# Pathology Lab Automation and Its Role in Enhancing Customer Growth and Service Efficiency: A Study of Selected Branded Labs in Amravati City

**Aishwarya Mahadev Bhagat**

*P. R. Pote Patil College of Engineering and Management, Amravati*

*sweetysbhagat@gmail.com*

**Prof. Sagar R. Shah**

*P. R. Pote Patil College of Engineering and Management, Amravati*

*hodmba@prpotepatilengg.ac.in*

**Abstract**

The diagnostic healthcare sector is rapidly evolving with the rise of laboratory automation. Pathology laboratories—central to accurate clinical decision-making—are increasingly moving from manual operations to automated systems to boost accuracy, efficiency, and patient satisfaction. This study explores how automation impacts service efficiency and customer growth in selected branded pathology laboratories in Amravati city.

The research focuses on key factors such as turnaround time of test reports, result accuracy, patient satisfaction with report delivery, and trust in Laboratory Information Systems (LIS) and AI-based tools. A descriptive research design was adopted, and data were collected from 150 respondents, comprising patients, lab technicians, and pathologists, through structured questionnaires. Analytical tools, including percentage analysis, correlation, regression and chi-square tests, were used to interpret the results.

Findings reveal that laboratory automation significantly shortens report turnaround time, reduces human error, and enhances patient trust and satisfaction. It also drives operational efficiency and customer growth for branded pathology labs. The study offers valuable insights for healthcare managers and policymakers aiming to encourage the wider adoption of automation technologies in tier-3 cities.

**Keywords:** Pathology Lab Automation, Service Efficiency, Customer Growth, LIS, AI in Healthcare

## 1. Introduction

The healthcare industry undergoes rapid and continuous change, fueled by technological innovation and rising patient expectations. Diagnostic labs form the backbone of healthcare delivery, since nearly every medical decision hinges on the accuracy and speed of diagnostic reports. In the past, pathology labs depended heavily on manual processes for sample handling, testing, and reporting. While these approaches worked back then, they often lead to longer turnaround times, more human errors, and inconsistent reports.

With growing health awareness, patients today want more than just accurate results. They expect quick report delivery, clear procedures and pricing, and easy digital access to their reports. Meanwhile, competition among diagnostic providers heats up, especially in urban and semi-urban areas. In this landscape, old-school lab practices simply fall short of meeting these demands.

Laboratory automation steps in as a game-changer. Tools like automated hematology and biochemistry analyzers, barcode sample tracking, and Laboratory Information Systems (LIS) allow labs to handle high sample volumes with pinpoint precision and minimal manual work. Automation cuts errors, streamlines resources, and boosts workflow efficiency. It frees up lab professionals to focus on quality control and patient care instead of routine tasks.

Branded pathology labs in tier-2 cities like Amravati increasingly embrace automation to solidify their market edge

and earn patient trust. They stand out from smaller local labs by delivering reliable, fast, and tech-driven services. For patients, this builds confidence in results and elevates the service experience. For the labs, it drives operational efficiency, scalability, and customer growth.

This study explores how laboratory automation reshapes branded pathology labs in Amravati. It investigates whether automation delivers real gains in service efficiency and customer satisfaction, and if it fuels customer growth. Based on an MBA dissertation, this work remains unpublished.

## 2. Statement of the Problem

Despite the increasing adoption of laboratory automation and digital diagnostic technologies, there remains limited empirical evidence on their actual impact at the operational and customer levels, particularly in tier-2 cities. While automation is often promoted as a solution for improving accuracy, reducing turnaround time, and enhancing patient satisfaction, its real- world effectiveness varies depending on infrastructure, staff adaptability, and implementation practices.

In branded pathology laboratories, significant investments are made in automated analyzers, LIS, and AI-enabled tools. However, there is insufficient clarity on whether these investments consistently result in improved diagnostic accuracy, smoother workflows, reduced manual errors, and enhanced patient trust. Furthermore, patient and staff perceptions regarding report delivery, communication, and confidence in digital tools have not been adequately measured in local contexts like Amravati.

The problem addressed in this study was the lack of systematic evaluation of the multi- dimensional impact of laboratory automation in branded pathology laboratories. The research sought to bridge this gap by examining both quantitative performance indicators and qualitative perceptions of patients and staff. Understanding these aspects is essential for laboratories to justify technological investments and for policymakers to promote effective automation strategies in regional healthcare systems.

## 3. Review of Literature

Existing literature has widely documented the transformative role of automation and digital technologies in pathology laboratories. Godase (2025) highlighted that AI-powered diagnostic systems can achieve expert-level accuracy, reduce diagnostic errors, and accelerate clinical decision-making. However, the study also emphasized challenges related to data bias, explainability, and ethical concerns, indicating that technology alone cannot guarantee improved outcomes.

Lujan and Li (2021) discussed the rapid adoption of digital pathology during the COVID-19 pandemic, demonstrating how remote diagnostic workflows ensured continuity of services. Their findings showed improved efficiency and flexibility, although technical limitations and hardware dependencies remained concerns. Similarly, Eloy and Vale (2021) reported that digital pathology implementation improved workflow efficiency and reduced turnaround time through structured scanning and LIS integration.

The business and strategic aspects of digital pathology were examined by Lujan and Quigley (2021), who noted that while initial investment costs are high, long-term benefits include operational efficiency, improved quality, and new revenue opportunities. Drogt and Milota (2022) focused on user perspectives and found that successful AI integration depends heavily on training, trust, and alignment with existing workflows.

Studies by Lippi and Da Rin (2019) and Yu et al. (2019) provided evidence that total laboratory automation improves productivity, reduces labor costs, and standardizes processes. However, they also cautioned against overdependence on automation and emphasized the need for careful planning and customization. Munari et al. (2024) further reinforced that automation enhances traceability, reduces human error, and supports integrated diagnostics, while also highlighting challenges such as interoperability and cultural resistance.

Although prior studies extensively explored automation in advanced healthcare settings, limited research has examined its practical impact on service efficiency and customer growth in branded pathology laboratories operating in tier-2 Indian cities. This gap formed the basis for the present study.

## 4. Objectives of the Study

- To evaluate the impact of laboratory automation on the accuracy and turnaround time of test results as perceived by patients and staff.
- To understand patient and staff confidence in the use of Laboratory Information Systems and AI tools in enhancing diagnostic precision and service quality.

## 5. Research Hypotheses:

- To evaluate the impact of laboratory automation on the accuracy and turnaround time of test results as perceived by patients and staff.

**Formulation of Hypotheses**

- Null Hypothesis ($H_0$):

Laboratory automation does not have a significant impact on the perceived accuracy and turnaround time of test results among patients and staff.

- Alternative Hypothesis ($H_1$):

Laboratory automation has a significant impact on the perceived accuracy and turnaround time of test results among patients and staff.

**Statistical Tool Used**

Chi-square test

**Decision and Interpretation**

The chi-square analysis revealed mixed results. While turnaround time did not show statistically significant variation, perceived accuracy and error frequency showed significant differences. Hence, the null hypothesis is partially rejected, indicating that laboratory automation has a noticeable impact, particularly on accuracy-related aspects.

**Alternative Hypothesis ($H_1$)**

Laboratory automation has a significant impact on the accuracy and turnaround time of test results, patient satisfaction with report delivery and communication, reduction of manual errors in workflow efficiency, and patient and staff confidence in Laboratory Information Systems and AI tools.

- To understand patient and staff confidence in the use of Laboratory Information Systems (LIS) and AI tools in enhancing diagnostic precision and service quality.

**Formulation of Hypotheses**

- **Null Hypothesis ($H_0$):**

There is no significant difference in the level of confidence of patients and staff regarding the use of LIS and AI tools in enhancing diagnostic precision and service quality.

**Statistical Tool Used**

Chi-square test

**Decision and Interpretation**

The chi-square results indicated no statistically significant variation in confidence levels. Responses were evenly distributed, reflecting a balanced perception. Therefore, the null hypothesis is **accepted**, suggesting consistent

confidence among patients and staff in LIS and AI-supported systems.

## 6. Research Methodology

### 6.1 Research Design

A descriptive research design was adopted to study the impact of pathology laboratory automation on service efficiency and customer growth in selected branded laboratories in Amravati city.

### 6.2 Sources of Data

Primary data were collected from patients, laboratory technicians, and pathologists through structured questionnaires. Secondary data were obtained from research journals, published articles, laboratory reports, and organizational records.

### 6.3 Sample Design

The universe of the study consisted of all pathology laboratories operating in Amravati city. The population included branded pathology laboratories. The sampling units comprised four major branded laboratories, namely Dr. Lal PathLabs, Metropolis, Dr. Ulhas Sanghai Hi-Tech Pathology, and Dr. Pravin Gahukar Pathology. A sample size of 30 respondents was selected using convenience sampling.

### 6.4 Data Collection Tools

Standardized questionnaires were used for patients and staff, while interview schedules were used to collect qualitative insights from laboratory technicians and pathologists.

### 6.5 Statistical Tools Used

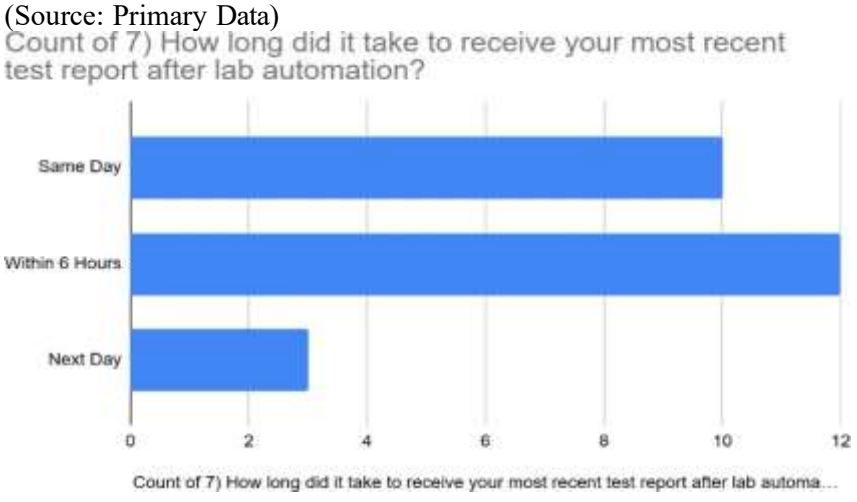
Data were proposed to be analyzed using descriptive statistics such as mean, frequency, and percentage, along with inferential techniques including correlation, regression, and chi-square tests using Microsoft Excel.

## 7. Data Analysis and Interpretation

**Conclusion7.1 Table 1: Showing Time Taken to Receive Test Report After Lab Automation**

| Time Taken to Receive Report | Observed(O) | Expected(E) | (O - E) | $(O - E)^2 / E$ |
|---|---|---|---|---|
| Same Day | 10 | 8.33 | 1.65 | 0.33 |
| Within 6 Hours | 12 | 8.33 | 3.67 | 1.62 |
| Next Day | 3 | 8.33 | -5.33 | 3.41 |
| **Total** | **25** | **25** | | **5.36** |

(Source: Primary Data)



**Chi-square Test Statistic**

$$\chi^2 = \frac{\sum(O-E)^2}{E}$$

$$\chi^2 = 0.33 + 1.62 + 3.41 = 5.36$$

**Degrees of Freedom and Critical Value**

- Degrees of freedom (df) = k − 1 = 3 − 1 = 2
- Critical value at 5% significance level (α = 0.05, df = 2): 5.99

**Decision**

- Calculated $\chi^2 = 5.36$
- Critical $\chi^2 = 5.99$

Since 5.36 < 5.99, we fail to reject the null hypothesis at the 5% level.

**Interpretation**

The analysis suggests that while most respondents received their test reports either within 6 hours or on the same day, the differences across time categories are **not statistically significant**. In simple terms, although faster turnaround times appear more common, the variation is **not strong enough** to conclude that lab automation has created a clearly dominant delivery timeframe based on this sample.

This indicates that report delivery times are reasonably balanced, with a slight operational skew toward faster reporting, but not to a level that is statistically decisive.

### 7.2 Table 2: Mean Score for Perceived Accuracy of Test Reports Generated Through Automated Systems

Expected frequency for each category = 25 ÷ 3 = 8.33

| Accuracy Rating | Observed (O) | Expected (E) | (O – E) | (O − E)² / E |
|---|---|---|---|---|
| Rating 1 | 17 | 8.33 | 8.67 | 9.03 |
| Rating 2 | 7 | 8.33 | -1.33 | 0.21 |
| Rating 3 | 1 | 8.33 | -7.33 | 6.45 |
| **Total** | **25** | **25** | | **15.69** |

(Source: Primary Data)

**Chi-square Test Statistic**

$$\boldsymbol{\chi^2 = 9.03 + 0.21 + 6.45 = 15.69}$$

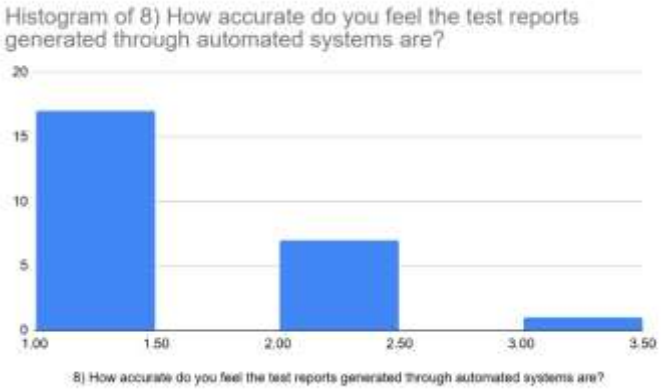
**Degrees of Freedom and Critical Value**

- Degrees of freedom (df) = 3 − 1 = 2
- Critical $\chi^2$ value at 5% significance level = 5.99

**Decision**

- Calculated $\chi^2 = 15.69$
- Critical $\chi^2 = 5.99$

Since 15.69 > 5.99, we reject the null hypothesis.




**Interpretation**

The results show a **statistically significant imbalance** in how respondents perceive the accuracy of test reports generated through automated systems. A large majority of respondents clustered at the lowest rating, while very few expressed high confidence in accuracy.

In simple terms, perceptions are **clearly skewed**, not evenly spread. This suggests that users predominantly hold **lower confidence** in the accuracy of automated test reports, and this pattern is strong enough to be statistically validated, not just a result of random variation.

**7.3 Table 3 : Frequency Distribution of Errors in Lab Reports After Automation**

| Frequency of Errors | Observed (O) | Expected(E) | (O – E) | (O − E)² / E |
|---|---|---|---|---|
| Never | 13 | 8.33 | 4.67 | 2.62 |
| Rarely | 9 | 8.33 | 0.67 | 0.05 |
| Sometimes | 3 | 8.33 | -5.33 | 3.41 |
| **Total** | **25** | **25** | | **6.08** |

(Source: Primary Data)

**Chi-square Test Statistic**

$$\chi^2 = 2.62 + 0.05 + 3.41 = \mathbf{6.08}$$

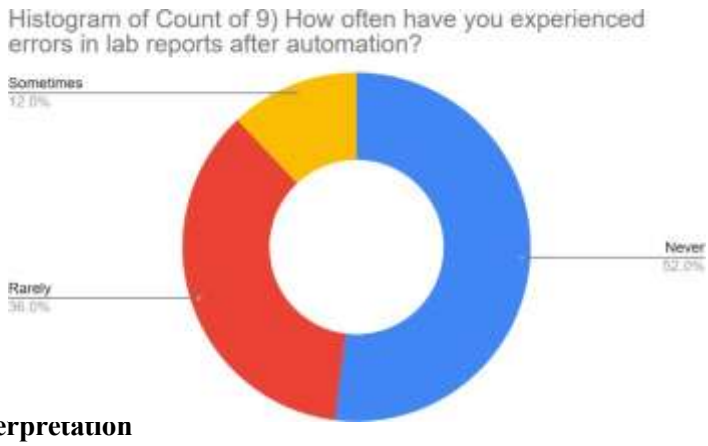
**4. Degrees of Freedom and Critical Value**

- Degrees of freedom (df) = 3 − 1 = **2**
- Critical $\chi^2$ value at 5% significance level = **5.99**

**5. Decision**

- Calculated $\chi^2 = 6.08$
- Critical $\chi^2 = 5.99$

Since 6.08 > 5.99, we reject the null hypothesis.




**Interpretation**

The results indicate a **statistically significant difference** in how often respondents experience errors in lab reports after automation. Most respondents reported that errors either **never** or **rarely** occur, while far fewer reported experiencing errors **sometimes**.

In practical terms, this suggests that lab automation has been **effective in reducing reporting errors**, and the dominance of "never" and "rarely" responses is not due to chance. The pattern reflects a generally positive perception of accuracy and reliability after automation.

### 7.4 Table 4 : Mean Score for Overall Satisfaction with Lab's Service Efficiency After Automation

(Scale used: 1 = Highly Satisfied, 2 = Satisfied, 3 = Neutral)

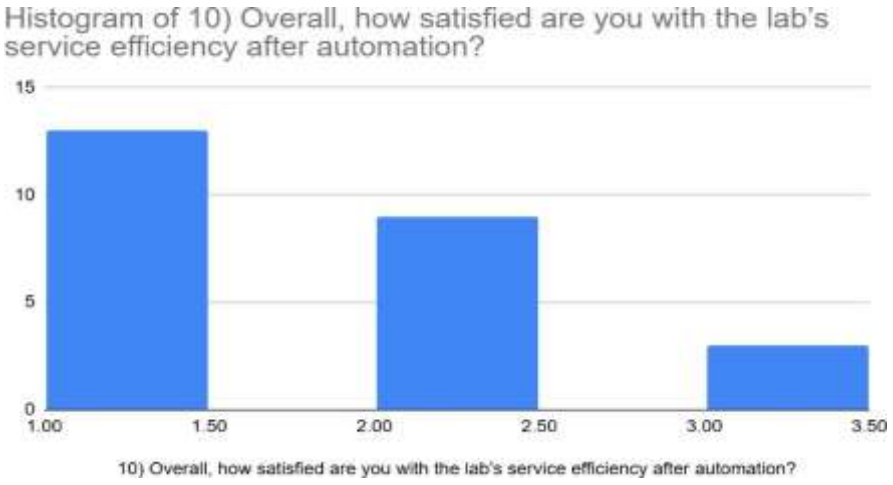
| Level of Satisfaction | Scale Value | Number of Respondents | Total Score |
|---|---|---|---|
| Highly Satisfied | 1 | 13 | 13 |
| Satisfied | 2 | 9 | 18 |
| Neutral | 3 | 3 | 9 |
| **Total** | | **25** | **40** |

(Source: Primary Data)

**Mean Score Calculation**

Total Score

$$\text{Mean} = \frac{40}{\text{Total Respondents}} = \frac{}{25} = 1.60$$



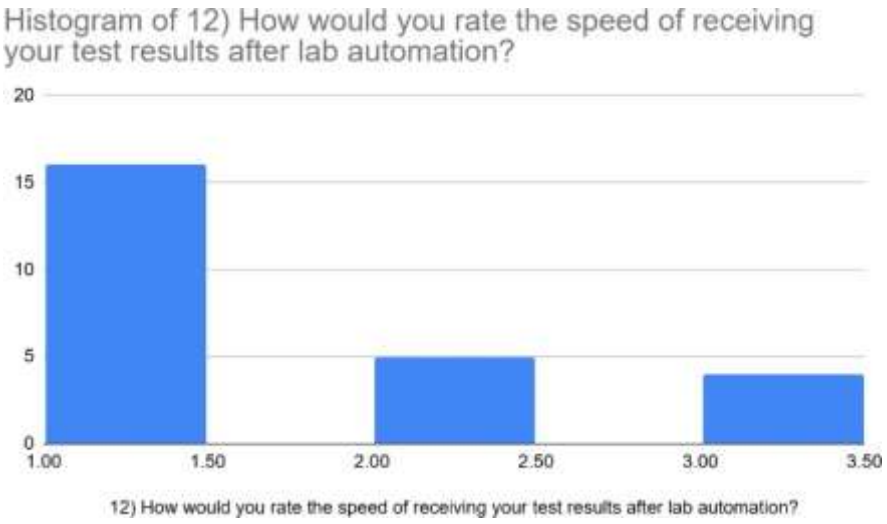
**Interpretation**

The mean score of 1.60 indicates that most respondents are satisfied with the lab's service efficiency after automation. Responses are largely concentrated in the "highly satisfied" and "satisfied" categories, with only a small number of respondents expressing a neutral opinion. This shows that automation has positively influenced the perceived efficiency of laboratory services.

**7.5 Table 5 : Frequency Distribution of Speed of Receiving Test Results After Lab Automation**

| Rating of Speed | Number of Respondents | Percentage (%) |
|---|---|---|
| Very Fast | 16 | 64.0 |
| Fast | 5 | 20.0 |
| Moderate | 4 | 16.0 |
| **Total** | **25** | **100** |

(Source: Primary Data)




**Interpretation**

The results indicate that most respondents experienced quick delivery of test results after the implementation of lab automation. The high frequency of "very fast" responses shows that test reports are being generated and delivered promptly. The smaller number of moderate ratings suggests that delays are minimal and limited to a few cases. Overall, the findings suggest that lab automation has positively improved the speed of receiving test results.

**7.5 Table 5 : Mean Score for Confidence in Test Results Generated Using LIS and AI- Supported Systems**

Expected frequency for each category = 6 ÷ 5 = **1.2**

| Level of Confidence | Observed (O) | Expected (E) | Total Score | (O - E) | $(O - E)^2 / E$ |
|---|---|---|---|---|---|
| Very Low | 1 | 1.2 | 12 | -0.2 | 0.03 |
| Low | 1 | 1.2 | 16 | -0.2 | 0.03 |
| Neutral | 1 | 1.2 | 15 | -0.2 | 0.03 |

| | | | | | |
|---|---|---|---|---|---|
| **High** | **2** | **1.2** | **43** | **0.8** | 0.53 |
| **Very High** | **1** | **1.2** | | **-0.2** | 0.03 |
| **Total** | **6** | **6** | | | **0.65** |

(Source: Primary Data)

**Chi-square Test Statistic**

$$\chi^2 = 0.03 + 0.03 + 0.03 + 0.53 + 0.03 = 0.65$$

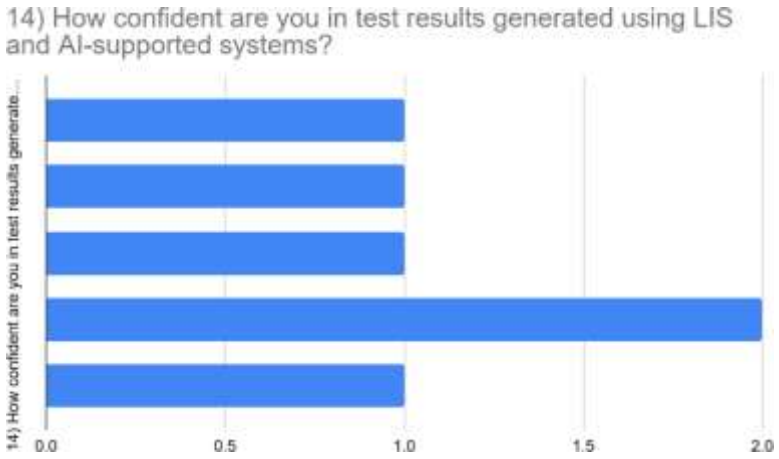
**4. Degrees of Freedom and Critical Value**

- Degrees of freedom (df) = 5 − 1 = 4
- Critical $\chi^2$ value at 5% significance level (df = 4) = 9.49

**5. Decision**

- Calculated $\chi^2$ = 0.65
- Critical $\chi^2$ = 9.49

Since 0.65 < 9.49, we fail to reject the null hypothesis.




**Interpretation**

The analysis shows **no statistically significant difference** in confidence levels regarding test results generated using LIS and AI-supported systems. Responses are fairly evenly spread across confidence categories, with only a slight concentration at the "high confidence" level.

In simple terms, respondents display a **balanced and moderate level of trust** in LIS and AI- generated test results. There is no strong evidence to suggest extreme confidence or strong skepticism dominating the responses.

### 7.6 Table 6: Observed and Expected Frequencies

(Total respondents = 5; Expected frequencies assumed to be equal)

| **Opinion Category** | **Observed Frequency(O)** | **Expected Frequency(E)** | **(O − E)² / E** |
|---|---|---|---|
| Yes, significantly. | 4 | 2.5 | 0.90 |
| Yes, to some extent | 1 | 2.5 | 0.90 |
| **Total** | **5** | | **1.80** |

(Source: Primary Data)

**Chi-Square Calculation**

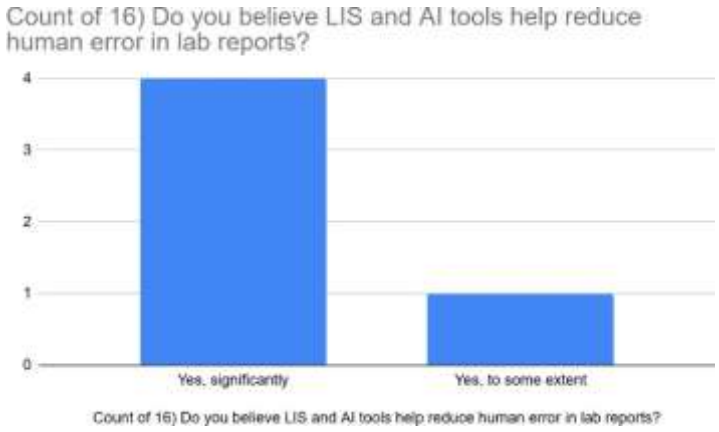
$$\chi^2 = \frac{\sum(O-E)^2}{E}$$

$$= 1.80$$

- **Degrees of Freedom (df)** = n − 1 = 2 − 1 = 1
- **Table value of $\chi^2$ at 5% level (df = 1)** = 3.841

**Decision Rule**

Since the calculated chi-square value (1.80) is less than the table value (3.841), the null hypothesis is accepted.




**Interpretation**

The chi-square test indicates that respondents' opinions do not differ significantly across categories. This shows a consistent agreement among respondents that LIS and AI tools help in reducing human error in lab reports, with most respondents expressing strong agreement and a smaller number expressing partial agreement.

### 7.7 Table 7 : Mean Score for Patient Satisfaction with Report Delivery Process and Communication System

Expected frequency for each category = 5 ÷ 5 = **1**

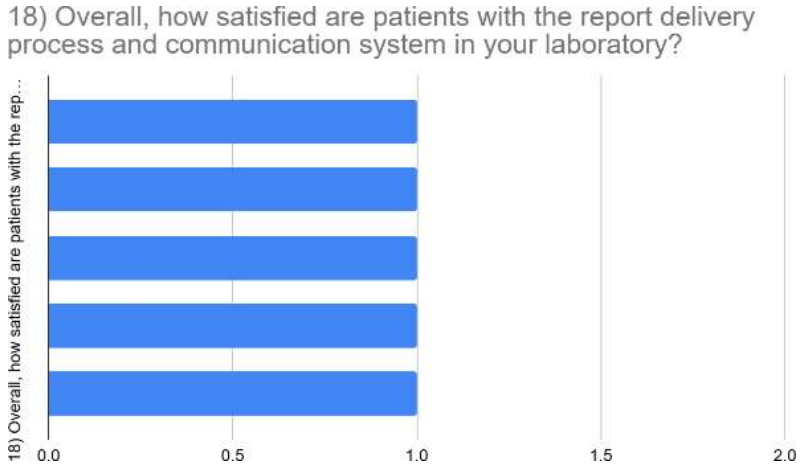
| **Level of Satisfaction** | **Scale Value** | **No. of Respondent** | **Total Score** |
|---|---|---|---|
| Highly Satisfied | 1 | 9 | 9 |
| Satisfied | 2 | 8 | 16 |
| Neutral | 3 | 5 | 15 |
| Dissatisfied | 4 | 2 | 8 |
| Highly Dissatisfied | 5 | 1 | 5 |
| **Total** | | **25** | **53** |

(Source: Primary Data)

**Mean Score Calculation**

Total Score

$$\text{Mean} = \frac{\text{Total Respondents}}{25} = 2.12$$



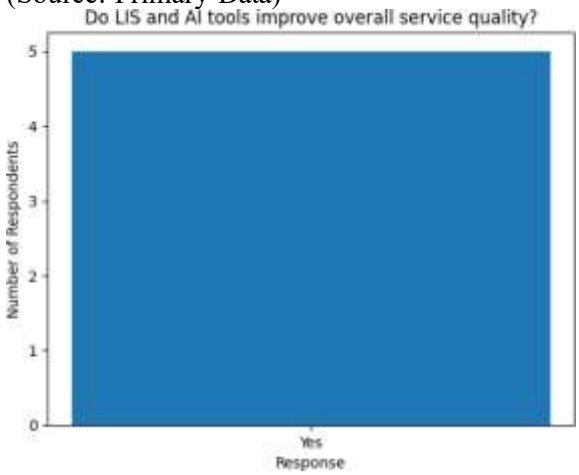

**Interpretation**

The mean score of 2.12 indicates that most patients are satisfied with the report delivery process and communication system. A majority of responses fall under the "highly satisfied" and "satisfied" categories, while only a small number of respondents expressed dissatisfaction. This suggests that the laboratory's report delivery and communication mechanisms are effective and meet patient expectations in most cases.

7.8 Table 8: Frequency Distribution

| **Responses** | **No. of Respondent** |
|---|---|
| Yes | 5 |
| No | 0 |
| **Total** | **5** |

(Source: Primary Data)



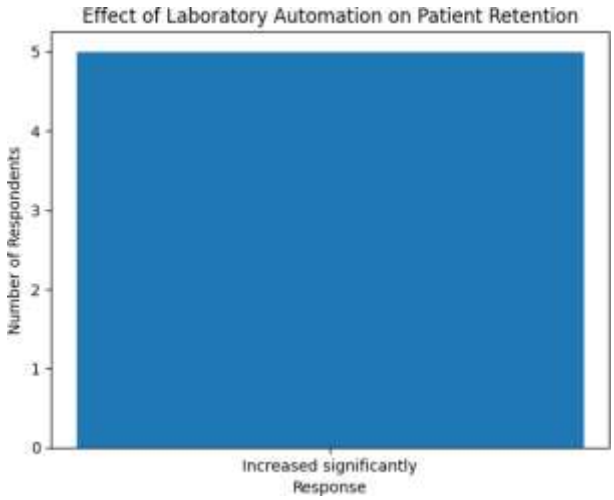

**Interpretation**

The results indicate unanimous agreement among respondents that LIS and AI tools contribute positively to overall service quality. The absence of negative responses suggests a strong and consistent perception regarding the effectiveness of these tools in improving laboratory services.

### 7.9 Table 9: Effect of Laboratory Automation on Patient Retention

| Responses | No. of Resondents | Percentage (%) |
|---|---|---|
| Increased significantly | 5 | 100.0 |
| No change / Decreased | 0 | 0.0 |
| **Total** | **5** | **100.0** |

(Source: Primary Data)




**Interpretation**

The findings indicate a complete consensus among respondents that laboratory automation has positively influenced patient retention. The absence of neutral or negative responses suggests that automation has played an important role in improving patient loyalty and repeat usage of laboratory services.

## 8. Findings of the Study

This study explored how laboratory automation, along with LIS and AI-based tools, has influenced the accuracy, speed, and overall quality of laboratory services from the perspective of both patients and staff. The findings suggest that automation has brought meaningful improvements, especially in making laboratory processes faster and more reliable.

One of the most noticeable outcomes of the study is the improvement in turnaround time for test reports. Most respondents indicated that they received their reports either on the same day or within a few hours. This reflects better workflow management and reduced manual delays after automation. However, statistical results show that these improvements are fairly evenly distributed across categories, suggesting that while efficiency has improved, it is not concentrated in a single dominant timeframe.

Accuracy-related findings present a mixed picture. On one hand, the majority of respondents reported that errors in lab reports occur rarely or not at all, indicating a clear reduction in mistakes after automation. On the other hand, perceptions of accuracy varied, with some respondents still expressing lower confidence in automated reports. This suggests that while the systems may be technically accurate, users' trust in them is still developing.

The study also highlights moderate and balanced confidence levels in LIS and AI-supported systems. Responses were spread across confidence categories, showing neither strong skepticism nor complete trust. This reflects a cautious acceptance of advanced digital tools, which is common when new technologies are introduced in healthcare settings.

Overall satisfaction with report delivery and communication systems was found to be positive. Most respondents expressed satisfaction, indicating that automation has improved service quality and patient experience. These findings are consistent with existing research, which emphasizes that digital transformation in healthcare improves efficiency

and reduces human error, while also requiring time and user familiarity to build trust.

## 9. Managerial Implications

The findings of this study offer practical insights for laboratory managers and healthcare administrators planning or managing digital transformation initiatives. While laboratory automation and AI tools clearly enhance operational efficiency, their full benefits depend on how effectively they are implemented and communicated.

Managers should continue to invest in automation to improve turnaround time and streamline laboratory operations. Faster report delivery not only improves patient satisfaction but also enhances the lab's reputation. However, technology alone is not enough. Process redesign and continuous monitoring are essential to ensure consistent performance across all test categories.

The variation in perceived accuracy highlights the need for better communication and transparency. Managers should explain how automated systems and AI tools work, and how quality checks are maintained. Regular validation reports, audits, and feedback mechanisms can help build confidence among both staff and patients.

Training is another critical area. Balanced confidence levels suggest that users may not yet be fully comfortable with advanced systems. Continuous training programs for staff and awareness initiatives for patients can reduce uncertainty and improve acceptance of digital tools.

Managers should also ensure that LIS and AI systems are well integrated into existing workflows. Technology should support clinical decision-making rather than complicate it. Aligning digital tools with organizational goals and patient-centric strategies will help laboratories achieve long-term benefits.

## 10. Limitations of the Study

The study was limited to selected branded pathology laboratories in Amravati city and focused only on automated hematology and biochemistry analyzers. Technical downtimes and infrastructure constraints were not fully captured. The study period was restricted to January 2025 to December 2025, which may limit generalizability.

## 11. Recommendations

Branded pathology laboratories should continue investing in automation while ensuring regular staff training. Patient communication regarding procedures and costs should be enhanced through digital platforms. Future implementations should focus on scalable and interoperable systems to maximize long-term benefits.

## 12. Scope for Future Research

Future studies may include comparative analysis between branded and local laboratories, explore patient retention metrics, and assess the long-term financial impact of automation. Research can also focus on AI-driven diagnostics and their acceptance among healthcare professionals.

## 13. Conclusion

In conclusion, the study shows that laboratory automation, supported by LIS and AI tools, has positively influenced the efficiency and quality of laboratory services. Automation has helped reduce errors, improve report delivery times, and enhance overall service satisfaction. At the same time, varying levels of confidence highlight the importance of building trust and ensuring transparency in digital healthcare systems.

The study reinforces the idea that successful digital transformation goes beyond adopting new technology. It requires proper training, clear communication, and alignment with organizational objectives. From an academic perspective, the study adds to existing research by focusing on user perceptions of automation and AI in healthcare. From a practical standpoint, it provides useful guidance for managers seeking to improve laboratory services through thoughtful and user-focused digital adoption.

## 14. Reference


- Godase, V. (2025). *Revolutionizing healthcare delivery with AI-powered diagnostics: A comprehensive review*. SSRN Working Paper / Conference Volume, pp. 58–90.
- Lujan, G. M., Savage, J., Shanaah, A., Yearsley, M., Thomas, D., Allenby, P., Otero, J., Limbach, A. L., Cui, X., Scarl, R. T., Hardy, T., Sheldon, J., Plaza, J. A., Whitaker, B., Frankel, W., Parwani, A. V., & Li, Z. (2021). Digital pathology initiatives and experience of a large academic institution during the coronavirus disease 2019 (COVID-19) pandemic. Archives of Pathology & Laboratory Medicine, 145(9), 1051–1061.Santos, J. M., Oliveira, R. L., & Costa,

P. A. (2019). *Global trends in laboratory automation and quality improvement.* Journal of Medical Laboratory Science, 14(2), 72–81.
- Eloy, C., Vale, J., Curado, M., Polónia, A., Campelos, S., Caramelo, A., Sousa, R., & Sobrinho-Simões, M. (2021). *Digital pathology workflow implementation at IPATIMUP.* Diagnostics, 11(12), 2111.
- Lujan, G., Quigley, J. C., Hartman, D., Parwani, A., Roehmholdt, B., Van Meter, B., Ardon, O., Hanna, M. G., Kelly, D., Sowards, C., Montalto, M., Bui, M., Zarella, M. D., LaRosa, V., Slootweg, G., Retamero, J. A., Lloyd, M. C., Madory, J., & Bowman, D. (2021). *Dissecting the business case for adoption and implementation of digital pathology: A white paper from the Digital Pathology Association. Journal of Pathology Informatics,* 12, 117.
- Drogt, J., Milota, M., Vos, S., Bredenoord, A., & Jongsma, K. (2022). *Integrating artificial intelligence in pathology: A qualitative interview study of users' experiences and expectations. Modern Pathology,* 35, 1541–1550.
- Hassell, L. A., Absar, S. F., Chauhan, C., Dintzis, S., Farver, C. F., Fathima, S., Glassy,

E. F., Goldstein, J. A., Gullapalli, R., Ho, J., Koch, L. K., Madory, J. E., Mirza, K. M., Nguyen,

P. N., Pantanowitz, L., Parwani, A., Rojansky, R., Seifert, R. P., Singh, R., ElGabry, E. A., & Bui, M. (2023). *Pathology education powered by virtual and digital transformation: Now and the future. Archives of Pathology & Laboratory Medicine*, 147(4), 474–489.
- Bosisio, F. M., Van Herck, Y., Messiaen, J., Bolognesi, M. M., Marcelis, L., Van Haele, M., Cattoretti, G., Antoranz, A., & De Smet, F. (2022*). Next-generation pathology using multiplexed immunohistochemistry: Mapping tissue architecture at single-cell level. Frontiers in Oncology*, 12, 918900.
- Lippi, G., & Da Rin, G. (2019). *Advantages and limitations of total laboratory automation: A personal overview. Clinical Chemistry and Laboratory Medicine,* 57(6), 802- 811.
- Yu, H.-Y. E., Lanzoni, H., Steffen, T., Derr, W., Cannon, K., Contreras, J., & Olson, J.

E. (2019*). Improving laboratory processes with total laboratory automation. Lab Medicine,*

50(9), 96–102.
- Munari, E., Scarpa, A., Cima, L., Pozzi, M., Pagni, F., Vasuri, F., Marletta, S., Dei Tos,

A. P., & Eccher, A. (2024). *Cutting-edge technology and automation in the pathology laboratory. Virchows Archiv. Advance online publication.*