Review Article

Increasing the impact and value of laboratory medicine through effective and AI-assisted communication

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Abstract

Effective communication is pivotal in maximizing the impact and value of laboratory medicine (LM) within healthcare. This review explores diverse strategies to enhance communication among healthcare providers, patients, laboratory personnel, and the general public. Key strategies include improving interdisciplinary collaboration through clear reporting, regular multidisciplinary meetings, and consultative services. Enhancing patient communication involves providing accessible test results via patient portals, developing educational materials, and fostering direct patient-provider communication. Implementing efficient information systems by integrating laboratory information systems with electronic health records and using automated alerts ensures timely data sharing and critical value notifications. Continuous education and training for healthcare providers and laboratory staff will keep them updated on advancements and improve communication skills. Fostering a culture of open communication encourages feedback and transparency, while leveraging technology such as telemedicine, mobile health applications, and artificial intelligence--(AI)-driven tools enhances real-time consultations and personalized insights. AI can be used to assist communication through providing advanced data analysis, personalized patient insights, enhanced communication, streamlined workflows, and demonstrable impact through research and analytics. These strategies collectively ensure accurate conveyance of critical information, improving patient and public insight and leading to better patient outcomes and more informed clinical decisions.

1. Introduction

Effective communication is a cornerstone in maximizing the impact and value of laboratory medicine in healthcare. It ensures that critical information is accurately conveyed, understood, and acted upon by the four main groups of stakeholders: healthcare providers, patients, and laboratory personnel and the general public.

In this article, we ask the following questions: *How can we improve communication between the laboratory and external stakeholders such that there is greater value and impact and how can we use new developments such as artificial intelligence (AI) to assist this process?*

One of the most important roles of a laboratory is to communicate results to stakeholders in the most efficient and cogent manner. The manner in which results are presented is largely geared towards clinicians and not to patients. Simply providing results to patients is not sufficient to facilitate participation in care because many may not be able to make sense of the results in the way the results are presented. *How can information be presented such that the recipient obtains the maximum value from the results?*

There are several different ways in which communication can enhance the value and impact of laboratory medicine. By employing these various communication strategies, the critical role of laboratory medicine in diagnosing, treating, and managing diseases can be more widely recognized and appreciated [1-4].

When considering the groups of stakeholders, the communication strategy has to be tailored to the particular group. The patients and general public should be considered uppermost in efforts to demonstrate the impact of laboratory medicine because these groups drive the demand for laboratory testing and it has the greatest impact on their lives.

2. Communicating with patients and the public

2.1 Enhancing communication with patients and education

Enhancing patient communication and education includes providing accessible test results through patient portals [1], developing educational materials, and ensuring effective direct communication between patients and providers.

Provide clear, simple and accessible test results [5]

Patients should have access to their laboratory results through patient portals integrated with electronic health record (EHR) systems [1]. Clear explanations of what the results mean and how these results impact their health can be provided alongside the raw data. Providing links to reputable sources for further reading can enhance understanding. However, often the design of patient portals may be geared towards presenting results in a table [1-4] and this presentation form is primarily geared towards clinicians. Providing patients with clear, easy-to-understand explanations of their test results helps them appreciate the importance of laboratory medicine. Accompanying results with visual aids, such as charts or infographics, can make complex information more accessible. Information portals for patients will require designs that feature information tailored to the medical context [4] and this is where AI-driven portals will find future value.

Public awareness and advocacy

Educational Materials and campaigns [6]

Laboratories and healthcare providers should develop educational materials that explain the use and purpose and implications of common laboratory tests. Brochures, videos, and online resources (eg. LabTestsOnline) can empower patients to understand their health better and engage more actively in their care.

Public health campaigns that educate the general public about common laboratory tests, their purposes, and their impact on health can increase awareness. These campaigns can use various media, including social media, brochures, and community workshops. National and community-level campaigns can highlight the role of laboratory medicine in public health. Topics can include the importance of screening programs, the impact of early diagnosis, and the contribution of laboratory medicine to disease prevention.

Media Engagement

Engaging with media outlets to share stories of how laboratory medicine has made a difference in patient outcomes can raise public awareness. Interviews with laboratory professionals and success stories from patients can humanize the science and highlight its value.

Social Media Presence

Utilizing social media platforms to disseminate information about laboratory medicine can reach a broader audience [7, 8]. Infographics, videos, and Q&A sessions can engage the public and increase understanding of the field.

Effective use of patient-provider communication, feedback and transparency [9]

Direct communication between patients and healthcare providers regarding test results ensures that patients can ask questions and receive personalized explanations. This can alleviate anxiety, improve understanding, and encourage adherence to follow-up plans. Fostering a culture of open communication encourages feedback from healthcare providers and patients, and emphasizes transparency in communication about laboratory processes.

Encouraging Feedback [10, 11]

Creating a culture where feedback is encouraged and valued can lead to improvements in laboratory services. Healthcare providers and patients should be able to provide feedback on the clarity of reports, the accessibility of information, and the overall communication process [10]. Such feedback can produce beneficial short-term emotional changes for laboratory

professionals and this can assist with low morale or staff burnout [10]. It therefore becomes important for laboratories to encourage such feedback in the same way as complaints may be entertained and recorded in the patient-facing context [11].

Transparent Communication [12, 13]

Transparency in communication about laboratory processes, potential delays, or issues with test results builds trust among healthcare providers and patients. Clear and honest communication helps manage expectations and reduces misunderstandings. A number of strategies have been proposed to assist entities involved in health care to increase trust amongst patients [12]. Of relevance to laboratory medicine is the need to develop standards, training and accountability systems [12].

Using AI for communication with patients

Developments in AI have led to the development of large language models (LLMs) that are probabilistic natural language processing systems trained on vast amounts of data. Generative AI applications such as chatbots can generate responses in a conversational style. It has been shown that chatbots can effectively communicate health information. It was hypothesized that this technology could be utilized in clinical decision support. However, multiple studies have indicated that, in its current form, this technology is too prone to errors and limitations to be effective in clinical settings. On the other hand, it has been found that chatbots can provide higher-quality responses and display more empathy than some physicians when answering patient questions. Chatbots have the potential to be used in a diagnostic setting to convey interpretative information on laboratory results. One cross-sectional study of 1134 reports examined the use of chatbots to simplify anatomical pathology reports [14]. The study found that chatbots could simplify anatomical pathology reports but there were inaccuracies and hallucinations indicating that such simplified reports should be reviewed by laboratory/healthcare professionals before transmission to the patients. There is support amongst laboratory professionals [15] for the use of AI as this could boost productivity and reduce errors.

Critical result reporting

AI can play a crucial role in the communication of critical results to clinicians or patients. Secure messaging apps offer significant advantages over traditional phone calls, particularly in enhancing the timeliness of reporting results [16, 17]. When healthcare organizations shift from reporting critical values by telephone to utilizing a secure messaging app, they can not only meet but often exceed accrediting agency standards. This transition enhances efficiency by delivering results directly to the appropriate person, reduces the time required to report outcomes, and provides a reliable communication record with automatically time-stamped messages upon sending, receiving, and reading. Additionally, built-in reporting features offer precise data on the communication process. The use of secure messaging apps that are coupled with AI-driven autoverification will facilitate rapid reporting of critical value results in clinical laboratories.

3. Communicating with healthcare providers including requesting clinicians

3.1 Clear and Concise Reporting [18]

Laboratory results must be reported clearly and concisely to clinicians. Standardized reporting formats, including the use of structured data and electronic health records (EHR), facilitate the easy interpretation of results. Avoiding jargon and using standardized terminology ensures that clinicians from different specialties can understand and utilize the information effectively. Reference has been made to the use of critical result reporting above.

3.2 Regular Multidisciplinary Meetings [19]

Improving interdisciplinary collaboration involves clear and concise reporting, regular multidisciplinary meetings, and consultative services to facilitate accurate interpretation and utilization of laboratory data. Holding regular meetings that involve laboratory personnel, clinicians, nurses, and other healthcare providers promotes interdisciplinary collaboration. These meetings can discuss complex cases, unusual findings, and ensure that laboratory data is integrated into patient care plans and laboratory operational challenges are understood. Regular interdisciplinary meetings and case discussions that include laboratory specialists can highlight the diagnostic value of laboratory tests. These discussions can showcase real-world examples of how laboratory results have led to accurate diagnoses and successful treatments. Anatomical pathologists are particularly adept at this because they often have to present tissue and biopsy results at clinicopathological meetings with different clinical specialties. Clinical chemistry generally finds a great partnership with endocrinology but this does not preclude interaction with intensive care/critical care specialists and nephrologists as examples.

3.3 Consultative Services [20]

Laboratories should offer consultative services where laboratory professionals, such as pathologists or clinical chemists, can discuss results with clinicians. This is generally an established part of laboratory medicine but will be greatly facilitated by the regular multidisciplinary meetings referred to above. This helps in the proper interpretation of complex test results and in deciding subsequent steps in patient management.

3.4 Educating health care providers

Integrating laboratory medicine into clinical pathways and guidelines ensures that healthcare professionals understand when and why specific tests are needed. Clear guidelines help providers appreciate the role of these tests in improving patient outcomes. Offering Continuing medical education (CME) courses focused on laboratory medicine keeps healthcare providers updated on

the latest advancements, testing protocols, and their clinical implications. Interactive sessions, case studies, webinars and online courses can make this education more engaging.

3.5 Implementing efficient information systems to assist communication

Integration of laboratory information systems (LIS) with electronic health records

Implementing efficient information systems focuses on integrating laboratory information systems (LIS) with electronic health records (EHR) for seamless data sharing, and employing automated alerts and reminders for critical laboratory values. Integrating LIS with EHR ensures seamless and real-time sharing of laboratory results with healthcare providers. This integration reduces delays, minimizes errors, and ensures that clinicians have immediate access to vital information.

Timely communication and automated alerts and reminders [21, 22]

Ensuring that laboratory results are communicated promptly to the relevant healthcare providers prevents delays in diagnosis and treatment. Real-time notifications and alerts can help keep providers informed and responsive. Automated systems can be set up to alert clinicians about critical values or significant changes in laboratory results. Reminders for follow-up tests or monitoring can also be automated, ensuring that important actions are not overlooked [16, 17].

Standardized reporting formats

Using standardized formats for reporting laboratory results ensures consistency and clarity, making it easier for healthcare providers to interpret and act on these results. Structured reports with clear conclusions and recommendations facilitate better clinical decision-making.

Feedback Mechanisms

Implementing feedback mechanisms where healthcare providers can discuss the relevance and clarity of laboratory reports with laboratory staff can lead to continuous improvement in communication practices.

4. Communicating with laboratory staff

4.1 Laboratory staff training [23]

Laboratory staff should also receive ongoing training to remain conversant with the latest technologies, methodologies, and communication strategies. This ensures that they can provide accurate information and effective consultations. Communication training [24] is particularly important because it is an aspect that is neglected in many training curricula. The inability of scientists and in this instance, laboratory professionals to communicate with the public, has led to mistrust [24].

4.1.1 Training in communication skills for laboratory staff

Workshops and Seminars

Conducting workshops and seminars for healthcare providers and laboratory staff on effective communication strategies ensures that all team members are skilled in conveying the value of laboratory tests. Role-playing scenarios and interactive sessions can enhance learning.

Certification Programs

Certification programs that include modules on communication skills specific to laboratory medicine can ensure that laboratory professionals are equipped to explain their findings clearly and effectively.

5. Leveraging Technology for Enhanced Communication

Telemedicine, mobile health applications and AI-driven tools can be used to enhance communication in laboratory medicine and provide real-time consultations and provide personalized feedback to patients.

5.1 Telemedicine and Remote Consultations and telehealth integration [25, 26]

Telemedicine platforms can facilitate consultations between laboratory specialists and clinicians, especially in remote or underserved areas. This ensures that even distant healthcare providers can access expert advice and interpretations. Integrating laboratory results into telehealth consultations allows patients and providers to discuss results in real-time, enhancing understanding and immediate decision-making. Visual aids can be shared on-screen to explain complex results.

5.2 Mobile Health Applications [27-30]

Mobile health applications can be used to deliver laboratory results, provide explanations, and offer follow-up advice directly to patient smartphones. This enhances accessibility and ensures timely communication. Developing mobile applications that notify patients of their test results and provide explanations and next steps can enhance patient engagement and understanding. Apps can also offer reminders for follow-up tests or appointments.A number of mobile apps have been developed for patients and health care professionals (reviewed in [27, 29]. In these studies [27, 29] it was found that mobile apps for laboratory medicine that deal exclusively with interpretation of results represented half of all apps and apps designed for patients were of the poorest quality, indicated that there is considerable scope for improvement.

5.3 Using AI and machine learning to improve communication and understanding of laboratory medicine [31-33]

AI-driven tools can help interpret laboratory results and provide clear explanations to both healthcare providers and

patients. These tools can identify patterns, predict outcomes, and suggest next steps based on the latest medical evidence.AI can be used to assist with communication from the laboratory to external stakeholders. It has the potential to help improve the understanding of the value and impact of laboratory medicine among healthcare providers, patients, and the general public (summarised in Table 1). With the use of advanced data analysis, personalized insights, and streamlined communication, AI can highlight the critical role laboratory medicine plays in modern healthcare.

5.3.1 Advanced Data Analysis and Interpretation

Automated Data Interpretation

AI algorithms can analyze large volumes of laboratory data quickly and accurately, providing automated interpretations of complex results. This can help healthcare providers or patients understand the implications of test results more clearly and make informed decisions. A study of 3200 patients showed that patients who received interpretations on abnormal results showed a much higher rate of followup (71% vs 49%) [34]. Patients stated that a significant benefit of this was the time factor compared to receiving interpretations from a doctor. It has been found in a prior study [35] that 26% of results are not followed up by patients and auto-generated interpretations will definitely increase the potential of results being followed up [34].

Predictive Analytics

AI can predict disease progression and treatment outcomes by analyzing historical data and identifying patterns [36, 37]. Predictive analytics can demonstrate the long-term value of laboratory tests in managing chronic diseases and improving patient outcomes [38]. In a study of close to 230 000 patients and results from nine laboratory tests, the data were subjected to visual analytics and used to predict the likelihood of Acute kidney injury (AKI) [37]. Clinical laboratories produce vast amounts of data and there is growing interest in using data to make decisions and improve patient care [38]. Challenges such as data accessibility, lack of resources and data literacy are still impediments to exploiting data literacy to the fullest extent [38].

Anomaly Detection

AI systems can detect anomalies and trends that might be missed by human analysts. Identifying these patterns can lead to early diagnosis and intervention, showcasing the importance of routine laboratory testing [39, 40]. In one example, a clustering approach was used to detect anomalies/outliers in HER data [40].

5.3.2 Personalized Patient Insights

Personalized Health Reports

AI can generate personalized health reports for patients, explaining their laboratory results in an understandable and context-specific manner. These reports can include visual aids, such as graphs and charts, to help patients comprehend their health status [41-44].

Risk Assessment and Management

AI tools can assess individual patient risks based on their laboratory results and medical history. Providing personalized risk assessments and management plans highlights the value of laboratory medicine in preventive healthcare.

Tailored Health Recommendations

By analyzing patient data, AI can offer tailored health recommendations and follow-up actions. This personalized approach helps patients see the direct benefits of laboratory tests in managing their health.

5.3.3 Enhancing Communication and Education

Natural Language Processing (NLP)

AI-powered NLP can translate complex laboratory data into plain language, making it easier for both healthcare providers and patients to understand [45-47]. This ensures that critical information is communicated effectively and comprehensively. An example of a large language model is GatorTron [47] which was developed from millions of patient records and contains > 90 billion words of text. Another example is Med-Bert [48].

Virtual Health Assistants

AI-driven virtual health assistants [49] can interact with patients and healthcare providers, answering questions about laboratory tests and their implications. These assistants can provide 24/7 support, improving accessibility to information.

Educational Platforms

AI can power educational platforms that offer interactive learning modules about laboratory medicine. These platforms can adapt to the user's knowledge level, providing customized content that enhances understanding.

5.3.4 Streamlining Workflow and Decision-Making

Integrated Decision Support Systems

AI can integrate with Laboratory Information Systems (LIS) and Electronic Health Records (EHR) to provide real-time decision support. AI-driven alerts and recommendations can guide clinicians in interpreting laboratory results and determining the next steps.

Workflow Optimization

AI can optimize laboratory workflows by automating routine tasks and managing resources efficiently. This ensures that laboratory staff can focus on more complex tasks, improving overall productivity and accuracy.

Real-Time Data Sharing

AI systems can facilitate real-time data sharing and communication between laboratories and healthcare providers. Instant access to up-to-date information ensures that clinical decisions are based on the latest available data.

5.3.5 Demonstrating Impact Through Research and Analytics

Clinical Research and Outcomes Studies

AI can analyze data from clinical research and outcomes studies to demonstrate the impact of laboratory medicine on patient care. Publishing these findings can help healthcare providers and policymakers understand the value of laboratory tests.

Cost-Benefit Analysis

AI can perform cost-benefit analyses by comparing the costs of laboratory testing with the benefits in terms of improved patient outcomes and reduced healthcare expenses. This information can be crucial for decision-makers in healthcare organizations.

Population Health Management

AI can analyze population health data to identify trends and the impact of laboratory medicine on public health. This can help in planning and implementing effective public health strategies and policies.

5.3.6 Public Awareness and Advocacy

Interactive Health Dashboards

AI-powered health dashboards can present laboratory data and health insights to the public in an interactive and engaging way. These dashboards can highlight the role of laboratory medicine in maintaining public health.

Social Media and Public Engagement

AI can analyze social media trends and public sentiments to tailor communication strategies that raise awareness about the importance of laboratory medicine. Targeted campaigns can educate the public and dispel misconceptions.

AI-Driven Storytelling

AI can generate compelling stories based on real-world data, illustrating the life-saving impact of laboratory medicine. Sharing these stories through various media channels can resonate with a broader audience [50].

Table 1: Summary of the applications of AI in enhancing the value and impact of laboratory medicine.

Application in improving the impact of Laboratory Medicine	Key Components	Role
Advanced Data Analysis and Interpretation	Automated Data Interpretation	analyze large volumes of laboratory data and provide interpretations
	Predictive Analytics	predict disease progression and treatment outcome
	Anomaly Detection	detect anomalies and trends
Personalized Patient Insights	Personalized Health Reports	explaining laboratory results in an understandable and context-specific manner
	Risk Assessment and Management	assess individual patient risks
	Tailored Health Recommendations	offer individualized health recommendations
Enhancing Communication and Education	Natural Language Processing (NLP)	translate complex laboratory data into plain language
	Virtual Health Assistants	can provide 24/7 support
	Educational Platforms	interactive learning modules
Streamlining Workflow and Decision-Making	Integrated Decision Support Systems	real-time decision support
	Workflow Optimization	automate routine tasks and manage resources efficiently
	Real-Time Data Sharing	real-time data sharing and communication between laboratories and healthcare providers

Demonstrating Impact Through Research and Analytics	Clinical Research and Outcomes Studies	data from clinical research and outcomes studies demonstrate the impact of laboratory medicine on patient care
	Cost-Benefit Analysis	by comparing the costs of laboratory testing with the benefits in terms of improved patient outcomes and reduced healthcare expenses
	Population Health Management	analyze population health data to identify trends
Public Awareness and Advocacy	Interactive Health Dashboards	present laboratory data and health insights to the public
	Social Media and Public Engagement	tailor communication strategies that raise awareness about the importance of laboratory medicine
	AI-Driven Storytelling	compelling stories based on real-world data

6. Specific AI tools that can assist with improving the understanding and impact of laboratory medicine (Table 2)

6.1. Machine Learning (ML) Platforms

TensorFlow and PyTorch

These open-source ML platforms provide powerful tools for building, training, and deploying machine learning models [51-53]. They can be used to analyze complex laboratory data, identify patterns, and predict outcomes. TensorFlow and PyTorch can be used to develop models that predict the likelihood of a patient developing a particular disease based on their clinical history, laboratory results, and other data or applied to create models that predict patient outcomes, such as the likelihood of recovery or relapse, based on their medical data [54].

Scikit-learn

This Python library is user-friendly and ideal for implementing basic to advanced machine learning algorithms [55, 56]. It can be applied to various data analysis tasks in laboratory medicine, such as clustering and classification [57]. In patients with non-alcoholic fatty liver disease, machine learning models were developed to predict the risk of hepatocellular carcinoma [57]. The model was able to predict the development of carcinoma with more than 90% accuracy[57].

6. 2. Natural Language Processing (NLP) Tools

spaCy and NLTK

These NLP libraries can process and interpret large volumes of textual data from laboratory reports, converting complex medical terminologies into plain language [58, 59]. They enhance the clarity and accessibility of information for both healthcare providers and patients. In one example, EHRs were interrogated in patients with lung cancer to identify clinical phenotypes such as cancer staging, treatment recurrence and organs affected to provide additional insights into patient health. Comparisons were made between scispaCy, medspaCy, Flan-T5-xl, Flan-T5-xxl, Llama-3-8B, GPT-3.5-turbo, and GPT-4 [58]. The study highlighted the potential of GPT-4 for accurate phenotype extraction and improved care [58]. In another example, EHRs were screened for a number of different parameters, including laboratory data [59] using a natural language processing tool, EXTEND (EXTraction of EMR Numerical Data).

IBM Watson Natural Language Understanding

This tool provides advanced text analysis capabilities, including sentiment analysis, entity recognition, and keyword extraction [60-62]. It can help in summarizing laboratory reports and providing actionable insights.IBM Watson has been used to infer gene-gene relationships and identify novel biomarkers [60].

6.3. AI-Powered Virtual Assistants

Chatbots (e.g., Microsoft Bot Framework, Google Dialogflow)

AI chatbots can interact with patients and healthcare providers, answering queries about laboratory tests, results, and implications [63, 64]. They provide real-time, accessible support, enhancing understanding and engagement. A chatbot was used in a general practice to collection information for 3 months [63]. The information was used to monitor health status and provide health recommendations to patients and significant reductions in patient ailments was observed and the primary care physician was able to response rapidly to patients [63]. ChatGPT was used at a conference to answer questions and the answers were compared to those provided by expert faculty [64]. The AI chatbot provided answers comparable to experts suggesting that future development should be anticipated in the use of AI Chatbots to answer questions in laboratory medicine.

Virtual Health Assistants (e.g., HealthTap, ADA Health)

These AI-driven assistants can offer personalized health advice based on laboratory results, medical history, and current

symptoms [65, 66]. They help patients understand their test results and make informed health decisions.ADA health was used to screen patients with mental disorders [65]. Good agreement was obtained for mental disorders in adulthood when comparing psychotherapists with the performance of the app. In another example, a virtual assistant called "Paola" was used to carry out a 12 week evaluation of physical activity and diet [66]. The virtual health assistant performed well during the structured weekly check-ins, but showed performance errors mainly when queries were outside the capabilities of the virtual assistant. However, dietary compliance was high [66].

6.4. Predictive Analytics Tools

IBM Watson Health

In addition to its NLP capabilities, Watson Health leverages AI to analyze health data and provide predictive insights [62]. It can help healthcare providers anticipate disease progression and tailor treatment plans based on laboratory results.

SAS Advanced Analytics

SAS provides comprehensive analytics solutions that can process and analyze vast amounts of laboratory data, offering predictive insights and supporting clinical decision-making [67].

6.5. Data Visualization Tools

Tableau and Power BI

These tools offer advanced data visualization capabilities, transforming complex laboratory data into intuitive and interactive dashboards [68, 69]. Visualizations help in understanding trends, patterns, and the impact of laboratory tests. Tableau and Power BI are being used across the healthcare spectrum to analyze data pertaining to health care provider analytics, medical device analytics and pharmacy analytics to improve efficiency and reduced costs.

D3.js

This JavaScript library allows for the creation of dynamic and interactive data visualizations on web platforms [70]. It can be used to present laboratory data in an engaging and comprehensible manner [71]. Data visualization plays a pivotal role in healthcare by enabling providers and researchers to make well-informed decisions from extensive datasets. Through effective visualization, healthcare professionals can detect trends, patterns, and anomalies that may not be immediately apparent in raw data. Additionally, it helps researchers present their findings in a more digestible and comprehensible manner, facilitating better interpretation and actionable insights by stakeholders.

D3.js offers valuable applications in various health tech scenarios, such as:

Electronic Health Records (EHRs)

D3.js can be employed to craft interactive visualizations of EHR data, allowing healthcare providers to discern trends and patterns that may suggest specific health conditions, ultimately leading to more informed patient care decisions.

Clinical Trials

Clinical trials generate complex datasets essential for medical research, but interpreting this data can be challenging. D3.js can be utilized to develop interactive visualizations of clinical trial data, enabling researchers to analyze the information in real-time, thereby identifying trends and patterns critical to their studies.

Health Analytics

D3.js can be instrumental in creating interactive visualizations of health analytics data, providing healthcare providers and researchers with the ability to explore the data dynamically and pinpoint relevant trends and patterns for their research.

6.6. Clinical Decision Support Systems (CDSS)

MedAware

These AI-driven CDSS tools integrate with electronic health records (EHR) to provide real-time decision support, based on laboratory results and patient data [72]. They assist healthcare providers in making accurate and timely clinical decisions. Medaware is a medication safety monitoring platform that can predict and avoid adverse drug events [73]. MedAware was compared to an existing CDSS and it was found that more than 60% of MedAware generated alerts were not detected by the existing CDSS in a 4 year data collection period [73, 74].

DXplain

This is an AI-based diagnostic decision support system that provides differential diagnosis suggestions based on clinical findings and laboratory data [75]. It helps in interpreting complex cases and improving diagnostic accuracy. A clinical decision support system was found to improve diagnostic accuracy in a group of 87 Family medicine residents and this had the potential to decrease diagnostic errors and improve patient safety [75].

6.7. Personalized Medicine Platforms

Foundation Medicine

This platform uses AI to analyze genetic data from laboratory tests, providing insights into personalized cancer treatments [76]. It highlights the role of laboratory medicine in tailoring treatments to individual patients.In a study of patients with lung cancer, considerable racial inequities were identified in next generation sequencing results [77]. Racial disparities were also identified in genomic profiling of prostate cancer patients [78] in a large retrospective analysis of more than 11 000 patients.

Flatiron Health
Flatiron Health leverages AI to integrate clinical and laboratory data, offering personalized treatment recommendations and improving cancer care [79]. It can be used to assist physicians adhere to evidence-based guidelines during cancer diagnosis and treatment helping to standardize treatments in haematology-oncology [79].

6.8. Automated Quality Control Systems

Bio-Rad Unity Real-Time
This AI-powered quality control system monitors laboratory testing processes in real-time, identifying errors and ensuring accuracy [80]. It enhances the reliability and value of laboratory results.

Abbott AlinIQ
AlinIQ uses AI to optimize laboratory operations, including quality control, workflow management, and data analysis, ensuring high standards and efficient laboratory practices [81].

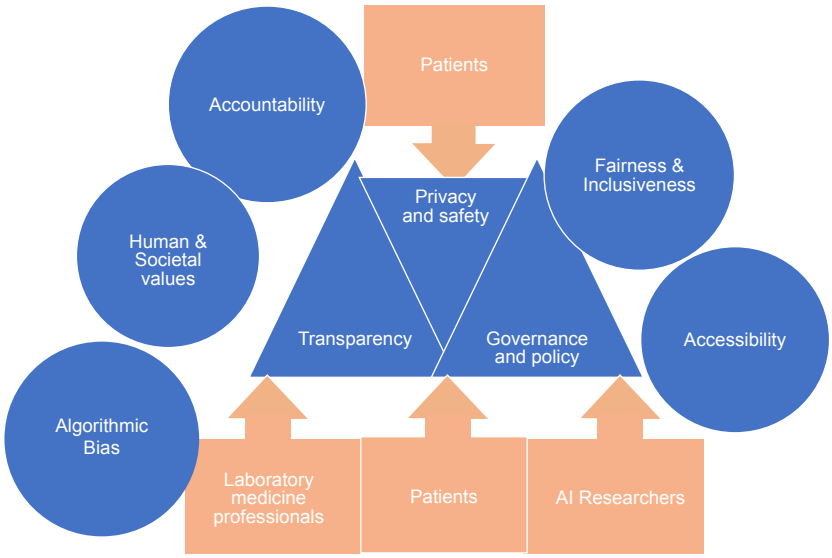
Table 2: Summary of the AI tools available to improve understanding of laboratory medicine.

AI Tool/Method	Function	Impact on Understanding
TensorFlow and PyTorch	Machine learning platforms for data analysis	Enhanced data analysis and pattern recognition in laboratory results
Scikit-learn	Machine learning library for clustering and classification	Improved analysis of laboratory data
spaCy and NLTK	NLP libraries for processing and interpreting textual data	Clearer translation of complex medical terminologies
IBM Watson Natural Language Understanding	Advanced text analysis capabilities	Summarized and actionable laboratory reports
Chatbots (Microsoft Bot Framework, Google Dialogflow)	AI chatbots for real-time support	Accessible and responsive patient-provider communication
Virtual Health Assistants (HealthTap, ADA Health)	AI-driven assistants for personalized health advice	Improved patient engagement and understanding of test results
IBM Watson Health	Predictive analytics for disease progression	Demonstrated long-term value of laboratory tests
SAS Advanced Analytics	Comprehensive analytics solutions	Supported clinical decision-making
Tableau and Power BI	Data visualization tools	Intuitive dashboards for trend and pattern recognition
D3.js	JavaScript library for dynamic data visualizations	Engaging presentation of laboratory data
MedAware	Clinical decision support systems	Real-time decision support based on laboratory results
DXplain	Diagnostic decision support system	Improved diagnostic accuracy through differential diagnosis suggestions
Foundation Medicine	Personalized medicine platform for genetic data analysis	Highlighted role of laboratory medicine in personalized cancer treatments
Flatiron Health	Integration of clinical and laboratory data	Enhanced personalized treatment recommendations
Bio-Rad Unity Real-Time	Automated quality control system	Ensured accuracy and reliability of laboratory results
Abbott AlinIQ	Optimization of laboratory operations	High standards and efficient laboratory practices

7. Ethical considerations

Notwithstanding the desirability of improving communications in laboratory medicine, a number of ethical issues need to be considered [82, 83] in the implementation of any of the recommendations discussed in this article. Whilst a detailed consideration is beyond the scope of this article, readers should always be cognisant of the ethical guidelines surrounding the use of patients' laboratory data. These include (Figure 1), amongst others, stewardship, and confidentiality of patient data; transparency in the development of software applications and scientific study and publication of AI applications and how commercial interests may impact on these in a rapidly growing field.

Figure 1: Key considerations in the use of AI to implement enhanced communication methods in laboratory medicine. Adapted from [83].



Conclusion

Effective communication is pivotal in maximizing the impact and value of laboratory medicine in healthcare. By improving interdisciplinary collaboration, enhancing patient education, engaging patients, implementing efficient information systems, promoting continuous education, fostering a culture of open communication, and leveraging technology, the full potential of laboratory medicine can be realized. By educating healthcare providers, engaging patients, fostering clear communication within healthcare teams, raising public awareness, leveraging technology, and promoting professional development, the critical contributions of laboratory medicine to healthcare can be better recognized and valued. These strategies ensure that critical information is accurately conveyed, leading to better patient outcomes, more informed clinical decisions, and a more cohesive healthcare system. These strategies not only improve the appreciation of laboratory medicine but also lead to better patient outcomes and more efficient healthcare delivery.

AI tools have the potential to significantly enhance the understanding of the value and impact of laboratory medicine. By providing advanced data analysis, personalized insights, streamlined communication, workflow optimization, and compelling demonstrations of impact, AI can ensure that the critical contributions of laboratory medicine are widely recognized and appreciated. Healthcare providers can offer better diagnostic accuracy, personalized care, and more informed clinical decisions, ultimately highlighting the critical role of laboratory medicine in modern healthcare. As AI continues to evolve, its integration into laboratory medicine will further highlight the essential role this field plays in improving healthcare outcomes and public health.

Abbreviations

EHR, Electronic Health Records, LIS, Laboratory information system, LLM, Large language models, LM, Laboratory medicine

Conflict of interest

None.

Ethical clearance

Approval from local institutional ethical clearance was not required.

Source of funding

None.

Data availability

Not applicable.

Authors' contribution

Tahir Pillay conceived the idea, retrieved literature and wrote the article.

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