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Assessment of Laboratory Sample Management Workflows in Selected Hospitals in Angono Rizal: A Basis For Operational Strategic Plan

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ABSTRACT

Introduction: This study aims to consider the improvement of the laboratory sample handling activities in the selected hospitals in Angono, Rizal, Philippines by using Lean Six Sigma and Laboratory Information Management System.

Methods: A descriptive quantitative correlational research design was used where data were gathered by questionnaires among 30 respondents who worked as MedTech, Admins, and Cashiers in selected hospitals in Angono, Rizal.

Result and Discussion: This study showed the demographic profile of the 30 respondents wherein the majority was female, middle aged, predominantly Medical Technologists who had served the organization for 1 to 10 years. There were significant positive relationships between Lean Six Sigma, Laboratory Information Management System indicators, and total efficiency in the work-flow ($p < 0.001$) demonstrating that both Lean Six Sigma and Laboratory Information Management Systems are effective in improving hospital work- flow.

Conclusion: This study demonstrated that Lean Six Sigma and enhanced Laboratory Information Management Systems capabilities significantly boost laboratory productivity and organizational performance. It provides guidelines for strategic planning and continues education in laboratory, and suggests future research on implementing these improvements across diverse healthcare settings and with new technologies.

Keywords: Lean Six Sigma, Laboratory Information Management System (LIMS), Sample Handling, Healthcare Efficiency, Laboratory Workflow Organizational Performance, Productivity Improvement, Strategic Planning, Continuous Education, Quantitative Correlational Research, Medical Technologist, Hospital Operations, Angono Rizal, Healthcare Innovation , Demographic Analysis

I. INTRODUCTION

Background of the Study

Trends

Following the right protocols for sample processing is essential in clinical laboratory services to ensure the provision of high-quality medical care. Improved laboratory practice leads to more accurate analysis, which impacts patient care results, according to research. Because preserving the purity of cultures is essential for the precision of analytical tests and extremely relevant to clinical laboratories that provide data to guide seemingly important medical decisions, Gallion et al. (2020) emphasize the necessity of retaining single cells in a physiological condition. This is in line with other research that advocates for best practices, such as the Centers for Disease Control and Prevention's (CDC) recommendations for improving laboratory procedures and, therefore, healthcare institutions in general.

To overcome the problems concerning sources of variability in laboratory methods and difficulties in meeting the requirements of laboratory metabolomics analysis, Izumi *et al.* (2019) describe the distance metric-based approach. Errors related to the determination of the peak and differences in sensitivity due to instrument variances are also considered and the usage of reference databases as a way of resolution is proposed by this methodology. This enhances the possibility of merging and contrasting metabolite data across distinct laboratories, which in turn increases preciseness. Such recommendations clearly show a need to harmonize the methodologies used across laboratories, thereby improving accuracy in analysis, as well as improving convergence of data and results in clinical practice.

Issues

These issues in laboratory techniques were addressed in research done in Angono, Rizal. This research aimed to bridge the gap between what was done internationally and what was done within regions, with a focus on the proper delivery of health services. This study, in particular, attempts to bridge a gap in the diverse procedures employed by various institutions in terms of sample handling and analysis, which impedes uniformity for diagnosis,

patient care, and safety. As a result, the purpose of this study was to identify the performance gap in laboratories by assessing the key impediments that hospitals in Angono, Rizal confront, and then to give actionable recommendations for improving laboratory performance. Approach to carrying out the sample tracking, storage, and transfer in a correct manner. It is valuable to his work because it enlightens the viewer on the importance of proper sample management within biomedical research facilities and how it can eliminate error in such functions, and increase functionality. Fouad has revealed the fact that proper procedures of handling the data are crucial in achieving diagnostic quality and avoiding contamination of samples and data loss.

Furthermore, Evans *et al*. (2020) in their systematic review of quality assurance and control measures covering the analysis of untargeted metabolomics using LC-MS emphasize the serious use of protocols including the use of quality control samples, internal standards, and analytical acquisition templates.

Objectives

The study stated that to enable the production of accurate metabolomics data, is a factor they consider important in healthcare, especially when the consequences of the data are significant. This research therefore ushers in the idea of emphasizing on the need to implement quality control measures no matter the center or the region.

Even though all these global experiments have eased the development of laboratory best practice, there still remains major deficiencies in transitioning these guidelines in the local level. A case study of a school in Angono, Rizal looks at the theoretical policies of the school and finds that there are gaps between the two. There are issues of conformity to best practices that operating hospitals in this region experience and these are primarily attributed to resource constraints as well as the lack of a well-developed infrastructure for the implementation of uniformly applicable analytical techniques. Such disparities do not only impact negatively on the quality of laboratory services, but on diagnostic accuracy and reliability which play central roles in patients' management.

Contributions

Through these gaps, this study aims at presenting a conceptual framework of strategic interventions that may be implemented in the context of Angono, Rizal. These interventions will improve the sample management, flow of laboratory services, and quality of data therefore contributing positively to the quality of health delivery. Adopting and implementing standardized processes in the hospitals of the concerned region will increase operational productivity, reduce wastage of resources, and at the same time make compliance with the legal requirements imperative to safeguard the lives of the patients and enhance the timely delivery of services.

Consequently, though frameworks of global studies can be helpful to enhance clinical laboratory services, such experiences must be adapted to the hospitals of Angono, Rizal because of existing constraints. Through the application of research findings and incorporating those into a healthcare local context, this work seeks to assess the laboratory sample management workflows in the selected hospitals in Angono, Rizal and use it as a basis for operational strategic plan. echnology in shortening specimen handling processing times, exemplified in Alhammad (2023) during emergencies, shows how laboratory automation is speeding up the specimen handling process. Proper sample preparation is of utmost importance not only in the medical field but also in research facilities.

Literature Review

The review synthesized global best practices and local challenges across key domains:

- **Processing Time**: Critical to emergency care and outbreak response (Torres et al., 2021; Flipse, 2024)
- **Error Rates**: Pre-analytical errors impact sample rejection and quality (Alcantara et al., 2022; Noor et al., 2023)
- **Handoffs**: Poor interdepartmental transitions cause delays and contamination (Yaw et al., 2020)
- **Waste Management**: Improper disposal affects safety and cost (Ahmed et al., 2019)
- **Functionality & Integration**: LIMS improves traceability and data reliability (Kotowicz, 2023; Jundzill, 2023)
- **Training**: Continuous education ensures proper sample handling (Chen et al., 2020; Ye, 2024)

Theoretical Framework

1. **Systems Theory (Markus, 2023)**

- Views healthcare as a system composed of interconnected components.
- Applied to show how sample tracking, data management, and compliance interact via the Laboratory Information Management System (LIMS).
- Emphasizes LIMS as a central tool ensuring synchronization and operational alignment.

2. Process Improvement Theory (Whitenight, 2023)

- Focuses on identifying inefficiencies and improving workflow quality and resource utilization.
- Aligns with LIMS to enhance sample management and compliance through structured process analysis.
- Integrates Lean Six Sigma to evaluate and optimize lab functions—removing bottlenecks, shortening turnaround time, and improving sample quality.

3. Total Quality Management (TQM) (Deming, 2021)

- Supports continuous improvement, customer satisfaction, and operational excellence.
- Enhances data accuracy and compliance in lab settings.
- Strengthens collaboration between systems, supports structured training, and elevates the role of LIMS and Lean Six Sigma.

Conceptual Framework

INPUT	**PROCESS**	**OUTPUT**
Dependent Variables 1. The laboratory sample management workflow using the Lean Six Sigma in the selected hospitals in Angono Rizal in terms of: 1.1 Processing Time 1.2 Error Rates 1.3 Amount of Handoffs 1.4 Waste Management 2. The laboratory sample management workflow using LIMS in the selected hospitals in Angono Rizal in terms of: 2.1 Functionality 2.2 Accuracy 2.3 Integration of other Systems 2.4 Training 3. The overall efficiency of the laboratory sample management workflow in the selected hospitals in Angono Rizal Independent Variable The selected hospitals in Angono Rizal	Submission of Necessary Letters Data gathering through the use of survey questionnaire Tabulation, Analysis and Interpretation of Data Collected	Proposed Operational Strategic Plan

The combined concept of Laboratory Information Management System and Lean Six Sigma provides a strong background for improving effectiveness and forecasting management strategies of laboratory samples in the healthcare context. Laboratory Information Management System can be considered as the foundation by being the infrastructure for so many laboratory functions such as sample tracking, data processing, quality assurance, and regulatory compliance. Its strengths enable the automation of many repetitive tasks, guarantee the clarity and accuracy of data, and promote informed decisions, which creates a robust framework for efficient workflow.

Lean Six Sigma methodology, on the other hand, provides a more systematic approach to the optimization of processes and elimination of wastes. Both Lean and Six Sigma approaches can be used in managing samples within healthcare facilities to enhance efficiency by eradicating non-value-added activities and employing techniques that reduce variation and defects.

These can help create a foundation for an Operational Strategic Plan that focuses on efficiency objectives, quality enhancement, compliance, and growth. The establishment of such a plan confirms that healthcare organizations are capable of providing remedies for existing and future eventualities whilst also strengthening the capacity of delivering high- quality patient care and standards within the field effectively.

Statement of the Problems

The study aims to assess the laboratory sample management workflows in selected hospitals in Angono, Rizal and use it as a basis for an operational strategic plan. Specifically, the study aims to answer the following questions:

1.What is the demographic profile of the respondents in terms of:

1.1 Age

1.2 Gender

1.3 Position

1.4 Years in Service?

2. What is the laboratory sample management workflow using the Lean Six Sigma in the selected hospitals in Angono Rizal in terms of:

2.1 Processing Time

2.2 Service Staff Diversity

2.3 Error Rates

2.4 Amount of Handoffs

2.5Waste Management?

3. What is the laboratory sample management workflow using LIMS in the selected hospitals in Angono Rizal in terms of:

Functionality

3.1 Accuracy

3.2 Integration of other Systems

3.3 Training?

4.What is the overall efficiency of the laboratory sample management workflow in the selected hospitals in Angono

5. Is there a significant relationship on Lean Six Sigma, LIMS, and the overall efficiency of laboratory sample management workflow in the selected hospitals in Angono Rizal?

6.Based on the findings of the study, what operational strategic plan may be proposed?

Hypotheses

Ho. There is no significant relationship on Lean Six Sigma, LIMS, and overall efficiency of laboratory sample management workflow in the selected hospitals in Angono Rizal.

Definition of Variables

Processing Time. The time it takes to complete a prescribed procedure (Vocabulary.com, n.d.). In this study, the time to gather, store, analyze, and report a sample.

Error Rates. Refers to a measure of the degree of prediction error of a model made with respect to the true model (Ting, n.d.). In this study, the rate of error that happens in analyzing samples.

Number of Handoffs. To transfer (something) to another's possession (Merriam Webster Dictionary, n.d.). In this study, the time it takes to transfer one sample from a site to another.

Functionality.The quality of being suited to serve a purpose well (Oxford Languages, n.d). In this study, the effectiveness of workflows in a certain hospital.

Accuracy. The quality or state of being correct or precise (Oxford Languages, n d). In this study, the accuracy of analysis of samples that stems from efficient laboratory sample management.

Waste Management. A streamlined process that organizations use to dispose of, reduce, reuse, and prevent waste (Safety Culture, 2024). In this study, the reduction of wasteful samples and activities for a more efficient workflow.

Integration. The action or process of integrating (Oxford Languages, n d). In this study, the use of other systems beside LIMS for a more efficient workflow.

Training. The action of teaching a person or animal a particular skill or type of behavior (Oxford Languages, n d). In this study, the training the staffs receives in terms of sample management.

Efficiency. The ratio of the useful work performed (Oxford Languages, n d). In thus study, the efficiency of the workflow in a certain hospital.

Workflow. The sequence of industrial, administrative, or other processes through which a piece of work passes from initiation to completion(Oxford Languages, n d). In this study, the overall workflow of the hospital

II. METHODOLOGY

Research Design

The researchers employed a descriptive quantitative correlation process, one of the most popular methods for examining the relationship between variables without changing the respondents' behavior, to analyze the data they had gathered. In order to investigate and record the current situation about a certain topic or issue, descriptive research examines a particular subject or phenomena inside a specific setting (Mc Combes, 2023). The parameters influencing laboratory sample handling at nearby hospitals were to be identified and confirmed for the current study. This research design is considered to be one of the most useful methods where identification of who, what, where, how, and how many factors within the specified issue are fundamental.

By analyzing quantitative data, descriptive-correlational studies are possible to examine the relationship between the variables. The approach often involves the use of structured instruments, such questionnaires, and can more simply and uniformly distribute surveys to a large population (Cohen et al., 2021). Therefore, in order to organize participant replies, self-administered questionnaires were employed in this study. This approach gave the team the capacity to provide detailed empirical findings and, depending on the circumstances.

Specific details in the present case by examining possible links between sample handling procedures and laboratory data with higher quality or accuracy in the health care context.

2.1 Research Locale

The study was implemented in selected hospitals situated in Angono, Rizal, Philippines, which was chosen as the site for the investigation because it presented a typical view of the facilities in the area. Angono, located in Rizal Province provides an opportunity to observe the variety of laboratories and their sample management enhancing the overall understanding of the topic depending on the type of the healthcare organization. To increase the generalizability of the results it was crucial to include a diverse range of hospitals in Angono and the final sample of participants was purposefully selected to include all members of the laboratory staff, including but not limited to laboratory technicians, pathologists, and quality assurance officers. The geographical consideration allowed the study to detail local variations in the obstacles and approaches as well as inequality in laboratory sample handling, which is crucial for forming precise strategies for improving working processes and patients' outcomes. In targeting a specific locale, namely Angono, the study was intended to identify and contribute solutions to the problems faced by other healthcare organizations in the Philippines, hence improving on the overall healthcare delivery and outcomes in the region.

2.2 Participants

The selected participants of this study included professionals that directly deal with laboratory samples on their hospitals located in Angono, Rizal. This was consisted of medical technologists and laboratory technicians, admins and cashiers who were directly involved in sample processing and analysis to ensure that the tests were precise and fast. Admins of all levels in the participating hospitals were also asked to provide information about managerial outlooks regarding such factors as organizational actions and plans, as well as resource distributions and patterns pertaining to the general functioning of laboratory services. Furthermore, the training and development staff facilitated experiences in ongoing professionally relevant education; guaranteeing that the laboratory personnel remained updated in all current methodologies for the handling and preservation samples. In recruiting this multidisciplinary sample, the study sought to obtain a broad view of current practice and issues, as well as to map out possibilities to improve laboratory sample management with the participating healthcare facilities in Angono, Rizal

2.3 Instruments

For the researcher's specific purposes, the instruments that were used to gather data are survey questionnaires. With the use of survey questionnaires, specifically constructed by the researcher for the purpose of data gathering, the sampled respondents provided inputs as to their demographic

characteristics and opinions regarding the topic on hand. All data gathered through the use of the aforementioned instruments were personally collected, sorted out, tabulated, analyzed, and collated by the researcher herself to ensure credibility and completeness.

2.4 Data Collection Procedure

The process of data collection in this particular study focused on hospital laboratory sample management in Angono, Rizal through the use of a structured research procedure which aimed to generate accurate data acquisition method. Firstly, the survey questionnaire was developed and precisely written down depending on the conceptual framework and the respective research questions. After that, a pilot study was carried out with a sample of respondents with the aim of subsequently applying the tested questionnaire in practice, determine its ease of understanding, and prevent the occurrence of mistakes in the course of data collection.

In this case, participants were selected based on purposive sampling and come from different significant positions in the hospital laboratories, such as medical technologists, cashiers and administrative staff. This selection was formed to include various viewpoints and views on contemporary workflow and issues related to sample management. The questionnaires were either administered online if most of the participants were comfortable with the online format or in printed form if the majority of the participants were more comfortable with the print media. It is important to note that next to every questionnaire, respondents were provided with clear instruction on how to fill the questionnaires as well as the timeline for submission.

The responses to the questions gave explicit time limitation enabling all participants enough time to provide their response. Each participant received messages for a constant effective follow-up to remind users how to participate and increase the response rate. The subsequent phase after the data collection exercise was categorizing the responses that have

Been obtained. Proper scrutiny methods were used to avoid the occurrence of errors in data collection and to ensure all necessary information has been gathered.

As mentioned earlier, the data collected include quantitative responses to Likert scales and qualitative info from open ended questions and the data were analyzed. The quantitative covered the measurement of time, frequency, percentage, and relationship between variables.

Ethical factors were always taken into consideration from the time the overall strategy was designed to the subsequent planning, implementation, and evaluation phases. The identity of the participants remained unknown, and due consent were sought from all the respondents in the study. These ethical concerns are intended to maintain the credibility of the study and protect the subjects' rights and welfare to ensure the study meets the prerequisite standards

2.5 Data Analysis

Descriptive statistics were used in the statistical treatment of the data including percentage and weighted mean. Other tools like Pearson's R for correlation, frequency distribution for summarization, and the Likert scale for measuring agreement.

For the interpretation of the scales to answer the assessment of current system, the data below were used.

Scale	Limit	Interpretation
1	1 - 1.75	Strongly Agree
2	1.76 - 2.5	Agree
3	2.51 - 3.25	Disagree
4	3.36 - 4.00	Strongly Disagree

2.6 Ethical Considerations

Principle of ethical considerations has been highly emphasized in research especially when using human subjects. Ethical concerns being followed in this study on laboratory sample management in hospitals in Angono, Rizal include:

Firstly, participants gave a signed and written informed consent. It was fully explained to participants the objectives of the study, their consent to participate, any risks if there are and benefits involved and the freedom to withdraw from the study at times with no explanations needed.

It was important to ensure that participant information remains private at all times. It is important to note that all the data collected through the activity, including the survey questionnaire, were kept confidential and stored in a secure manner. Participants' identity was concealed or pseudonymized to avoid disclosure of their identifiers.

The participant's decision-making and their right to privacy are not be violated at any time during the whole study process. They have the right not to answer a question and to leave the survey or not to complete a specific question without any penalties.

The study was carried out in compliance with the pertinent ethical standards and the requirements set forth in the laws and rules governing research involving human participants, the researchers secured a permission from the institution (SBLC). In case of any other interest that may conflict with the ones that the author has declared, they shall be addressed as per the set standard.

Further, the research sought to ensure the patients and participating healthcare organizations benefit from it while any harm suffered is kept to zero. Recommendations from the study were grounded in the research findings to sensitize laboratory sample management practices, which should lead to a better delivery of healthcare services and, therefore, overall patient results

3. PRESENTATION, INTERPRETATION OF RESULTS, AND ANALYSIS

This chapter contains a detailed review of the results and a thorough analysis of the outcomes. The outline adheres the sequence of the study's specific problems.

3.1 Demographics

- Majority female (83.33%) and aged 36–45 years
- MedTechs dominated (83.33%)
- Most had 1–10 years in service (73.33%)

3.2 Lean Six Sigma Indicators

Indicator	Mean Score	SD	Interpretation
Processing Time	1.10	0.70	Strongly Agree
Error Rates	1.11	0.63	Strongly Agree
Handoffs	1.26	0.70	Strongly Agree
Waste Management	1.23	0.71	Strongly Agree

With high agreement scores in Processing Time, Error Rates, Handoffs, and Waste Management, respondents firmly supported the use of Lean Six Sigma in hospital workflow improvements. In line with earlier research that focused on time savings and established procedures to improve hospital performance, the composite mean validates the sense of overall efficiency.

3.3 LIMS Indicators

Indicator	Mean Score	SD	Interpretation
Functionality	1.61	0.71	Strongly Agree
Accuracy	1.28	0.87	Strongly Agree
Integration of Systems	1.68	0.85	Agree
Training	1.18	0.76	Strongly Agree

The effectiveness of LIMS in enhancing hospital processes, namely in the areas of functionality, accuracy, and training, was strongly agreed upon by the respondents. Although Integration of Systems had a high rating, it might yet be improved. According to the composite score, LIMS is generally seen favorably, which is consistent with previous research that highlights how it can improve data management, sample handling, and operational effectiveness.

3.4 Overall Efficiency of Workflows

Indicator	Mean	SD	Verbal Interpretation
Efficiency	1.48	0.6413	Strongly Agree

Composite Mean	**1.48**		**Strongly Agree**

Table 3.4 With a mean score of 1.48, 4 indicates that respondents strongly agree that hospital workflows are generally efficient. The findings, which are corroborated by research that links efficient workflow to enhanced team performance, patient outcomes, and laboratory productivity, show satisfaction with well-organized systems and few bottlenecks. It is advised to make constant improvements in order to maintain these high levels of efficiency.

3.5 Correlation Analysis

Variable	r-value	p-value	Significance
Processing Time	0.845	<0.001	Significant
Error Rates	0.874	<0.001	Significant
Handoffs	0.949	<0.001	Significant
Waste Management	1.000	<0.001	Significant
Functionality	0.907	<0.001	Significant
Accuracy	0.835	<0.001	Significant
Integration	0.870	<0.001	Significant
Training	0.912	<0.001	Significant

Table 3.5 shows that Lean Six Sigma and LIMS variables have strong, statistically significant relationships with the total efficiency of hospital workflow. Processing time, error rates, handoffs, waste management, functionality, accuracy, integration, and training are just a few of the indicators that demonstrate their influence on performance with positive r-values and p-values below 0.001. The two main contributors are Waste Management and Functionality. These conclusions are supported by literature, which highlights the value of Lean Six Sigma in workflow optimization, error reduction, and the enhancement of LIMS effectiveness through staff training and system integration.

3.6 Proposed Strategic Plan

Strategic Goals Matrix

Goal	Lean Six Sigma Approach	LIMS Mechanism	Expected Outcome
Improve Turnaround Time	DMAIC methodology	Automate tracking and notifications	Faster diagnosis and reduced sample loss
Enhance Accuracy	Poka-yoke (error-proofing)	Standardized test protocols	Reliable and replicable results
Reduce Waste	Value Stream Mapping	Real-time inventory monitoring	Lower costs and safer disposal practices
Strengthen Staff Performance	Capability Analysis	SOP tracking and training logs	Improved competency and accountability

By optimizing workflows, guaranteeing data integrity, enhancing inventory management, and facilitating data-driven decision-making, the integration of Lean Six Sigma with LIMS improves laboratory performance. While control charts and real-time monitoring aid in maintaining quality and efficiency, DMAIC techniques combined with LIMS automation minimize delays and errors. In healthcare labs, this well-coordinated approach fosters operational excellence and ongoing improvement.

4. Discussion

The outcomes demonstrate how well LIMS and Lean Six Sigma can improve sample workflow management. Integration promotes real-time decision-making, reduces waste, and greatly enhances functionality. High correlations among all variables attest to the fact that efficient workflows enhance patient outcomes and diagnostic accuracy while also saving time and money.

Implications

For Hospitals

- Regularize sample procedures by applying Lean Six Sigma.
- Implement a modular LIMS to ensure compliance and traceability.
- Invest in process automation-related personnel training.

For Laboratory Personnel

- Take part in ongoing professional development
- Use interconnected systems to make tasks more efficient.
- Encourage a culture of accountability and quality

For Future Research

- Examine how Lean Six Sigma might be used in other departments.
- Levels of benchmark system integration with foreign laboratories.
- Assess the training's long-term effects on operational results.

5. Conclusion

In order to improve laboratory sample management in regional hospitals, this study makes a strong case for combining Lean Six Sigma and LIMS as strategic tools. The results show a substantial correlation between improved performance and efficiency and both frameworks. For organizations looking to update laboratory operations while adhering to regulatory and diagnostic standards, the suggested operational strategic plan provides a replicable road map.

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