Patient Perspectives on The Implementation of Specimen-Tracking Services Through Total Laboratory Automation In Dammam, Saudi Arabia

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Abstract: Introduction: Total laboratory automation (TLA) is a system in which performs several diverse categories of assessments on different types of specimens. This study aims to study patient perspectives on the implementation of specimen-tracking services through TLA in Dammam. **Materials and methods**: The study was based on a cross-sectional research design. A self-administered questionnaire was developed, and data was collected from patients who utilized the laboratory services in Dammam from January 2022 to January 2023 and who were more than 18 years old. **Results:** The total number of 283 responses was included in the analysis. A descriptive analysis of the demographics shows that 57.95% of the respondents were females, 52% aged between 18–29, 53.7% had a bachelor's degree, and 53.4% were employed full-time. Results shows that the majority had visited the hospital more than three times for laboratory services (45.58%) between January 2022 and January 2023. Over 80% of the respondents agreed that the TLA led to higher satisfaction. The TLA services reduce long waiting hours and higher levels of patient satisfaction. The findings of this study have several practical implications for health-care facilities and institutions. **Discussion:** Patients who receive specimen-tracking services tend to visit the health-care facility more than once, which indicates patient satisfaction and trust toward TLA. Mostly female patients and younger people were found to have received specimen-tracking services through TLA. The findings of this study also highlight several benefits of TLA. It was revealed that the services, when offered through TLA, tend to show improvements from time to time. The results are available in a timely manner and are highly accurate. Laboratory automation also raises the levels of efficiency in service delivery. Furthermore, it improves the performance as well as the functions of the laboratory. Monitoring and evaluation systems also improve. There are several ways through which the time-tracking services result in added value to TLA, including increased efficiency and accuracy and reduced time. **Conclusion:** Management at health-care facilities and institutes can increase patient satisfaction by adopting TLA for providing specimen-tracking services.

Keywords: Patients, Laboratory Services, Specimen-Tracking Services, Total Laboratory Automation, Satisfaction, Patient Experience.

1. INTRODUCTION

Since the 1990s, medical laboratories have developed rapidly with the incorporation of advanced technologies concentrating on automation [1,2]. The motives for leading mechanization differ based on the application, as the extent of automation relies on the requirements and assets of the laboratories. The various developments and abundance of automation technologies have greatly

affected clinical laboratory firms; numerous physical tasks have now been moderately or completely replaced by mechanized devices [1,3].

Total laboratory automation (TLA) can be described as a system in which analyzers perform several diverse categories of assessments on different types of specimens, such as citrated plasma, serum, and whole blood. Specimens are interconnected as flexible systems or attached to association lines (such as girdles, tracks, and other types of conveyors). Many of the analysis and post-analysis steps in broader TLA models (such as specimen entry, check-in, separation, de-capping, closing, sorting, centrifugation, and storage) are executed mechanically at laboratories that are tangibly associated with the analyzers and are efficiently managed by the software [4].

In the modern laboratory, TLA is a substantial context because it exemplifies the automatic nature of the total testing process (TTP). No matter the size of the scenario, it can be a resource—one that would be even more valuable if it became more functionally adaptable, flexible, efficient, and dynamic [5]. Since automation and electronics have previously led to the most noteworthy developments in mechanization, the adoption of so-called artificial intelligence (AI) through information technology capabilities appears to be the only conceivable way to augment its use [5].

Contemporary progress in automation equipment permits clinical laboratories to increase their workloads, including upping specimen numbers, expanding test panels, setting higher quality expectations, and establishing shorter target completion times. Considering that the clinical laboratory is considered the essential sector in the hospital because it affects clinical decisions and 60%–70% of the decisions related to patient discharge and admission; In addition, the results of various laboratory tests depend in part on patients' use of therapies [6,7], and enhancing patient care has become critical for all health-care providers in attaining a high level of patient contentment [8]. Patient satisfaction is the de facto guide to the effectiveness of health-care delivery management and a vital measurement tool for evaluating the efficiency of health facilities delivered in hospitals [9].

TLA has improved the process of laboratory health-care delivery, such as improving efficiency [10,11], optimizing workflow, and automatically shifting or prioritizing specimen analysis [12]. In addition, improving test quality automation would allow the control of daily laboratory activities in different ways, such as reducing possible diagnostic errors. However, laboratory-related services may face some challenges, such as tracking some specimens entered through TLA; challenges may occur due to the risk of system interruption, the complexity of the system, and the risk of stopping, delaying, and prolonging the analysis of specimens [13].

This research that aims to determine whether time-tracking technology would add value to the TLA for patient specimens, measure patient knowledge and awareness about the specimen-tracking services of the TLA system in Dammam, determine the organizational benefits of implementing the TLA specimen-tracking services, and determine whether there is any association between implementing the specimen-tracking services of the TLA system and patient satisfaction in Dammam.

2. MATERIALS AND METHODS

A cross-sectional research design was selected for this study, which is based on primary data analysis. The setting and the targeted population of this study were the patients who utilized laboratory services in Dammam.

The total sample calculated of this research study was 278 patients. The simple random sampling technique was employed to obtain an adequate sample for the research project. This research project included only patients who utilized the laboratory services in Dammam from January 2022 to January 2023 and who were more than 18 years old. Patients who did not utilize the laboratory services in

Dammam from December 2022 to January 2023 were excluded, as were those who were younger than 18 years old and those residing outside of Dammam.

The survey approach was used to collect data through an online self-administered questionnaire. The questionnaire was divided into two major parts, which included demographic questions and questions related to the topic of the study. In the first part of the questionnaire, four questions were used to measure the demographic characteristics of the participant. These demographic questions were related to age, gender, education level, and employment status.

In the second part, 14 questions were used to measure the patient's perspective on the implementation of specimen-tracking services through TLA in Dammam. A detailed overview of previous literature helped in formulating and developing the questions for measuring the demographic characteristics and the perceptions of participants regarding the specimen-tracking services. The Likert Scale questions were utilized for measuring patient perspective on the implementation of TLA specimen-tracking services in Dammam.

Questions and items for analyzing the perceptions of the patients toward the use of specimen-tracking services offered through TLA in the Dammam region were selected and based on factors identified in similar studies conducted previously.

Descriptive statistics were suitable for the primary data approach because they deliver a complete description and presentation of the data characteristics. The descriptive statistics contain the mean, mode, and median, which were utilized for the calculation of the value representing the center in the dataset. The measures of frequency, central tendency, variance, and range were utilized for this purpose. MS Excel was used for the purpose of data analysis. The pie chart and bar chart were also created on the basis of frequencies and percentages frequency.

3. ETHICAL CONSIDERATIONS

Anonymity was ensured in order to gather unbiased responses and comply with ethics guidelines. Questions related to the personal information of participants, such as addresses, names, and contact information, were omitted. Before taking the survey, the participants were required to complete the consent form.

An ethical approval was granted on December 27, 2022, by the Institutional Review Board Office at King Fahad Specialist Hospital-Dammam (national registration number H-05-D002) before the process of data collection began (IRB Study Number LAB0327). In addition, administrative approvals were also obtained.

4. RESULTS

The total number of 283 responses was included in the analysis. A descriptive analysis of the demographics in Table 1 provides a detailed overview of the demographic characteristics. The gender distribution of responses was also important for this study. The findings show that 42.05% of the respondents were male, while 57.95% of the respondents were female.

Table 1: Descriptive statistics of demographics (N = 283)

Demographic characteristics	n	% *
Age		
18-29	146	52.00%
30-39	86	30.40%
40-49	27	9.50%

50-59	14	4.90%
60 or older	10	3.20%
Gender		
Male	119	42.05%
Female	164	57.95%
Education level		
High School	60	21.20%
Diploma	45	15.90%
Bachelor	152	53.70%
Master	12	4.20%
Doctoral	3	1.10%
None of the above	11	3.90%
Employment Level		
Not Working	78	27.60%
Job Seeker	33	11.70%
Employed Part Time	4	1.40%
Employed full-time	151	53.40%
Prefer Not to Say	17	6.00%

*Percentage of total column

The age distribution was also important for this study. The findings indicated that the majority of the respondents (52%) belonged to the age group of 18–29. Those 30–39 years old comprised 30.4%, while those 40–49 years old made up 9.5%. Respondents aged 50–59 years make up 4.9%, while the lowest number of respondents were recorded in the age group of 60 or older, accounting only for 3.2% of the total sample.

The educational levels of the respondents were also included. The findings indicated that the majority of the respondents (53.7%) had a bachelor's degree, while 21.2% of respondents had a high-school diploma, 15.9% had diploma, 4.2% had a master's degree, 3.9% had no education, and only 1.1% had a doctoral degree. Respondents also recorded their employment levels, and the findings revealed that the majority (53.4%) were employed full-time, while 6% preferred not to share their employment level. Another 27.6% were not working, while 11.7% were seeking jobs. Finally, 1.4% of the respondents were employed part time.

The respondents recorded their hospital visits between January 2022 and January 2023. As presented in Figure 1, the majority reported that they had visited the hospital more than three times; specifically, 45.58% responded that they had visited the hospital for laboratory services between January 2022 and January 2023. Another 26.15% had visited the hospital once during that time for laboratory services, 14.49% had visited the hospital three times for laboratory services, and 13.78% reported visiting the hospital two times for laboratory services.

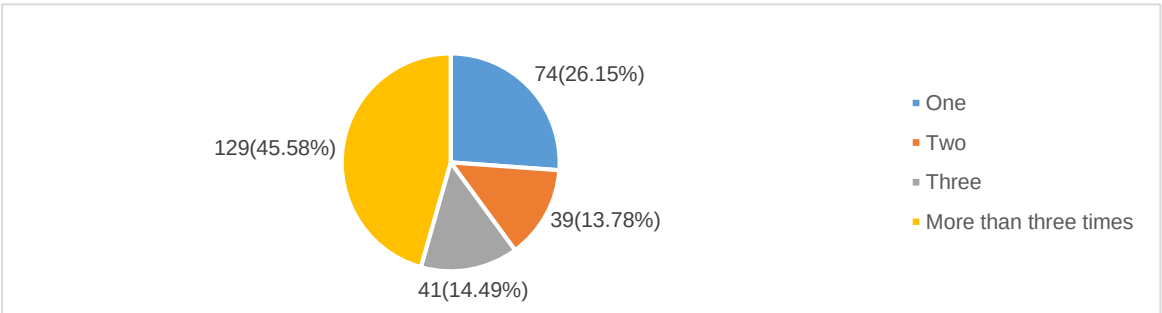

Figure 1: Patients' hospital visits from January 2022 to January 2023 (n=283).

The descriptive analysis of patients' responses regarding TLA specimen-tracking services is presented in Table 2. The majority (33.92%) of the respondents agreed that improvements in laboratory

services are required from time to time, while 37.46% strongly agreed with that statement. Only 0.71% strongly disagreed that improvements in laboratory services are needed from time to time. Interestingly, 37.81% of respondents strongly agreed and 44.88% agreed that test results were released according to the patient's expectations, and only 1.06% of the respondents strongly disagreed with that statement.

Most respondents reported being aware of the laboratory automation services: 33.22% strongly agreed that they were aware of the specimen-tracking services provided through TLA, and 2.12% of the respondents strongly disagreed with the statement. As presented in Table 2, most participants agreed that laboratory automation saved time and reduced medical errors. Interestingly, only 0.35% of the respondents answered strongly disagreed. The majority of the respondents agreed that specimen-tracking services provided through TLA provided test results in a timely manner. Another 39.93% and 40.99% of the respondents strongly agreed or agreed that specimen-tracking services, when offered via TLA, provided results on time. Only 0.35% of respondents strongly disagreed with that view. More than 70% of respondents reported that laboratory automation leads to services in an efficient manner, while only 0.35% of respondents disagreed with that statement.

Table 2: Patient knowledge and perceptions about the specimen tracking services provided through Total Laboratory Automation (N= 283)

Statement	n (%)*				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Improvements in laboratory services from time to time	96 (33.92%)	106 (37.46%)	66 (23.32%)	13 (4.59%)	2 (0.71%)
Release of test results as expected	107 (37.81%)	127 (44.88%)	32 (11.31%)	14 (4.95%)	3 (1.06%)
Awareness of specimen tracking services through total laboratory automation.	94 (33.22%)	103 (36.40%)	56 (19.79%)	24 (8.48%)	6 (2.12%)
Laboratory automation has reduced medical errors and saved time.	105 (37.10%)	122 (43.11%)	51 (18.02%)	4 (1.41%)	1 (0.35%)
The specimen tracking services through laboratory automation provide test results on time.	113 (39.93%)	116 (40.99%)	46 (16.25%)	7 (2.47%)	1 (0.35%)
Laboratory automation provides services more efficiently.	112 (39.58%)	120 (42.40%)	44 (15.55%)	6 (2.12%)	1 (0.35%)
Total laboratory automation has reduced the crowding in hospitals.	101 (35.69%)	119 (42.05%)	48 (16.96%)	13 (4.59%)	2 (0.71%)
Total laboratory automation provides accessible digital reports	125 (44.17%)	120 (42.40%)	30 (10.60%)	4 (1.41%)	4 (1.41%)
Laboratory automation improved the quality of laboratory test results.	107 (37.81%)	130 (45.94%)	38 (13.43%)	4 (1.41%)	4 (1.41%)
The laboratory automation increased the accuracy of the results of test reports.	108 (38.16%)	127 (44.88%)	39 (13.78%)	8 (2.83%)	1 (0.35%)
Automation has enhanced laboratory performance and functions.	112 (39.58%)	127 (44.88%)	38 (13.43%)	4 (1.41%)	2 (0.71%)
Laboratory automation has reduced long waiting times.	116 (40.99%)	114 (40.28%)	41 (14.49%)	10 (3.53%)	2 (0.71%)

Automation has improved the monitoring and evaluation of test reports.	119 (42.05%)	118 (41.70%)	36 (12.72%)	8 (2.83%)	2 (0.71%)
Satisfaction with medical laboratory services	119 (42.05%)	117 (41.34%)	38 (13.43%)	4 (1.41%)	5 (1.77%)

*Percentage of total raw

Interestingly, 35.69% of the respondents reported that the TLA had reduced crowding in hospitals; 42.05% of those agreed with this view, while merely 0.71% of respondents strongly disagreed. Also, 44.17% of the respondents strongly agreed that TLA provides access to digital reports, in contrast to 1.41% who strongly disagreed, indicating their belief that TLA does not provide access to digital reports. At the same time, 37.81% of the respondents strongly agreed and 45.94% agreed that laboratory automation has improved the quality of the results of test reports. In contrast, only 1.41% disagreed and 1.41% strongly disagreed that laboratory automation results in improved quality of laboratory test results. In addition, 38.16% of respondents strongly agreed that laboratory automation had increased the accuracy or precision of the results of tests, while 44.88% agreed that laboratory automation results in higher accuracy of test results. Interestingly, only 0.35% of the respondents strongly disagreed that laboratory automation leads to increased accuracy of test results, while 13.78% of the respondents remained neutral.

Also, 39.58% and 44.88% of respondents strongly agreed and agreed, respectively, that automation increases laboratory performance and enhances its functions. Around 80% of the respondents strongly agreed or agreed that laboratory automation has led to a decline in lengthy waiting times. Conversely, only 0.71% of respondents strongly disagreed that laboratory automation leads to reduced waiting times. More than 80% strongly agreed or agreed that automation has improved the monitoring and evaluation of test reports. In contrast, only 0.71% of respondents showed strong disagreement with the statements. Over 80% strongly agreed or agreed that the medical laboratory services led to higher satisfaction. Yet only 1.77% of the respondents disagreed that the medical laboratory services result in satisfaction.

5. DISCUSSION

The findings of this study revealed that the majority of the respondents were female, which indicates that specimen-tracking services through TLA are mostly received by female patients; this finding was expected as the majority of patients who received lab services at the selected health-care facility are known to be females. Another finding of this study is that respondents who belong to younger age groups, such as 18–29 or 20–39, represent the majority of those who answered, and this matches what was reported by the General Authority for Statistics [14], with younger group dominating in society. More than half of the respondents were found to have at least a moderate level of education, that is, a bachelor's degree. This could be because holding a bachelor's degree has become a requirement for many jobs, and there is a focus in society on completing higher education.

The majority of respondents were full-time employees. This may be attributed to the strategy adopted to achieve Vision 2030 through providing suitable job opportunities in terms of numbers and wages that lead to the full employment of Saudi human resources and the creation of a competitive advantage for the national economy. A descriptive analysis of hospital visits for the specimen-tracking services highlighted that most of the patients had visited more than three times. It may be that patients are more satisfied with the laboratory automation services and thus prefer to use them over other alternatives. Pillemer et al. [15] have provided field evidence in research work indicating that timely and efficient services have strong influences on patient satisfaction and experience. This improvement in the quality of services encourages patients to spread positive reviews or word-of-mouth for such services.

5.1. Benefits Of Implementing Specimen-Tracking Services

The majority of the patients believed that the provision of specimen-tracking services through TLA has brought improvements in these services from time to time. This finding is consistent with prior research studies on laboratory automation. Yeo & Ng [16] suggested that improvements in the accuracy of test results, as well as the operational efficiency of laboratories, can be tracked easily in TLA. Therefore, it is easier to identify any critical issues or lags within the systems immediately, resulting in regular and consistent improvements in the system.

TLA has been considered a breakthrough in clinical research as it leads to the provision of test results in a timely manner. Most of the patients agreed, suggesting that TLA enables the provision of test results at the expected time. That is, the specimen-tracking services, when provided through TLA, provide results at the pre-adjusted or expected time. A major reason for this time-efficient delivery of results is the reduction in TAT, which can be described as the time span between the receipt of the specimens at the laboratory and the time test results are dispatched. This accords with findings in the literature that laboratory automation results in significant reductions in TAT, which results in time-efficient specimen-tracking services [16,17]. Other studies have suggested that technologies such as auto validation (AV) and a post-analysis report validation tool for TTP also help in reducing manual work and accelerating the time efficiency of the processes [18,19].

In addition to time efficiency, the respondents were also asked about the efficiency of laboratory automation as a whole. Overall, patients suggested that laboratory automation has increased the efficiency of specimen-tracking services. Other researchers have also shown that laboratory automation leads to increased efficiency [10,11]. Overcrowding at medical or health-care facilities is associated with increments in the economic burden, resulting in a shortage of services. TLA significantly lowers the crowding at hospitals, consistent with what was mentioned in a study conducted by Genzen et al. [20].

Laboratory automation has been found to have a strong influence on the functions and performance of the laboratory. The findings of this study revealed that laboratory automation leads to improvements in lab performance levels and functions. This could be due to the reduction in time required for processing and analyzing the specimens. Moreover, the results derived through laboratory automation are more precise, which further ensures higher performance levels, which concurs with a study by Lippi and Da-Rin [12].

Quality control is perhaps the most crucial factor in laboratory testing, as it ensures the accuracy and precision of the test results for patients. The findings of this study showed that laboratory automation had increased the quality of the test results in the laboratory, which is consistent with the findings of Plebani [6] and Rohr et al. [7]. Laboratory automation also underlines the utilization of software that helps automate the equipment, reducing human supervision. This minimal human intervention leads to increased quality and efficiency in results. This study also attempted to examine another potential benefit of laboratory automation in the form of better monitoring and evaluation of the specimens. The majority of respondents found improvements in the evaluation and monitoring of the test reports. This finding is in line with previous researches [18,19,21]. Lee and Yom [8] have also suggested new technologies, such as laboratory automation, would lead to improvements in the system.

The results of this study also demonstrate that time-tracking services add value to the TLA of patient samples, which can happen in different ways. Time-tracking services have led to added value as these services increased their efficiency. Most respondents also agreed that TLA tracking services for patient samples lead to higher efficiency [10,11]. The various processes included in laboratory automation reduce delivery time, leading to enhanced efficiency. Also, TLA services provide more accurate, precise results and shorter target completion times, which adds value to TLA [6,7], and the majority of patients agreed that TLA tracking services provide more accurate results.

5.2. Patient Experience Of Specimen-Tracking Services

The findings indicated that the majority of the patients had awareness regarding the specimen-tracking services provided through TLA. A major reason for the increased awareness could be the trend toward adopting laboratory automation within Saudi Arabia. These findings are similar to those of Al-Naam et al. [22], who highlighted the increasing implementation of TLA in Saudi Arabia.

One of the benefits of TLA was found to be a reduction in medical errors. Results showed that laboratory automation reduces medical errors while saving time. TLA replaces the laborious and repetitive manual processes of laboratory testing with automation, which allows technicians to focus their energy and time on quality assurance. This eventually leads to reductions in overall medical errors. Previous studies have documented similar findings, indicating that TLA leads to reductions in medical errors [12,13].

TLA leads to the timely delivery of test results to patients. The majority of respondents agreed that they had received their test results on time. This could be due to the fact that laboratory automation reduces the time for gathering and processing specimens. It has been previously found that laboratory automation leads to a reduction in processing time and provides time-efficient results [16]. Pillemer et al. [15] have provided field evidence in research work which indicates that timely and efficient services have strong influences on the patient's satisfaction and experience.

Digitalization is another aspect of TLA that has been gaining great recognition in Saudi Arabia after the implementation of Vision 2030. The majority of the patients agreed that laboratory automation results in increased access to digital reports. Another important benefit documented by this study was the accuracy of test results. Most of the patients agreed that laboratory automation leads to increased accuracy of test results. Laboratory testing is prone to human errors, which reduces the accuracy of test results. Laboratory automation reduces the human intervention within the testing process, and the automation of key tasks such as tracking specimens, calculating precise quantities, and producing error-free results are some of the factors that improve the accuracy of results [17-19].

Another important factor related to the patient experience regarding the specimen-tracking services through TLA was the impact on waiting hours. Most of the respondents agreed that laboratory automation leads to reductions in long waiting times. Previously, studies have revealed that reductions in waiting time in laboratory automation are due to the reductions in manual work or processing time required for the specimens, which not only reduces waiting time but also enhances the quality of services [23,24]. Tan et al. [25] have also identified that long waiting hours lead to a reduction in patient satisfaction levels.

The last and most important goal of this study aimed to assess the satisfaction of patients with the specimen-tracking services provided through total automation services. The responses of patients clearly indicated that medical laboratory services provided through laboratory automation increase patient satisfaction. These findings are in line with those of previous studies such as that of Kim et al. [26], which also suggested that laboratory automation leads to increased patient satisfaction, eventually creating value not only for the patient but also for the health-care institute providing these TLA facilities. The study further provided some explanation for this increased satisfaction, including a reduction in waiting times, increased accuracy, and, most importantly, the efficiency of services.

CONCLUSION

The focus of this research is on evaluating different perceptions of patients that are related to the implementation of specimen-tracking services provided through TLA. This research work is among the very few studies to examine the link between TLA within the context of the Dammam region of Saudi Arabia and that might contribute to strengthening the founding of tracking services in this area.

Patients who receive specimen-tracking services tend to visit the health-care facility more than once, which indicates patient satisfaction and trust toward TLA. Mostly female patients and younger people were found to have received specimen-tracking services through TLA. The findings of this study also highlight several benefits of TLA. It was revealed that the services, when offered through TLA, tend to show improvements from time to time. The results are available in a timely manner and are highly accurate. Laboratory automation also raises the levels of efficiency in service delivery. Furthermore, it improves the performance as well as the functions of the laboratory. Monitoring and evaluation systems also improve. There are several ways through which the time-tracking services result in added value to TLA, including increased efficiency and accuracy and reduced time.

Awareness levels of the patients regarding TLA are generally high, which could be due to their higher education levels. Interestingly, the TLA services were found to reduce medical errors. These services also reduce delivery time and provide test results to patients on time. Digital services have also increased due to the adoption of TLA, resulting in higher accuracy. Most importantly, TLA services also reduce lengthy waiting hours and produce higher levels of patient satisfaction. The findings of this study have several practical implications for health-care facilities and institutes. Health-care facilities can adopt TLA to reduce medical errors and provide accurate results. A major concern at health-care facilities is long waiting hours, something that is also related to the patient experience. Management at health-care facilities and institutes can increase patient satisfaction by adopting TLA for providing specimen-tracking services.

This study has several strengths. First, it recorded the perceptions of patients regarding the utilization and benefits of the specimen-tracking services provided through TLA. Second, the study collected data from patients who have used the specimen-tracking services, providing more accurate and detailed findings. The lack of previous studies on specimen-tracking services can also be seen as a strength of this study. Another important strength of this research lies in the nature of the data collected for analyzing the research problem where the cross-sectional data was gathered, which helped in the comparison of several variables at a given point in time. Moreover, the cross-sectional nature of the research study reduced the time and costs associated with the research process. On the other hand, this study has limitations as well. The findings are limited to a specific health-care facility in the Dammam region of Saudi Arabia, which might affect the generalizability of this study. Another limitation is that it captured only the patients' perceptions and did not focus on the individual organizational impacts of TLA.

Based on the findings of this research study, several recommendations can be formulated for directing future research on the subject. Future research should focus on using a larger sample size for analyzing patient perceptions regarding specimen-tracking services. In addition, respondents from other regions in Saudi Arabia should also be included in the sample. Future studies should also look at factors such as managerial skills, organizational structure, health-care standards, and investments in research and development for analyzing the benefits of specimen-tracking services provided through TLA.

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HUMAN AND ANIMAL RIGHTS

Not applicable

CONFLICT OF INTEREST

None

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