crucial for making informed clinical decisions. Blood sampling procedures are a critical step in obtaining blood specimens for analysis, but they are also prone to errors. Pre-analytical errors, including patient identification errors, improper venipuncture techniques, sample mishandling, and transportation issues, can significantly affect the reliability of laboratory results.

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II. Methods

Fast in Action to Reduce Rejection (FARR): Phases

Phase 1: Error identification and tracking
phase 2: Analysis
Phase 3: Improvement and implementation
Phase 4: Impact of the campaign, and
Phase 5: Sustenance of the improvement

The campaign's methodology centered on addressing **pre-analytical errors in blood sampling by the nurses across various hospital departments** (haematology, histopathology, microbiology, and biochemistry).The campaign spanned 3 months and comprised 5 distinct phases(as depicted in Figure:1).The objective was to decrease errors by implementing specific measures: proper patient preparation, accurate identification, and labelling, adopting a closed method for sample collection hospital-wide, correct sample handling and transportation, ensuring timely processing, and incorporating quality control measures.

The campaign's primary focus was on three areas:

- **Sample Rejection and Rectification:** The campaign emphasized strengthening the daily monitoring of the sample rejections and subsequent corrective actions by the relevant unit.
- **Staff Nurse Competency Assessment:** The campaign aimed to assess the competency of individual staff nurses involved, ensuring their proficiency in adhering to correct procedures.
- **Hands-on Training in Error-Prone In-Patient Units (IP):** A key aspect was enhancing hands-on training within the error-prone in-patient units to improve skills and adherence to correct blood sampling protocols.
- Throughout the campaign, these measures were systematically integrated into each of the five phases, with the overall objective of reducing pre-analytical errors in blood sampling procedures carried out by the nurses.

Phase 1: Error Identification and Tracking:

-Phase 1, spanning **a week**, in which A thorough evaluation of the sample collection data was fetched from the**laboratory tracking system** (Med-Mantra) hospital-wide to identify areas/units prone to errors. All the non-

Phase:1 Error Identification and Tracking

Biochemistry lab.

LOG OF REPEAT / REJECTED SAMPLES

DURATION: 1 WEEK (17TH JULY TO 23RD JULY 2022)

CRITERIA	18-07-2022	19-07-2022	20-07-2022	21-07-2022	22-07-2022	23-07-2022	TOTAL
SAMPLE HAEMOLYSED	2	2	2	5	3	3	18
SAMPLE CLOTTED	0	1	0	0	0	0	1
QNS	0	0	0	1	0	1	2
UN-LABELLED SAMPLE	0	0	0	0	0	0	0
MISMATCHED SAMPLE TYPE	0	0	0	0	0	0	0
MISMATCHED PATIENT ID	0	0	0	0	0	0	0
OTHER REASON	0	DILUTED SAMPLE	0	0	RECHECKED	WRONG VIAL	3
COLLECTED BY/AREA	0	0	0	0	0	0	0

Figure 1: Phase 1-Error Identification and Tracking showing sub categorization of phlebotomy error within a week from biochemistry Lab compliances were recorded, and subcategorized, concerning the sampling error done by the nurses which were analyzed for frequency, root causes, and potential impact on patient safety.

Within this week, the most common error was the occurrence of "haemolysed samples", "totalling 18 cases. Other errors included 2 instances of inadequate quantity, 1 case involving the incorrect vacutainer selection, and 1 instance of clotting from the biochemistry lab(as depicted in Figure:[1]).

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Phases:1 Error Identification and Tracking — Med-Mantra-Haematology lab

Criteria	Noncompliance Rate						
	18-07-2022	19-07-2022	20-07-2022	21-07-2022	22-07-2022	23-07-2022	*Average (Duration:1 Week)*
Total Sample Collected by the Nurses	576	465	551	487	481	483	3043
Collection Acknowledgement Time (T1)	366	334	415	348	343	331	2137
Collection Acknowledgement by the Nurses	366	334	415	348	343	331	2137
Dept Acknowledgement Time (T2)	29	18	44	29	14	12	146
Dept Acknowledgment by the Nurses	29	18	44	29	14	12	146
TAT(T2-T1) (MIN)	366	333	414	348	333	331	2125

Figure 2: Phase 1-Raw data Collection through Laboratory Tracking System Med-Mantra (Electronic Portal) from the Haematology lab depicting the rate of noncompliance by the nurses in 1 week

Further insight was provided through Figures [2]& [3], Illustrating the **rate and percentage of sample acknowledgment delays by nurses** over the same week. This data was sourced from the **Haematology lab via med-Mantra** (a Lab tracking system). For example, on July 18, 2022, Nurses collected a total of 576 samples. Among these, only 210 samples were collected and acknowledged on time (T1) by the nurses. Consequently, 366 (in terms of rate) were not promptly acknowledged, resulting in a noncompliance rate of 37%.

Fast In Action to Reduce Rejection (FARR): Phases:1 Error Identification and Tracking

Criteria (From Haematology)	Noncompliance Percentage						
	18-07-22	19-07-22	20-07-22	21-07-22	22-07-22	23-07-22	Average (Duration:1 Week)
Sample Collected By	0%	0%	0%	0%	0%	0%	0%
Collection Acknowledgement Time (T1)	37%	28%	25%	29%	29%	32%	30%
Collection Acknowledgement By	37%	28%	25%	29%	29%	32%	30%
Dept. Acknowledgment Time (T2)	95%	96%	92%	94%	98%	98%	96%
Dept. Acknowledgment By	95%	96%	92%	94%	98%	98%	96%
TAT(T2-T1) (MIN)	37%	28%	25%	29%	31%	32%	30%

Criteria	*Average Percentage Noncompliance (17th to 23rd July 2022)*
Sample Collected by the Nurses	0%
Collection Acknowledgement Time (T1)	30%
Collection Acknowledgement by the Nurses	30%
Dept Acknowledgement Time (T2)	96%
Dept Acknowledgment By	96%
TAT(T2-T1) (MIN)	30%

Figure 3: Phase 1--Raw data Collection through Laboratory Tracking System Med-Mantra (Electronic Portal) from the Haematology lab depicting the Percentage of noncompliance by the nurses in 1 week.

Consequently, the investigation revealed that only **70% of samples collected by nurses were timely acknowledged within the lab tracking system**. On Average, a **30% collection rate** was observed where samples **were not acknowledged promptly**, (as depicted in Figure [4])contributing to various sample errors during the week-long duration.

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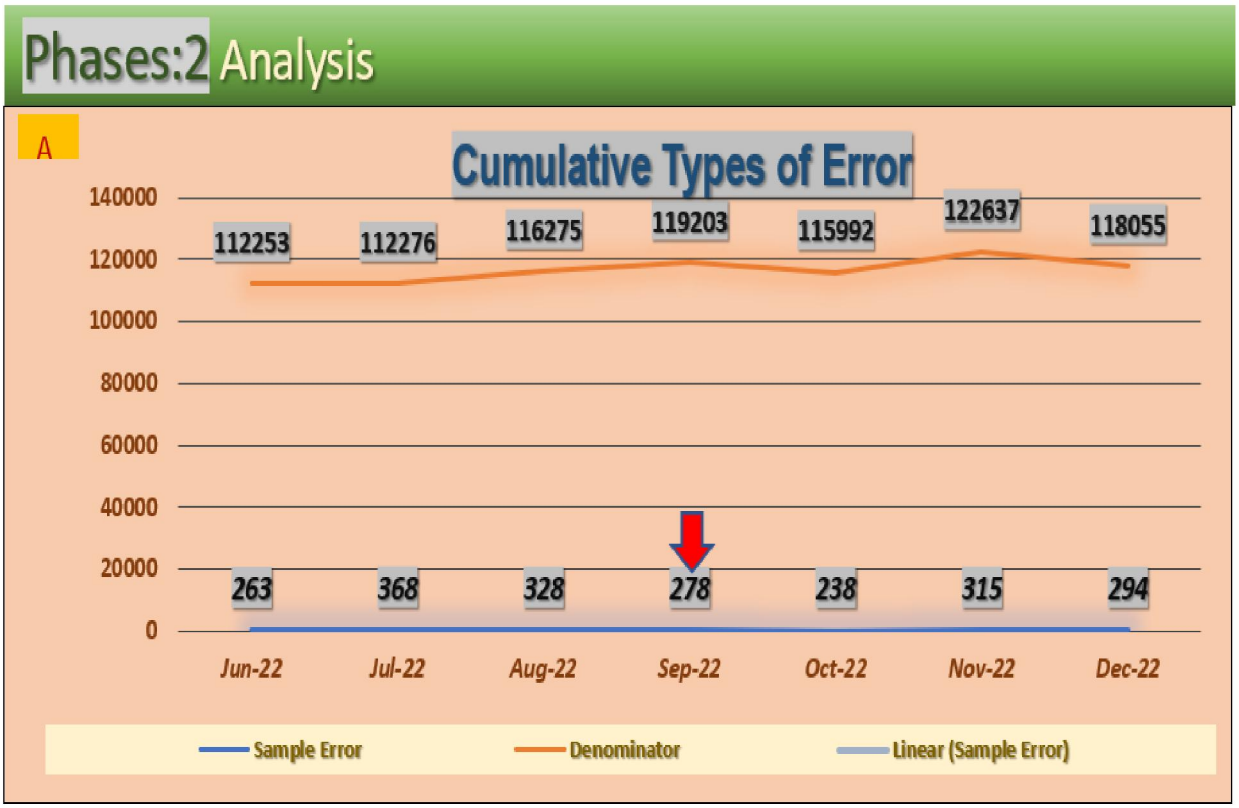
Phase 2: Analysis:

The sample errors are analyzed and categorized as follows:

- **Pre-analytical Errors:** These errors happen before the blood sample reaches the laboratory. They can include mistakes in patient identification, improper sample collection such as quantity not sufficient, haemolyzed, clotted, incorrect handlings such as diluted samples, transportation, or inadequate sample labelling.
- **Analytical Errors:** These errors occur during the actual testing process in the laboratory. They can involve instrument malfunctions, calibration issues, reagent or equipment errors, or human error during the testing and result interpretation.
- Cumulative Errors:
- **Random Errors**: Random errors are unpredictable and can occur sporadically during the different stages of blood sample analysis. They can be caused by various factors such as equipment variations, biological variability, or external influences.
- **Systematic Errors:** These errors are consistent and reproducible errors that can affect the accuracy and precision of blood sample analysis. They can arise from faulty equipment calibration, improper testing techniques, or biased interpretation of results.

It is important to note that errors can have cumulative effects throughout the entire process of blood sample analysis, from sample collection to result from interpretation. Regular quality control checks, standardized protocols, and continuous training of healthcare professionals can help minimize these errors.



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Errors In September			Cumulative Errors	
Types of Error	*Biochemistry Lab*	*Haematology Lab*	*Histopathology Lab*	*Microbiology Lab*
Haemolyzed Sample	80	1	Nil	Nil
Sample Clotted	1	141	Nil	Nil
Quantity Not Sufficient	2	14	Nil	Nil
Mismatched Sample Type	3	3	Nil	Nil
Mismatched patient ID	Nil	Nil	1	4
Diluted Sample	14	Nil	Nil	Nil
Rechecked Samples	14	Nil	Nil	Nil
Total Sample Errors	114	159	1	4
Grand Total:	278			B

Figure 4: Phase 2- ANALYSIS revealing A graphical presentation (A) showing cumulative sample errors focusing on September 2022 & and Subcategorization of the Sample Errors (B) in September 2022.

In the analysis phase, the cumulative errors were analyzed to identify patterns, trends, and common causes of errors by using root cause analysis techniques to determine the underlying reasons behind the errors which were done by the nurses (The graphical presentation of the cumulative errors and the list of sub-categorizations of the Phlebotomy errors happened in September 2022 are showing in figure: [4](A and B) The errors wereprioritized based on theirseverity and potential harm to patients.

Phase 3: Improvement and Implementation:

Sample Collection Process Flow with the order of Draw:

-In the improvement and implementation phase,to mitigate preanalytical blood sample errors followed a**standardized sample collection process flow**by applying the correct**order of draw**by the nurses throughout the Apollo Indraprastha Delhi (Figure [5]: Phase 3 Improvement and Implementation- showing the Sample Collection Process Flow & Order of Draw).

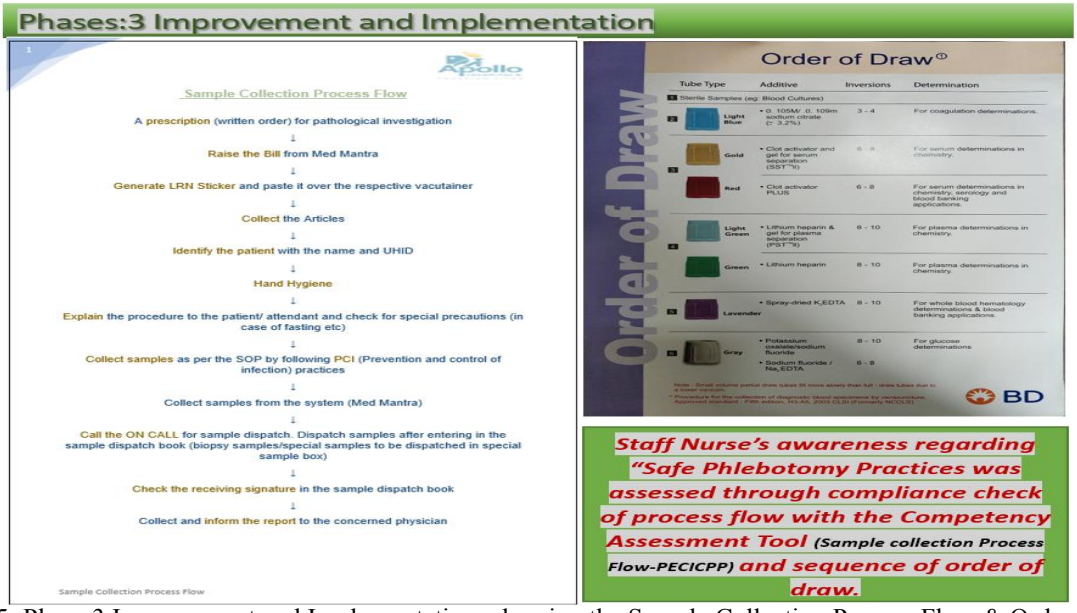

Figure 5: Phase 3 Improvement and Implementation- showing the Sample Collection Process Flow & Order of Draw

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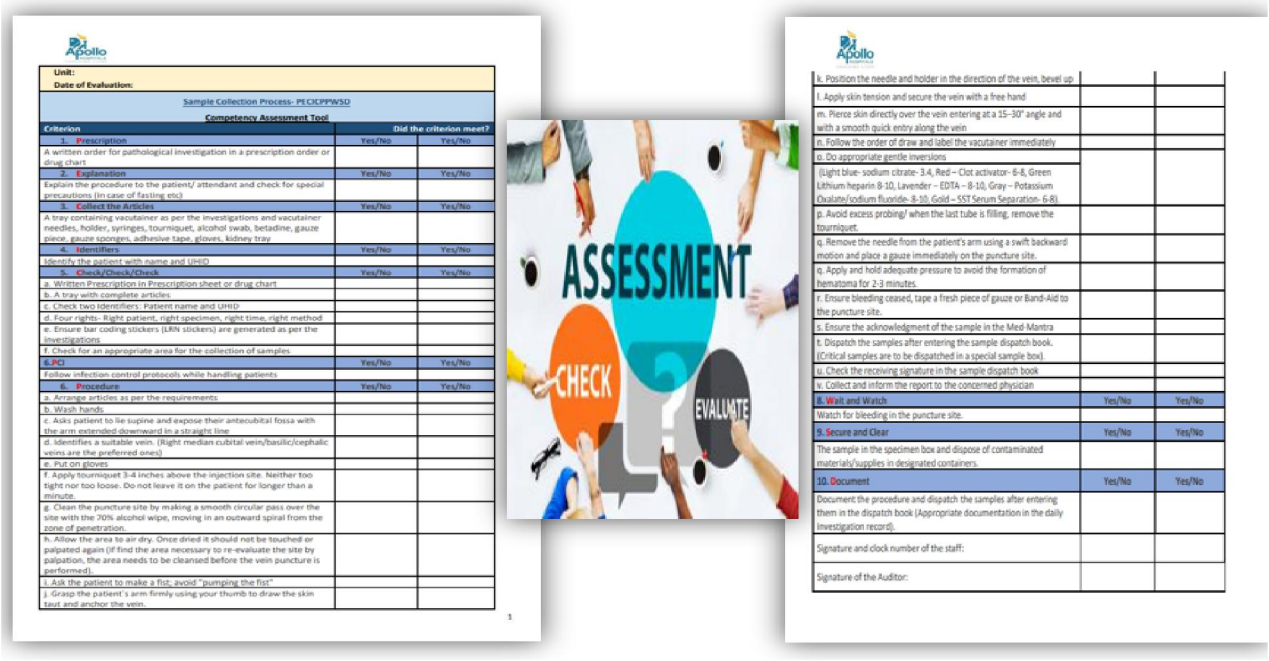

Figure 6: Phase 3-Quality check through a Competency assessment Tool (Checklist)

Staff nurse's knowledge was analyzed through a Competency assessment tool as shown in Figure [6]: Phase 3 (Checklist) Begin with a written prescription, raising a bill with an LRN sticker, collecting the articles, verifying patient identification, disinfecting the site, and allowing it to dry. Use the appropriate venipuncture technique, ensuring proper needle insertion and blood flow. Employ the correct order of draw to prevent cross-contamination or sample contamination. And, call on-call staff for sample Transportation, sample collection in the system (Med-Mantra), and documentation in the laboratory dispatch register with the sender and receiver's signature.

Reinforcement Training for All the Nurses on Sample Collection and Common Errors: Reinforcement training to all the nurses has been given on sample collection techniques by adopting the **Sample**

Figure 7: Phase 3 Improvement and Implementation- Showing glimpses of reinforcement training for all the nurses on sample collection and common errors.

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Collection Process Flow with the **Order of Draw** throughout the hospital [10]. Developed and implemented targeted interventions to address the identified errors and their root causes through daily tracking of the repeated samples from the respective laboratory for rectification by the concerned in-patient units for early action. Collaborate with healthcare providers and stakeholders to implement changes and ensure their effective adoption (Figure [7]: Phase 3 Showing glimpses of reinforcement training for all the nurses on sample collection and common errors).

Result:

Phase 4: Impact of the Campaign:

In the 4th phase of the campaign, it was found that tracking, analyzing, and implementing a campaign had a significant positive impact on minimizing preanalytical blood sample errors from**386** (in July) to **278** (in September) **within three months** (as shown inFigure [8]- Phase 4- Impact of the campaign revealed a positive impact on the number of sample errors (declining trend).Close monitoring and tracking of the frequency and types of errors occurring during sample collection by the nurses. It has become easier to identify patterns and root causes. Through data analysis, areas prone to errors were identified for incorrect patient identification, improper disinfection techniques, or deviations from the recommended order of draw.

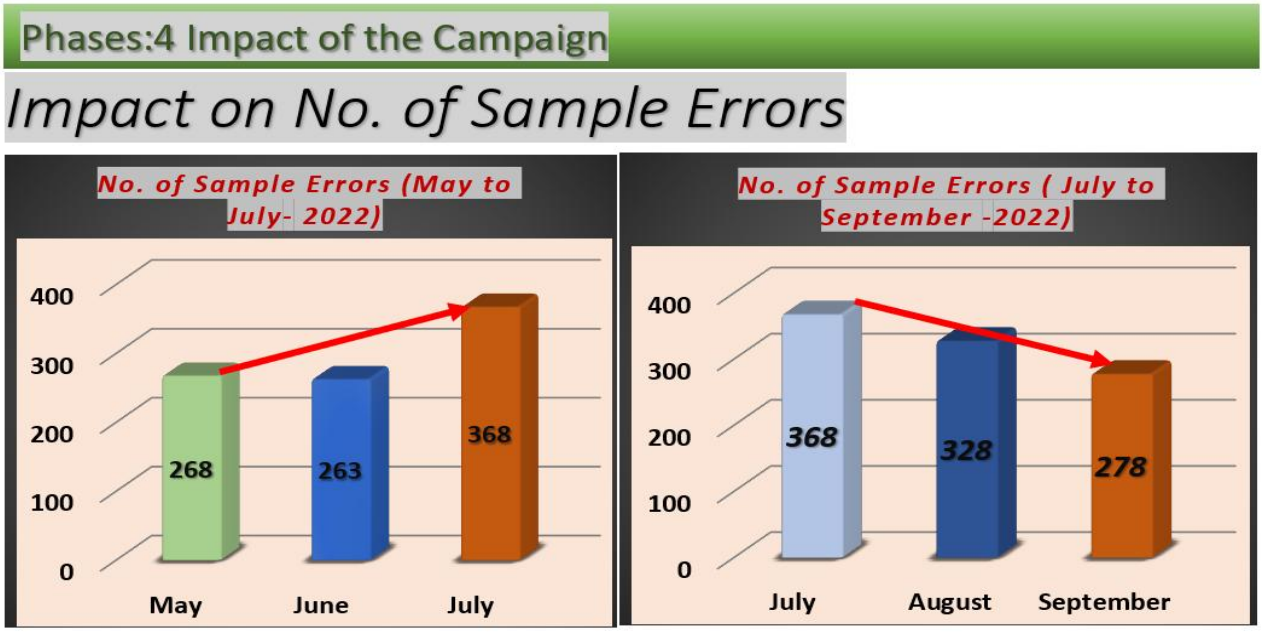

Figure 8- Phase 4- Impact of the campaign revealed a positive impact on the number of sample errors (declining trend)

Once the key areas of concern were identified, an educational campaign was implemented as the preventive strategy**to raise awareness amongst nurses** involved in sample collection [18]. This includes standardized Blood Sampling Protocols, training, and education, distribution of educational materials, and Quality Control Measures by conducting regular audits to ensure compliance, improve effective communication between healthcare professionals, including clinicians, nurses, and laboratory staff to reduce errors and improve patient safety and with opting for the**closed method of sample collection** as a best practice initiative [8].

III. DISCUSSIONS AND CONCLUSIONS

Before and After Comparison of CTQs (Critical-to-quality):

Based on the before and after comparison of the data, it appears that the campaign focused on **improving the critical-to-quality (CTQ) aspect of post-analytical blood sample rejection rates**. The average sample rejection rate per 1,00,000 samples decreased from**4% to 2.96%**(average total samples received by the laboratories were approximately 1L to 1.25L per month)after the campaign, indicating a positive impact on quality improvement (Figure [9]- Revealing improving outcomes in before and after comparisons of the critical-to-quality aspect of post-analytical blood sample rejection rates).

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Furthermore, the campaign successfully influenced a significant change in the method of blood collection. More than **1,000** nurses now feel confident in practicing the closed method for sample collection, transitioning from the previously utilized open method. This shift from open to closed method suggests a successful implementation of proper aseptic techniques and infection control measures, which can contribute to reducing pre-analytical errors associated with blood sample collection.

Before-After Comparisons of CTQs (Critical-To-Quality)

CTQ (s)	Unit of Measurement	Baseline Data	Improvement Target	After project Achievement
A high No. of Sample rejections	Reduce No. of sample rejections	Pre campaign Last 3 months average sample rejection rate per 1000 samples was **(4%- The target not achieved)**	Achieve < 10 for the next 3 months	Post post-campaign average sample rejection rate per 1000 samples is reduced to **2.96 from 4%.**
70% open method system usage for sample collection.	Adoption of the close method for sample collection	0%	The transformation from the open to the closed method for sample collection	>500 nurses were trained and felt confident to practice the closed method for sample collection.

Figure 9- Revealing improving outcomes in before and after comparisons of the critical-to-quality aspect of post-analytical blood sample rejection rates.

Overall, it is evident that the campaign has achieved remarkable success in mitigating pre-analytical blood sample errors. The reduction in rejection rates and the adoption of closed sample collection methods by a significant number of nurses demonstrate positive outcomes in maintaining sample quality and integrity.

Continuing training and education of the nursing staff [13]on proper sample collection techniques and adherence to established protocols are crucial in maintaining the success of the campaign. Regular quality control measures, such as proficiency testing and internal audits, should be conducted to identify any potential areas for improvement. It is important to note that while the closed method of sample collection reduces the risk of errors, it does not eliminate the possibility entirely. Human error can still occur, and therefore, ongoing vigilance and adherence to proper protocols are essential.

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