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Laboratory information systems: Enhancing efficiency and patient care

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***Abstract*--- Background** _ Laboratory services are an integral part of the decision-making process for physicians, especially in ambulatory care settings, where timely and accurate laboratory results are crucial for effective medical treatment. Communication errors commonly occur when information is shared on paper, which can adversely affect patient outcomes and operational efficiency. The advent of electronic communication systems presents an opportunity to enhance this communication between ambulatory care facilities and laboratories. **Aim of Work –** The aim of this review was to analyze research conducted on the impact of electronic communication between ambulatory care facilities and laboratories. The review sought to assess the benefits and implications of transitioning from traditional paper-based communication methods to electronic interfaces in laboratory services. **Methods** –A comprehensive search was performed across multiple databases, including PubMed, Embase, Cochrane, and Web of Science, to identify relevant studies. Inclusion criteria were set to focus on studies published in English between the years 2000 and 2021, and only those with accessible full texts were selected. **Results** – The findings indicated that electronic communication between ambulatory care facilities and laboratories offers numerous advantages. These advantages include improvements in economic efficiency, enhanced organizational processes, and superior quality of service delivery. The review highlighted the significance of the data underscoring the positive impact of electronic communications on local investment and acceptance within healthcare systems. **Conclusion** – The review concluded that the implementation of electronic communication between ambulatory care facilities and laboratories can mitigate errors associated with traditional paper-based methods. The benefits observed in terms of

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economic efficiency, organizational improvements, and enhanced quality of care underscore the importance of investing in and adopting electronic communication systems to streamline laboratory services and improve patient outcomes. The support for electronic communications is a critical component in fostering local investment and driving acceptance within the healthcare community.

***Keywords*---**Laboratory Communication Management, Laboratory Test Request, Laboratory Test Result, Exchange Of Laboratory Information, Interchange Of Health Information, Outpatient Care Centers.

Introduction

Laboratory services play a crucial role in medical care by aiding the patient, physician, and other care providers in making informed choices. Diagnostic tests have a significant impact on over 70% of healthcare decisions. Despite this, they are usually the least expensive option for healthcare and provide unbiased information about an individual's health. Patient referrals to ambulatory care centers are more common compared to other healthcare centers. Ambulatory care centers that offer laboratory services can provide ongoing care by conducting regular laboratory tests on patients with chronic illnesses **[1-4]**. Additionally, these tests can inform caregivers about heightened risks and potential areas where care may be lacking. Therefore, laboratory services have a crucial impact on directing medical operations in ambulatory care facilities **[5]**.

The accessibility of laboratory services is greatly influenced by the problem of communication. Communication in this context pertains to the transmission of a physician's test request and the subsequent delivery of the test findings from the laboratory to the requesting physician. This may be accomplished by several conventional or contemporary methods. In conventional modes of communication, patients often bear the burden of carrying information on paper, resulting in significant time and energy wastage as they travel between ambulatory care centers and independent laboratories. This process leads to numerous delays and interruptions in the transmission of laboratory results, making it difficult for physicians to promptly access and review the findings **[6,7] (Figure 1)**. This sometimes poses a challenge in timely identification of anomalous findings, therefore compromising the quality of therapy and patient safety and satisfaction. Physicians and laboratories sometimes use methods such as e-mail, fax, dedicated telephone lines, and printer setups to exchange traditional information like test requests and results. However, these methods have several issues, including lack of documentation and reliability **[8–11]**.

The use of modern or electronic information exchange systems between ambulatory care centers and labs may aid healthcare practitioners in making well-informed choices to enhance patient safety and address issues associated with paper-based processes. Nevertheless, the strategies used by industrialized and developing nations vary in this aspect **[12-15]**. In developing nations, the majority of primary care centers lack electronic medical records, and ambulatory care centers and offices are often not digitally connected to their reference

laboratory. Developed countries, which are leading in this area, have not fully resolved all the issues related to interoperability **[16-20]**. The limited focus on electronic communication between laboratories and ambulatory care centers, compared to hospitals, as well as the unreliability of traditional communication methods, prompted this study to investigate the impact of information technology on information exchange between laboratories and ambulatory care centers through a literature review.

Methodology

The study was conducted in collaboration with all authors of this study, as well as database experts and Internet information science experts. Their input was sought to design a search strategy for multiple electronic bibliographic databases, namely PubMed, Web of Science, Embase, and Cochrane. These databases were chosen as the main sources of information. Additional information was obtained by referring to the sources cited in the publications. The search approach, as outlined in the appendix, included examining the titles of the publications and picking keywords that had a high level of sensitivity and specificity. We chose phrases that were closely associated in meaning and were used in publications that specifically addressed interoperability and information sharing for each idea that was searched. Once the keywords were approved, they were concatenated with suitable wildcards and truncations using OR and AND operators.

We included all English research papers with complete texts that were published in print or online from 2000 to 2021. These studies were sourced from journals or conferences that are indexed in searchable databases. This systematic review focused on selecting studies that examined electronic information exchange between diagnostic laboratories and various ambulatory care centers, such as hospital outpatient wards, primary health centers, emergency departments, and doctors' offices. The acceptability of information interchange between laboratory information systems (LIS) and the electronic health record (EHR) system was determined in studies that did not include the research setting. In this study, exchanges that involved the transfer of health and laboratory information, including alerts, were included. These exchanges could be either unidirectional, going from the laboratory to ambulatory centers or from ambulatory centers to the laboratory, or bidirectional, involving both the laboratory and ambulatory centers or only ambulatory centers and the laboratory. Excluded from the analysis were papers that examined the connection between labs and inpatient facilities, namely hospitals, with a primary emphasis on the inpatient ward and without addressing ambulatory care services and departments.

Economic Advantages

Ambulatory care facilities, often managed privately by doctors, must prioritize the cost-effectiveness of implementing infrastructure and software to facilitate information sharing with labs. Research indicates that the use of electronic communication between ambulatory care centers and laboratories can result in overall cost savings for society at the national level **[21-23]**. This suggests that patients and healthcare providers are likely to benefit more than other parties.

However, a study conducted by Ross et al. **[24]** found that electronic information exchanges did not have a significant impact on the cost of laboratory tests.

Advantages for the organization

Organizational benefits refer to advantages that are advantageous to e-communication partners in terms of saving time, enhancing workflow, and improving communication.

Efficiency

Time efficiency is a commonly cited advantage in the majority of research (48%) **[22,24-28]**. Electronic exchanges have the potential to save time in many stages of their process. These interactions initially result in the prompt delivery of results to physicians and decrease the time spent on exchanging results between laboratories and ambulatory care centers. Additionally, they enhance the response time and timely follow-up of patients by the physician. A reduced response time can be crucial in certain situations. Research has shown that electronic exchanges are beneficial for patients suffering from AIDS and TB. These patients rely on prompt replies from doctors on their laboratory findings, as it is crucial for their speedy recovery and to minimize the danger of viral transmission. In contrast, Singh et al **[23]** did not see a comparable outcome. They said that the implementation of automated warnings would not result in prompt follow-up of laboratory findings. Electronic exchanges also lead to a decrease in turnaround time, which refers to the duration between the test being conducted and the communication of the findings to the physician.

Electronic exchanges may also be efficient in delivering prompt medical attention to patients. Electronic exchanges may greatly improve the timing of antiretroviral medications for patients with human immunodeficiency virus, and sometimes they can also increase the timeliness of the screening program. Given the involvement of several stakeholders in electronic transactions, time savings may be seen from numerous angles. As a result, electronic exchanges can effectively speed up nurses' task performance and decrease the time taken by providers. Electronic exchanges can also be more time-efficient for administrators compared to physicians and nurses. However, electronic exchanges do not have a significant impact on patients as a potential stakeholder, and they do not reduce the time spent on visits and waiting time **[29, 30]**.

Enhanced Cobas Workflow

Electronic exchanges will modify the sequence of tasks. By reducing paperwork and tasks that require human intervention, they can enhance workflow. The workflow in electronic information exchanges between offices and laboratories can exhibit managerial and clinical patterns involving multiple stakeholders, such as physicians, patients, laboratory staff, nurses, and nonclinical personnel **[16, 22]**. The positive impact of electronic exchanges on patient workflow acceleration and management is evident in certain cases. Electronic exchanges also enhance administrative work. However, the efficiency of electronic exchanges on the

workflow of clinical and nonclinical staff may vary, with managers benefiting more than physicians and nurses in some instances **[28-30]**.

Enhanced Communication

Communication is the primary component of information conveyance. Hence, enhancing communication is crucial for the prompt and precise dissemination of information to the appropriate recipient. Several research **[9, 16, 27, 31-35]** have shown enhanced communication as a positive outcome of electronic exchanges. Enhanced communication may be evaluated from the viewpoint of several parties, such as doctors, care providers, labs, and sometimes patients.

Advantages of High Quality

Electronic interchange between offices and labs offers many advantages that enhance the quality of transmitted information. These benefits include enhanced quality of treatment, decreased sources of errors, and better patient medical records.

Enhanced Standard of Care

Electronic exchanges have been found to improve the quality of care in various healthcare settings, as indicated by the reviewed studies **[10,26,27,33,36]**. These studies highlight the positive impact of electronic exchanges on emergency care, screening programs, preventive care, ambulatory care, and care for patients with AIDS. It is worth noting that enhancing care for individuals with AIDS can also contribute to broader public health objectives, such as reducing the transmission of the virus.

Electronic exchanges have the potential to enhance treatment in several ways. Enhancing the quality of care can be achieved by ensuring the accurate reception of test results, ensuring that the results align with the requested tests, and enabling faster response times. Consequently, improving the standard of AIDS care relies on promptly addressing crucial laboratory results and fostering high-quality communication. Electronic exchanges can enhance care by facilitating the improved monitoring of patients' health in certain situations. Additionally, physicians can enhance care by better assessing their diagnostic hypotheses and applying evidence-based methods in laboratories. Finally, improved care can be indicated by higher levels of patient satisfaction **[37-41].**

Decrease in the number of factors contributing to errors

Inadequate communication often leads to issues between ambulatory centers and laboratories. Information technology has the potential to decrease errors that happen when information is transmitted between ambulatory care centers and laboratories. It can also help resolve communication issues to some degree **[9,16,27,28,30,34,35,37,39]**. Errors in information transfer can occur when requesting and conducting a test, as well as when returning the test results. The use of electronic exchange can assist in reducing errors in both of these areas.

The utilization of electronic exchange in the request and execution stages of a test leads to a decrease in the rate of inappropriate requests, redundancy of test, and an increase in the accuracy and appropriateness of requests **[27, 30, 35, 37, 39]**. Additionally, electronic exchanges can prevent the loss of test results and reduce errors in the entry of test data, as well as errors that may arise in manual systems due to transcription or illegible handwriting **[16]**.

Electronic exchanges may enhance the process of transferring samples during the test request phase, reducing the likelihood of mistakes. Electronic exchanges provide many advantages, including enhanced process tracking, particularly for sample tracking to ensure accurate insertion of sample specifications. Additionally, electronic exchanges help avoid mislabeling of laboratory samples, resulting in improved efficiency and accuracy **[16, 28, 30].**

Based on our analysis of the research, electronic exchanges have a beneficial impact on eliminating mistakes in the return phase of laboratory test results. Electronic exchanges guarantee the accuracy of tests and the relevance of their results. They also minimize reporting mistakes and enable the investigation of issues in result delivery through electronic reporting. Additionally, the physician's follow-up can be automatically recorded and quantifiable. Another advantage of electronic exchanges is the prevention of result loss **[9, 27, 34]**.

Enhanced Patient Medical Records

Enhancing the veracity and comprehensiveness of information, as well as increasing the precision and reliability of data, are some of the factors that eventually contribute to the enhancement of patient medical records **[16, 22, 30]**. One further advantage of electronic exchanges is the widespread acceptance and willingness of consumers to use the Electronic Health Record (EHR) **[11]**.

Difficulties in facilitating electronic communication between laboratories and offices

In addition to numerous studies that have examined the advantages of electronic communication between laboratories and ambulatory care centers, there have also been reports of its adverse effects. These negative effects have been documented in studies **[9, 28, 31, 40]**. Despite the mentioned benefits, electronic communication can be difficult due to the inadequate design of interfaces and inaccurate analysis of workflow. The problems mentioned in the studies we examined include provider record issues, logical errors of routing results and interfaces, the problem of collecting and resending lost results in the transmission path, the configuration and maintenance problems of the EHR system, creating potential hazards for patient care, creating the potential for decentralized decisions by displaying undesirable and misleading results in the system, loss of the ability to control the aspects of the requesting process, and the uncertainty of completeness, accuracy, and adequacy of laboratory test requests for facilitating the efficient processing of laboratory operations **[9, 31, 40]**. In one study, the failures of the established model were criticized by laboratories and clinicians in terms of problems and difficulties in resolving errors and the need to

adapt to new nomenclature, respectively **[28]**. Therefore, in order to prevent problems, achieve high productivity, and enjoy the benefits mentioned here, various aspects of the design and development of electronic exchanges should be taken into consideration.

Discussion

Ambulatory care centers are crucial healthcare institutions that address the majority of ambulatory care requirements. Physicians at ambulatory care facilities often rely on test findings to inform their treatment choices. Hence, there is an unavoidable requirement for the transmission of requests and laboratory results between offices and laboratories. Electronic exchanges are suggested as a means to prevent errors that may occur in paper-based exchanges. To persuade ambulatory care centers, offices, and laboratories to adopt information technology for electronic exchanges, it is crucial to demonstrate the advantages of these exchanges to them. Nevertheless, a comprehensive evaluation of the impacts of electronic health information exchanges (HIEs) between ambulatory care facilities and labs is still pending. Wu and LaRue **[42]** conducted a review of studies published between 2010 and 2015 on the factors that hinder or support the adoption of electronic health information exchange among different healthcare settings. However, their review did not specifically address the sharing of information with secondary care centers like laboratories. Fontaine et al. **[43]** conducted a systematic study and highlighted the advantages of electronic information interchange, which include better workflow, greater patient quality and safety, cost savings, and higher productivity. While the evaluation did not precisely examine the information flows between primary care facilities and labs, it did acknowledge that enhanced access to test findings was seen as a dependable advantage.

The current research evaluation specifically examines references that highlight the advantages of electronic exchanges between ambulatory care centers and labs. These two healthcare facilities need information sharing in order to provide optimal patient care. The peer-reviewed publications were classified into two groups: conference papers (with just one instance, case 41) and journal papers. All studies provide advantages that may be categorized into three categories: financial, organizational, and quality benefits. The advantages of electronic exchanges between ambulatory care centers and labs are significant for ministry and government authorities. They act as a motivation to urge health facilities to adopt the usage of these electronic exchanges. Furthermore, Fontaine et al. **[44]** conducted research on motivating factors (perceived and anticipated advantages) for involvement in HIEs. The study found that internal variables such as cost reduction, efficiency, quality of treatment, and patient safety were significant. All of these criteria have been addressed in the papers included in this study review.
Cost savings is a motivating factor for accepting electronic exchanges, which may be attributed, in part, to the direct electronic transmission of test findings to the Electronic Health Record (EHR). Electronic exchanges of results significantly decrease employee time consumption and paper usage, resulting in cost savings. The literature has highlighted the positive impact of electronic exchanges on costs, with specific mention of this issue in the emergency department by Frisse et al. **[35]**. The researchers reported a collective yearly societal cost reduction of

around $1.95 million. The research period had an estimated annual operating cost of about $880,000, but the net societal savings amounted to roughly $1.07 million. 97.6% of the overall savings may be attributed to the decrease in admissions from the emergency department. According to a study, the yearly earnings from the exchange of information between external laboratories and independent outpatient centers were $18.8 billion for electronic communications using nonstandard data, and $31.8 billion for electronic communications using standardized and coded data (full interoperability). The net profit from these communications amounted to $13.9 billion.

Limitations

There are constraints to this research review, such as the exclusion of publications that were not accessible in the English language. Furthermore, research that failed to explicitly specify whether the setting being evaluated was outpatient or inpatient were not included in this analysis.

Conclusion

The primary significance of this systematic review is in its emphasis on ambulatory care centers, which are responsible for the bulk of healthcare services and, as a result, must engage in information exchange with external institutions, such as labs. Ambulatory care facilities, often managed by independent entities and individuals, require a deeper understanding of the advantages and impacts of information technology in order to persuade them to embrace and use it. This research examines the financial, organizational, and quality advantages of electronic exchanges between ambulatory care facilities and labs, which may improve the acceptance and attractiveness of this technology for investment.

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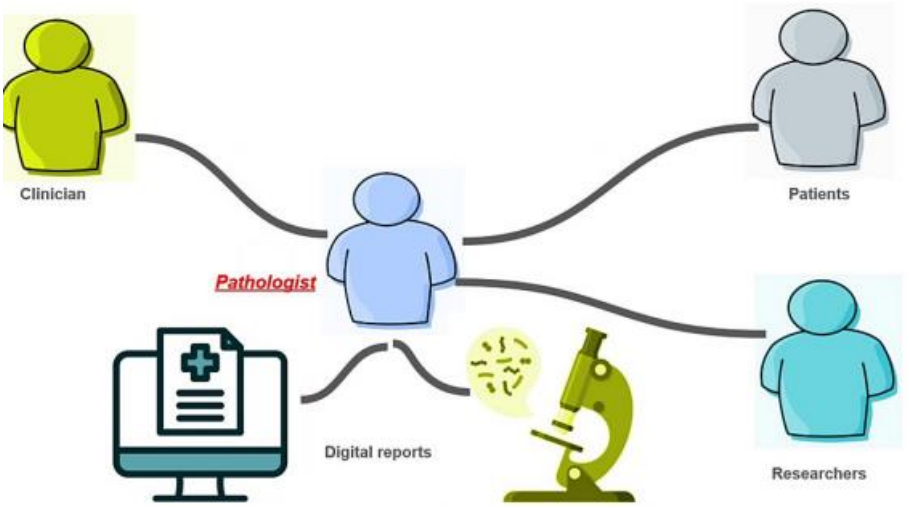

Figure 1. Interactions of a pathologist