Spring 4-24-2018

How Laboratory Informatics has Impacted Healthcare Overall

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April 2018

Abstract

Health information technology has improved key areas of healthcare such as academia, research, and practice. Technology is one of the key driving forces in healthcare that is set to enhance the overall provider-patient experience. The future of healthcare is aimed at improving patient satisfaction, quality of care, and practice methods. Laboratory information systems (LIS) is a fundamental component of the diagnostic or pathology department (Henricks, 2016). In the era, where laboratory reports have become complex and high-dimensional, the need to develop and implement a cost-effective platform or tool to collect, process, store, and manage such processes is required. A systematic review of literature was conducted, wherein relevant articles associated with laboratory information systems. The study was based on a qualitative design, wherein key concepts or themes from articles and reports were qualitatively identified. The advantages of laboratory information systems can be considered as a platform to enhance patient satisfaction, quality care, and patient safety.

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CHAPTER-I Introduction

In the past few years, technology has significantly improved the healthcare system in context to quality of care, patient safety, and operational efficiency. Technology is one of the key driving forces in healthcare that is set to enhance the overall provider-patient experience. The future of healthcare is aimed at improving patient satisfaction, quality of care, care process, and practice methods. The adoption of technology would improve 3 key areas of patient-centered care, monitoring, consultation, and treatment (Thimbleby, 2013). Health information technology has improved key areas of healthcare such as academia, research, and practice. Efficient treatment and management of patients across healthcare sectors, specifically during a medical-emergency has become possible with the help of advanced health information technology (Bajwa, 2014).

In the past decade, one such technological development has been witnessed which has emerged to improve overall diagnostic and assessment processes in the healthcare system, i.e. laboratory information systems (LIS). The modern-day or 21st century laboratory requires an efficient system that would handle and process large amounts of information daily. The LIS has emerged as a live-saver for medium-to-large scale laboratories in context to improving pathology workflow processes, management of reports, and allied monitoring operations. The LIS is a fundamental component of the diagnostic or pathology department (Henricks, 2016). In the era, where laboratory reports have become complex and high-dimensional, the need to develop and implement a cost-effective platform or tool to collect, process, store, and manage such processes is required. The LIS has helped in improving laboratory operations and overall patient care. Based on current evidence, some of the key areas that need to be improved in LIS include; (i) Information security (ii) specimen selection (iii) quality management (iv) result

reporting and (v) operational issues (Sepulveda & Young, 2013). There is a need to develop a robust and comprehensive LIS in order to improve overall laboratory operations.

Background

Pathological services have changed in the past few years with a great demand for service among providers and patients. There has been a significant increase in cost constraints, workloads, and the demand for technological advancement. The rising patient database and increasing health accessibility and utilization had put a strain on the existing pathological services or products. In the era of such high-volume and demand of services, improving data exchange processes with electronic record systems has become the need of the hour. These new technology systems have emerged due to the need for fast, better, and efficient data collection, storage, and processing needs (Jones, Johnson, & Batstone, 2014).

Although the inclusion of laboratory information systems or technology may have a profound impact on overall operations, new challenges associated with the technology may emerge. For example, issues with format of content or coding of datasets that would be exchanged within and outside the system need to be addressed. Thus, the need to develop and implement an intelligent system that could improve all key technological parameters is required. LIS would also help in improving communication between laboratory information specialist and clinicians within the healthcare system which is of paramount importance. The need for information technology (IT) in pathology services has increased beyond the scope of analytical data. The demand to implement intelligent services to transform data into useful information has become an integral part of laboratory medicine (Jones, Johnson, & Batstone, 2014). The importance of accurate diagnostic approaches, emergence of evidence-based medicine, and the need for efficient and effective processing has raised the bar for laboratories worldwide. The translation of complex medical/genetic data into useable information has

emerged as one of the key components or services of the modern laboratory. The ease of communication and coordination between clinicians, nurses, and laboratory technicians has become possible through the integration of LIS (Park, Pantanowitz, Sharma, & Parwani, 2012).

Purpose of the study

Health informatics and/or technology has revolutionized patient-provider interaction, quality of care, and safety. Laboratories have witnessed a significant demand in patient volume and the need to process complex reports or data. The purpose of the study is to review current literature and understand the advantages and limitations of laboratory information systems across healthcare settings.

Significance of the study

Understanding the role of informatics or technology in laboratory medicine is critical and essential. Technology within the laboratory segments is a powerful tool as it could be used to implement various pathology processes and the introduction of new diagnostic modalities. Based on current evidence, laboratory systems have emerged to process genomic and proteomics data. Laboratory information systems have also helped in developing and managing evidence-based disease processes. Modernized tech-based laboratories are efficient, wherein they are capable of using limited resources, specifically those on the costlier end. The laboratory systems have emerged to provide useful and appropriate information to even patients making the whole process transparent and credible. Laboratory systems are adopting new and innovative technology to help patients in self-management of long-term health issues. Access to laboratory information in real-time has enhanced credibility and reliability among providers and patients (Tuthill, Friedman, Balis, & Splitz, 2014)

Theoretical Framework

The adoption of laboratory information systems (LIS) is a critical and essential component in the healthcare. It is part of a change process; wherein healthcare professionals would adopt new technology to enhance the overall operational efficiency of laboratory-based work. The lab-based information systems are aimed at replacing paper-based report collection and assessment to digital or electronic formats that reduce both time and resources required to disseminate or exchange information. The adoption of LIS in this study would be based on John P. Kotter's 8-step change model (Rappleye, 2014). The model is based on needs assessment, need to change, and drivers of the proposed change. The 8-steps of change as per the adoption of LIS can be explained here below: (i) Sense of urgency: The increase in patient volume, risk of diagnostic/pathology errors, and demand for operational efficiency has increase the sense of urgency for change in lab-based settings (ii) Establishment of core group to lead change: A multidisciplinary team of experts such as laboratory technician, clinician, nurse manager, laboratory assistance, and lab manager would lead the need to change and adopt an LIS (iii) Definition of end goal: Improvement in quality care, reduction in errors, increased operational efficiency, and enhanced patient satisfaction (iv) Sharing the end goal: The core team would share the end goals with the hospital network in order to foster the process of change on a wider scale (v) Encourage participation: Education and training of staff and allied healthcare providers would be required for wide-scale participation. The core team would need to develop training programs to motivate and encourage staff participation in the overall process of LIS adoption (vi) Short-term goals: Complete replacement of paper-based data and tools to digital/electronic formats is expected within the next 12 to 18 months. Other short-term goals include enhance patient satisfaction and provider acceptance (vii) Persistence in driving change: Developing healthcare models, improvising IT-based solutions, and upgrading

compute-based systems within the laboratory would help in perceiving the proposed change (viii) Organization culture and proposed change: It is critical to understand the organization's culture in context to developing and implementing change practices. In this case, provider and patient perceptive on information technology would need to be determined. Knowledge and attitude towards digital platforms in diagnostic modalities among provider and consumers would need to be assed (Rappleye, 2014).

Research questions

The adoption of laboratory information systems is the key to improved workflow processing, increased patient satisfaction, and quality of care. The review is aimed at identified key themes and trends associated with the development and implementation of LIS within healthcare facilities. Some key research questions that were answered after the review include: (i) Does laboratory information systems improve operational efficiency within and across healthcare settings? (ii) Does the inclusion of LIS influence patient satisfaction? (iii) What are the key limitations or barriers towards the limitations of LIS? (iv) What are the cost-effectiveness and quality of care outcome implications post-LIS implementation?

Apart from quality of care and efficiency, the inclusion and adoption of LIS in healthcare facilities is associated with significant cost-savings, increased revenue/profitability, and reduced risk of human error. However, these hypotheses need to be confirmed through a review of literature (reports, articles, trials, and/or case studies).

Definition of terms

Laboratory information systems also known as LIS can be defined as an integrated and comprehensive software that is based on the collection, storage, management, and retrieval of data from clinical laboratories. LIMS is referred to as Laboratory information management

systems that are based on a software that helps in overall operations of a laboratory including financial modelling, inventory management, and order prediction.

Limitations

The study was based on a random selection of articles from a single database This was one of the biggest disadvantages of the review as it clearly depicts researcher/selection bias. The sample size (number of articles) was low to generalize the study results. Other scholarly databases were not reviewed which could have increased the generatability of the study results.

CHAPTER-II Review of literature

The development and implementation of a computer-based or laboratory information systems (LIS) within a healthcare facility is a complex and challenging process. The availability of various software and hardware modules in the open market make it difficult for providers or organizations to identify and implement the most appropriate LIS. Apart from the quality, budget, and long-term impact of LIS, the staff members should be aware if building a custom LIS would be more cost-effective and efficient than a stand-alone open-maker system. In a recent report, a team of experts indicated that developing and implementing a customized in-house LIS is much more effective and efficient. The developmental team could even involve a single programmer who could handle and develop specific solutions for the laboratory. Many of the risks associated with LIS could be easily mitigated by the use of open-source tools and well-structured development process. The experts indicated that in-house solutions had a relatively better prospect and advantage as it could easily modified based on departmental needs which in turn contributed to better, higher, and efficient quality patient care (Sinard, & Gershkovich, 2012). The development of a laboratory information and management system (LIMS) is an effective approach to process lab data in an efficient and faster manner. Since most processes such as data processing, storage, and retrieval would be automated, there would be significant time and effort savings. The inclusion of an LIMS in hospital-care settings is bound to save time and increase overall productivity. In a recent review, a team of healthcare professionals indicated that LIMS not only saved time but also resulted in efficient resource utilization. It enhanced overall patient engagement and satisfaction which in turn translated to improved quality care outcomes (Carmona-Cejudo, et al., 2012).

LIMS or LIS has helped several healthcare facilities to combat high-influx of patients efficiently and effectively. The use of LIMS/LIS replaces conventional paper-based collection,

storage, and handling of patient reports or information. Data collected and archived is in digital/electronic format which has lesser risk of loss or theft when compared to paper-based collection and storage. Most of the LIS/LIMS can develop and produce reports in real-time to patients which increases overall credibility and reliability of the laboratory. The inclusion of

Based on a review of literature, some of the key advantages or benefits of LIMS include: (a) Real-time tracking of samples (b) time savings (c) improved logistics efficiency (d) reduced human error (e) increased savings (f) reduced risk of death (g) reduced spending and (h) enhanced business opportunities and/or escalation. The inclusion of LIS can allow the technician to track samples in real time as the entire process is automated, wherein the samples are individually bar-coded. The most complex, challenging, and time-consuming task in laboratories is the collection, registering, and re-registering of samples. However, with the help of the LIMS, lab technicians can have batch-based system to track all samples collected and evaluated (Fig. 1-2). Batch-based assessment helps save time and delivers a large number of samples efficiently without the risk of any human error (Jones, Johnson, & Batstone, 2014).

The assessment of critical reports by individual doctors and pathologist is a time-consuming process. However, with the help of LIMS, a unique-authorization code would automate the process of approving samples that are within normal values. The process of automated authorization not only saves time but also increases overall operational efficiency (Fig. 1-2). Doctors and pathologist would have to authorize only reports with abnormal values which reduces their workload, effort, and time (Guo, et al., 2016).

The processing of samples from the centers is time-consuming process. However, with the help of batch-based bar coding system, lab technicians and managers can track and monitor samples in real-time. This would give them sufficient time to arrange for resources such as

reagents, chemicals, and other materials required for testing. Efficient resource management before arrival of samples gives technicians the ability to screen and evaluate a large number of samples with a short time-frame (Fig. 1-2). (Jones, Johnson, & Batstone, 2014).

A major risk observed in pathology laboratories is the risk of human error, either during data entry, interpretation, or evaluation (Agarwal, 2013). However, advanced computer-based systems eliminate the need for manual effort. These systems are based on the integration of lab equipment and devices to a secure platform, wherein data is automatically transferred to the LIMS. Thus, the time taken to process samples is not only reduced but it eliminates the need for laborious manual effort and human error (Oral, Cullen, Diaz, Hod, & Kratz, 2013). The safety of patients is crucial is the pathology and laboratory department. In case of life-threatening or medical-emergency cases, the results of lab reports draw a line between life and death of a patient. An integrated and comprehensive LIMS has a pre-coded alert mode (program), wherein any abnormalities in the reports would be directly informed or communicated to the referring physicians. This enables the physician to make informed decisions immediately which in turn could be a life-saving approach (Lee & Park, 2013).

Apart from patient safety, healthcare facilities could have significant savings and even boost overall revenue. Powerful LIMS dashboards would help technicians assess financial, inventory, operational, and lab-based reports in customized formats (Fig. 1-2). Large number of analytical data could be mined and crunched to develop trends, patterns, and projections. This would help the lab head to maximize revenues and increase overall profitability (Cucoranu, 2015). Automated systems would send an alarm to the lab head/technician about expired products, chemicals, or reagents. Through artificial intelligence, the LIMS could process predictive pre-ordering of samples or products. The entire process would prevent unnecessary costs, eliminate wastages, and end pilferages. The use of cloud-base systems

increases open collection and processing of samples in remote locations. Escalating business through cloud-based computer severs is possible for lab owners and staff (Wu, et al., 2015).

In the most recent update, the University of Mississippi healthcare system had adopted a comprehensive laboratory information system. The adoption of the new laboratory system was aimed at improving the quality of care, increase in efficiency in context to integration of clinical data, and assessment of return on investment (ROI). The overall assessment was carried out by Dr. Brad Brimhall, Medical Director of Clinical Laboratories and Bryan Clements, the Director of Finance Decision Support. The project was aimed at facilitating both clinical operations efficiency and cost-savings for the hospital. The integration of the laboratory information system was found to be seamless across 3 key departments of the hospital, i.e. radiology, Intensive Care Unit, and pharmacy. The experts indicated that the integration and adoption of the new laboratory analytical system helped improve overall clinical operations with an estimated projection of >$375,000 in ROI. The project also included the use of point of care instruments to facilitate patient referral and care across radiological procedures. The use of integrated networks between the laboratory and radiology department was associated with improved patient satisfaction (Shirts, et al., 2015).

CHAPTER-III Methodology

A review of literature was conducted to assess and evaluate the benefits and advantages of implementing laboratory information systems across healthcare facilities. The review was based on the identification of key advantages associated with quality of care, patient safety, operational efficiency, and profitability post-implementing LIMS/LIS. Key trends and themes associated with the benefits of LIS were identified and reviewed in the report.

Research design

A systematic review of literature was conducted, wherein relevant articles associated with laboratory information systems. The study was based on a qualitative design, wherein key concepts or themes from articles and reports were identified.

Population and sample design

Many articles were shortlisted, wherein the benefits of laboratory information systems were qualitatively identified. The study did not include participants, wherein the sample in this case would be the number of articles shortlisted and reviewed based on the research question and study rationale.

Data collection procedures

Articles and reports were collected from scholarly databases such as PubMed and Google Scholar. Since the study was based on a qualitative design, relevant articles were shortlisted based on the rationale/objective of the study. Considering the research questions, articles and reports from PubMed were identified and selected for review.

Data collection instrument

Case studies, reports, reviews, interviews, trials, and editorials were key data collection instruments that were identified and reviewed in the paper.

Data analysis

The data obtained from research articles and reports were qualitatively evaluated. Since there are no participants included in the study, no response rate or representativeness of sample were evaluated. In this study, data analysis was entirely based on the research question outcomes, i.e. the cost-effectiveness, quality of care, patient satisfaction, and operational efficiency.

Response rate

This is not applicable in the study, as it was based entirely on a qualitative/systematic review of articles.

Representativeness of sample

Many research articles and reports were critically evaluated to answer the research questions. All the research articles were identified and shortlisted from PubMed (as the primary database). Qualitative assessment of key themes/trends associated with the use or adoption of LIMS were reviewed.

Profile of sample/population: Only articles published on or after 2012 were included in the study. The sample included papers published in English from PubMed as the primary database. The sample (articles) comprised of reports, case studies, narratives, and editorials.

Reliability of scales in instrument: No key instruments were used in the study apart from John P. Kotter's 8-step change model. The model was used to describe the change process in

adopting laboratory information systems as an innovative, cost-effective, and feasible tool to improve quality of care, patient safety, and overall operational efficiency.

Research questions: Since the paper was based on a qualitative review of articles and reports, no statistical evaluations were required in context to answering the questions. However, key concepts and themes were identified, wherein the benefits, need, and advantages of laboratory information systems were demonstrated.

Level of significance: The paper was based on a small sample of papers (20) that were reviewed to answer the research questions. Thus, considering that no statistical evaluations were made and that the paper was based on a qualitative review of themes and articles, the level of evidence or significance was established to be Level III, Grade A (Martins, & Buschang, 2015).

CHAPTER-IV Results

The development and adoption of laboratory information systems is a cost-effective and efficient approach to improve quality of care, save costs, effort, and time. It is an innovative strategy to enhance evidence-based disease management. The research design was based on a qualitative review of evidence to establish the advantages and benefits of laboratory information systems across healthcare facilities. Apart from key limitations such as privacy and security of patient data through data exchange and collection processes in LIMS/LIS, no significant issues or risks were identified (Cucoranu, et al., 2013). In context to the sample, a total of 20 research articles and reports from PubMed were identified and reviewed qualitatively. In context to the data collection procedure and data collection instruments, case studies, reports, reviews, interviews, trials, and editorials were key data collection instruments that were identified and reviewed in the paper.

Based on a review of evidence, 7 key advantages or benefits were identified from the shortlisted articles, i.e. enhanced real-time tracking of samples, time/effort savings, immediate processing of reports, improved logistic efficiency, reduced human error, increased patient safety, and improved profitability/revenue. It is imperative to understand that quality and safety are the two pillars of the healthcare system. In order to facilitate quality and efficiency along with cost-adjustment, adoption of technology has become imperative in healthcare facilities. In this case, the research questions and rationale of the study can be answered as follows: Since LIMS/LIS is based on bar-coded batch-based processing, it can help improve overall operational efficiency. Since patient's can access their reports electronically through a secure and integrated network, the overall credibility increases and so thus, patient satisfaction. Lastly, since large volumes of samples can be processed at a faster and efficient rate with real-time

tracking and assessment, lab technicians and owners can increase their overall revenue and profitability without the fear or risk of human error (List, et al., 2014).

Based on a hypothetical projection, 4 key areas of the hospital/healthcare facility would significantly improve, i.e. clinical error, patient safety, increased revenue, and time savings. The projected outcomes are based on a personal estimate and does not relate to statistical evaluation or result from another study. Since the LIMS/LIS would based on complete automation, the risk of clinical error would reduce (±10%) while patient safety is projected to increase by 50%. Complete automation would result in increase in operational efficiency which in turn would save time and costs. In this case, the projected savings is hypothesized to be ±75% while the net times savings is expected to be ±60% (Fig. 4).

CHAPTER-V Conclusions and recommendations

Despite the several efforts to improvise healthcare efficiency and quality of care, there is a need to include information technology to enhance overall operational efficiency. Clinical laboratories have witnessed significant criticism worldwide due to clinical errors and lack of efficiency in reporting. The use of laboratory information and/or management systems has helped revolutionize the overall process such as registration of specimens, regulation of lab workflow, dissimilation of lab reports on a timely basis, and efficient quality assurance measures. The evolved infrastructure of laboratories through the adoption and integration of LIMS/LIS, patient safety, quality of care, and overall profitability has increased significantly (Park, Pantanowitz, Sharma, & Parwani, 2012).

Implications of the study

There is need for clinical laboratories to develop and implement cost-effective and feasible interventions to not only improve quality care but also reduce unnecessary wastage, and clinical errors. In this study, the advantages and benefits of laboratory information systems as a platform to enhance patient satisfaction, quality care, and patient safety were reviewed qualitatively. The study is important in the field of evidence-based practice and quality improvement interventions, wherein researchers, policymakers, and health leaders may identify the need to adopt laboratory information systems.

Recommendations

Although the study focused on the usefulness and benefits of laboratory information systems, key issues such as privacy and security of patient data were not briefly reviewed. Despite the plethora of advantages offered through laboratory information systems, there is a

need for further research to identify limitations or drawbacks. There is a need to conduct a qualitative study to assess if the benefits or advantages of laboratory information systems outweigh potential risks and drawbacks (Baron, et al., 2014).

Appendix

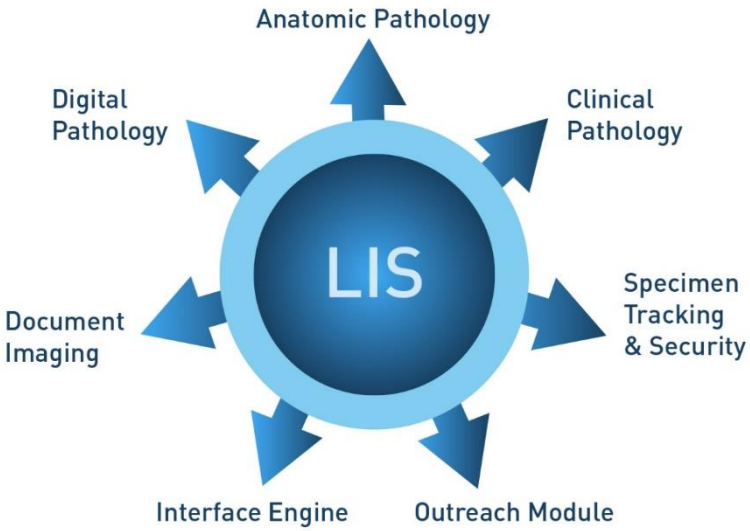

Figure 1. Model Infrastructure of Laboratory Information Systems (Beckloff, 2015).

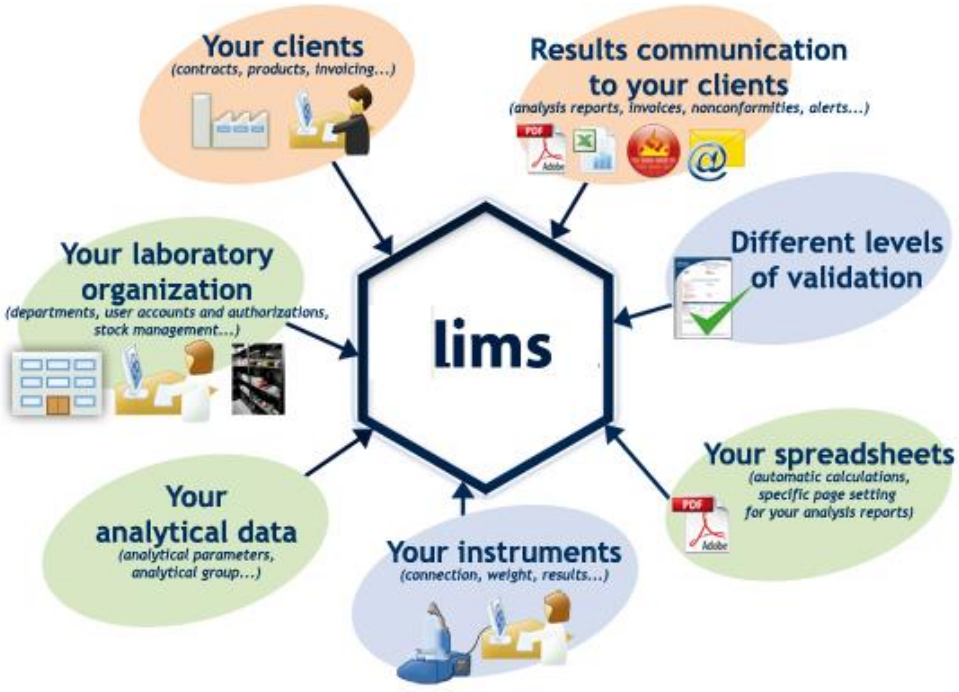

Figure 2. Laboratory Information Systems Model Workflow (Scuotto, 2014).

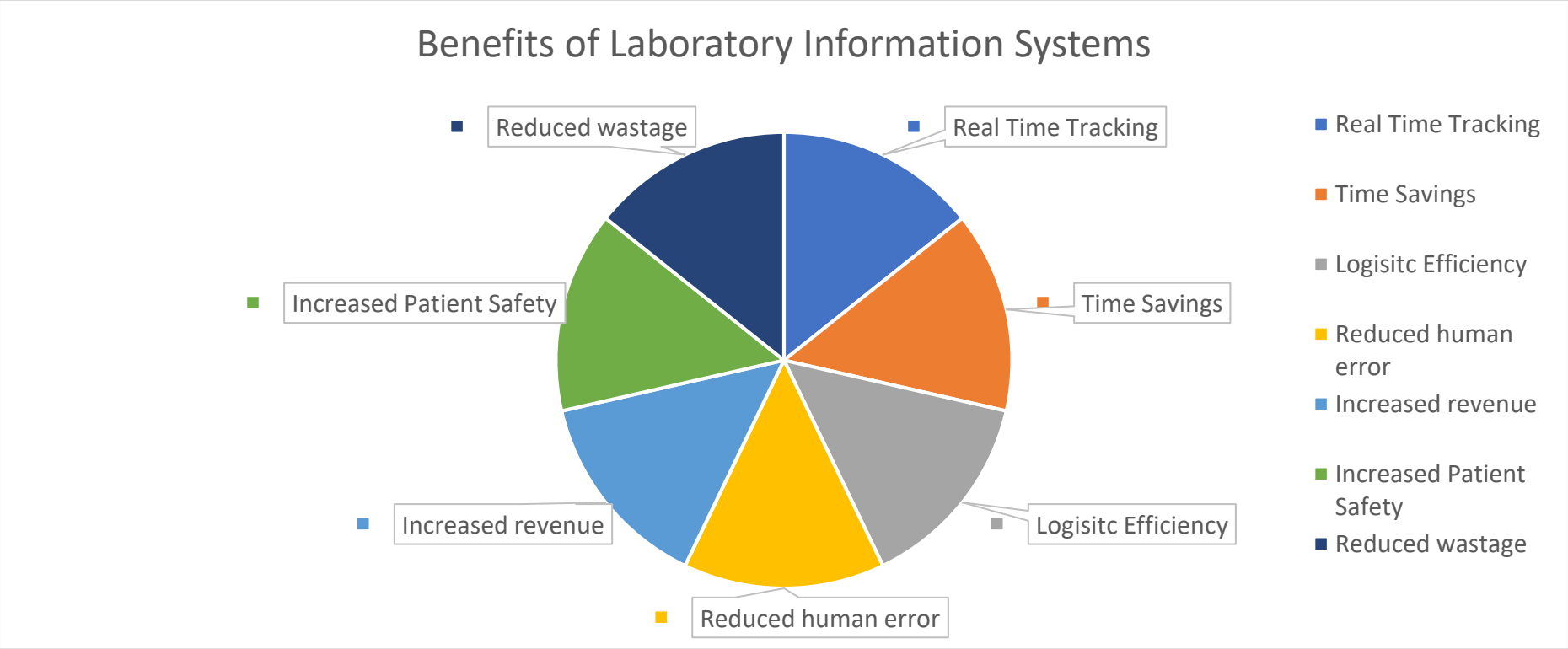

Figure 3. The benefits/advantages of Laboratory Information Systems

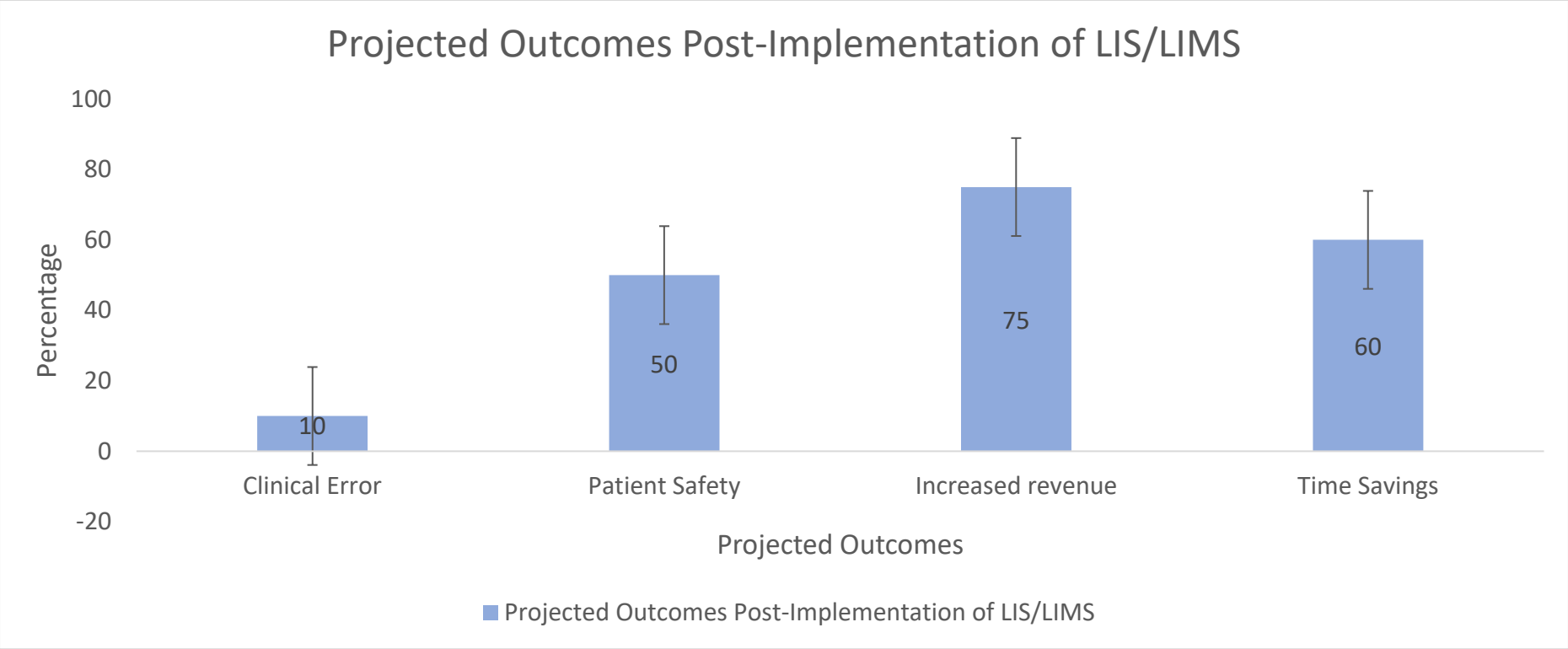

Figure 4. Projected (hypothetical) outcomes post-implementation of LIS/LIMS

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