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Laboratory automation in clinical analysis and its impact on the biomedical professional's routine and the quality of laboratory processes.

Laboratory automation in clinical analysis and its impacts on the biomedical routine and on the quality of laboratory processes

Automation of laboratories in clinical analysis and its impacts on biomedical routine and on the quality of laboratory processes

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ABSTRACT

Introduction: Laboratory automation in clinical analysis represents one of the main technological advances in the health field, promoting greater speed, precision, and safety in laboratory processes. It represents not only a technological update but also a strategic transformation of laboratory practice, aiming to generate measurable value for patients and healthcare professionals. **Objective:** To analyze the impacts of automation on the biomedical professional's routine, highlighting operational changes, benefits to the quality of tests, and challenges related to professional and technological adaptation. **Methodology:** This is an integrative review conducted between August 2025 and May 2026. Descriptors from DeCs were used in databases such as SciELO and PubMed, selecting studies published in the last ten years that addressed laboratory automation. **Results:** 6,050 studies were identified. After applying the inclusion and exclusion criteria, 10 articles were selected . Clinical analysis laboratories play a fundamental role in the diagnosis, monitoring, and prevention of diseases. With technological advancements, laboratory automation has become an indispensable tool for optimizing analytical processes and increasing the reliability of results. In this context, biomedical professionals have begun to work not only in performing tests, but also in managing automated equipment, quality control, and interpreting results . **Conclusions:** Laboratory automation represents a significant advancement for clinical analyses, providing substantial improvements in process quality and test reliability. The role of biomedical professionals has become more strategic, requiring competencies related to the use of technologies and laboratory management .

Keywords: *Automation, Clinical Analysis, Laboratory Quality, Biomedical, Exams.*

1 INTRODUCTION

Clinical analysis laboratories play a fundamental role in diagnosis and in disease monitoring, being responsible for providing results that directly assist in medical decision-making. The increasing incorporation of technologies in healthcare services has promoted one of the biggest transformations that have occurred in clinical analysis laboratories in in recent decades, those responsible for performing and interpreting laboratory tests (Antonios; Croxatto; Culbreath, 2021).

Automation is the application of computerized or mechanical techniques in a laboratory, with the The objective is to make the process more efficient, maximize production with lower energy consumption, and ensure... Greater safety. The introduction of automation in laboratory medicine was highlighted by the integration

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of equipment, new software, hardware and middleware features, technological systems that
They perform laboratory processes in a standardized way, contributing significantly to the
improving the quality of laboratory methods, promoting greater analytical precision,
Sample traceability, biosecurity, and reduction of human error (Naugler; Church, 2019).
The main objective of an automated system is to optimize the analytical process, streamlining the...
laboratory procedures. According to the Brazilian Society of Clinical Pathology/Medicine
Laboratory tests (SBPC/ML, 2019) are essential to ensure that the correct test is ordered for the patient.
The timing is appropriate and cost-effective, contributing to an effective and safe clinical outcome.
The integration of automated technologies has become a growing trend in laboratories.
Clinical tools, expanding analytical capacity and facilitating diagnoses . The use of these
Technology contributes to improved laboratory management and quality control. Therefore,
Laboratories have begun offering faster and more reliable results, which improves safety.
of the patient and clinical decision-making (Yu *et* al., 2019).
By combining technological innovation with human expertise, automation enhances accuracy, capability, and
clinical relevance throughout the entire testing process. As laboratories...
They continue to evolve towards process automation and integrated diagnostics, playing a role .
an increasingly central role in providing timely, meaningful, and patient-centered information.
to health systems and society (Naugler; Church, 2019).
Given the increasing incorporation of automated systems in clinical laboratories, it becomes
It is important to understand its impacts on the professional routine of biomedical professionals and on the quality of their work.
laboratory processes. Thus, this research aims to evaluate the importance of automation.
Laboratory analysis in clinical analyses, addressing its contributions, benefits, challenges, and implications .
in biomedical practice and diagnostic reliability.
To that end, the aim is to describe the main concepts and applications of laboratory automation in
Clinical analyses: understanding the impacts of implementing automated systems on routine practice.
From a biomedical perspective and within the dynamics of clinical laboratories, identify the benefits related to reduction.
error reduction, increased productivity, traceability, and quality control of processes.
laboratory practices, in addition to discussing the importance of automation as a strategic tool for improvement.
of diagnostic efficiency, patient safety and optimization of services, contributing to the
Modernization of clinical analysis laboratories and strengthening the quality of services.
health.

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2 METHODOLOGY

This study is an integrative literature review developed from the synthesis and critical analysis of studies, with the aim of interpreting and discussing the theme "Laboratory automation and its impacts on the routine of biomedical and process quality", focusing on studies that investigate and correlate automation laboratory work with the quality of laboratory processes and with the work of the biomedical professional in the laboratory. clinical analyses. The literature review took place between August 2025 and May 2026. 2026, with a structured search conducted in the Scielo, PubMed, and SBPC/ML databases, using the The following descriptors were obtained from the search in the Health Sciences Descriptors (DeCS): Automation, Clinical Analysis, Laboratory, Quality, Biomedical, and Exams, which were combined with the Boolean connector. AND. The following structured searches were performed: *Automation* AND *laboratory, laboratory* AND *clinical analysis, quality* AND *exams, biomedical* AND *laboratory,* selecting articles published in the last 10 years.

The inclusion criteria adopted were: articles available in full that address the relationship between the Laboratory automation in clinical analysis, its impacts on the biomedical professional's routine, and its influence. in the quality of laboratory processes. Studies related to automation were included. analytical processes, quality control, laboratory productivity, biosafety and technologies applied to clinical laboratories. As exclusion criteria, articles were considered duplicates, studies with restricted access, and publications not directly related to automation in clinical analysis laboratories or those involving biomedical professionals in this context. The analysis of The articles were selected through screening to determine their suitability to the inclusion and exclusion criteria, and Subsequently, the articles were evaluated based on methodological quality and relevance to the objectives of the review.

3 RESULTS

Based on a structured search conducted in the databases, 6,050 studies were identified. Through reading titles and abstracts and applying inclusion and exclusion criteria, 10 were selected. articles (Figure 1) for the *corpus* of analysis.

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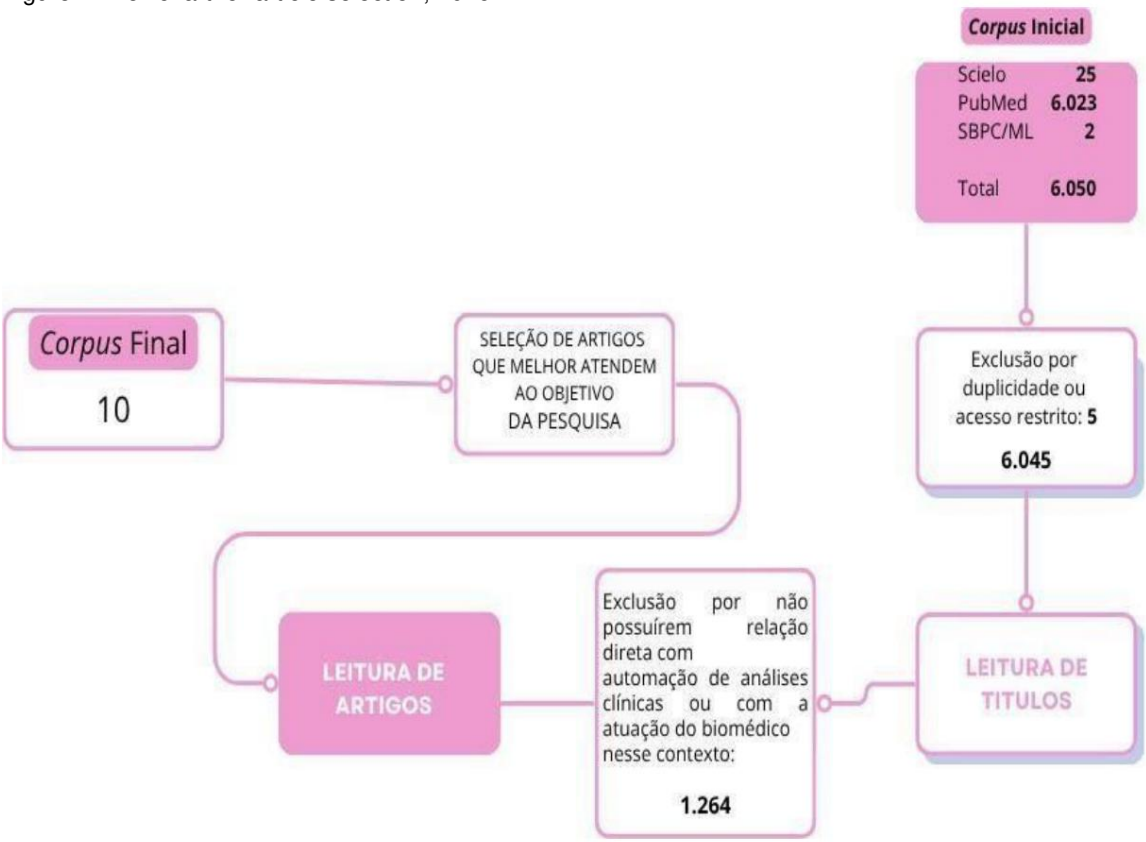
Figure 1. Flowchart for article selection, 2026.



Source: Prepared by the author, 2026

Among the 10 articles selected for review, several studies were identified that address the Laboratory automation in clinical analysis, focusing on its impact on the biomedical professional's routine, in efficiency of laboratory processes and the quality of diagnostic results. The work Those evaluated analyze aspects such as the reduction of analytical errors, the increase in productivity, and control. quality, sample traceability, and the application of automated technologies in laboratories clinical. Details of the evaluated articles are available in Table 1 (information on title,

(Authors, year of publication, objectives and results).

Table 1. Characteristics of the selected scientific articles, according to title, authors, year of publication, objective and results, 2025.

Title Authors		Year Objectives	Results
Automation in value-based laboratory medicine: driving precision, capacity, and better outcomes	Gruson D, Zima 2026 T, Plebani M	Discussing the role of automation in laboratory medicine based on value-based automation, analyzing technologies... these diagnostic processes, contributes and expands the capacity. increased productive capacity of Operational efficiency and Clinical outcomes.	how laboratory medicine It increases the accuracy of to greater diagnostic precision, improvement of clinical laboratories.

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Identifying Opportunities for Workflow automation in Haque SN, Lessons Learned from Others Industries	Zayas Cabán T, Health Care: Kemper N.	2021	Identifying opportunities for automation in the healthcare field, process automation in the area of Based on experiences and health data, strategies already applied in other industries can be significantly improved by analyzing... the operational efficiency, how these practices can reduce rework and be adapted to the context human errors and of health services. optimize workflows.	
Current State of Laboratory Automation in Clinical Microbiology Laboratory	Antonios K, Croxatto THE Culbreath K.	2021	reduces the time for releasing results, decreases human labor, and increases process standardization. Analyzing the current state of laboratory automation efficiency in clinical microbiology, describing the available technologies, their applications, practices in laboratories, and impacts of these innovations on workflow efficiency, sample traceability, and quality, although challenges you remain. and in microbiological results, such as high	Laboratory automation improves workflow efficiency, errors and the Present costs and the need to adapt services.
Mass spectrometry and total laboratory automation: opportunities and drawbacks	Salvagno GL, Danese E, Lippi 2020 G		analyzing opportunities and spectrometry of limitations of mass integration and automation in mass spectrometry improves overall automation in analytical precision. Clinical laboratories increase efficiency by highlighting their impact on workflows and analytical efficiency, and contribute to greater... Organization of processes. Standardization of processes.	The integration between Laboratory technology
Improving you processes laboratories with Full automation from the lab	Hoi-Ying Elsie Yu, Harold Lanzoni, Tracy Steffen, Warren Derr, Kim Cannon, Jeanene Contreras, Jordan Erik Olson	2019	Analyze how process automation the laboratory (Total – improve TAT tests and optimize focus efficiency addition to operational efficiency and Integration of productivity and work and improvement of...	The study demonstrates that total laboratory automation improves efficiency. increases the overall efficiency of standardization reduces Laboratory Automation TLA response time can laboratory processes, with workflow laboratory. In standardization, this highlights gains. flows, traceability of samples, quality of laboratory results.

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Automation and Artificial Intelligence in the Clinical Laboratory	Naugler W, Church DL.	2019	discussing the role of automation and artificial intelligence in medicine improves laboratory accuracy, increases operational efficiency, and reduces costs in the laboratory processes, thus optimizing the analysis of tests, its applications and impacts on efficiency, accuracy, and precision.	The study highlights that management of errors laboratory. clinical process management.
Recommendations from Brazilian Society Pathology Clinic/Medicine Laboratory (SBPC/ML): Clinical laboratory innovation node	Society Brazilian Pathology Clinic/Medicine Laboratory (SBPC/ML)	2019	To present how technological innovation in the clinical laboratory is transforming clinical laboratories, bringing improvements to laboratory routines, highlighting the modernization of laboratory processes, particularly in relation to quality, and the incorporation of new technologies. technologies and the improvement of diagnostic quality in examinations.	Agility and security in
Recommendations from Brazilian Society of Pathology Clinic/Medicine Laboratory (SBPC/ML): Automation history, selection, implementation, and management	Society Brazilian Pathology Clinic/Medicine Laboratory (SBPC/ML)	2018	presents technical recommendations regarding laboratory automation. laboratory work, addressing its historical standardization, criteria, and processes, as well as system selection. of automated planning processes. Implementation and appropriate strategies in the selection and management of laboratory systems.	It highlights that it the It contributes to the of the emphasizes the importance
Nonanalytic Laboratory Automation: A Quarter Century of Progress	Hawker CD	2017	reviewing the evolution of laboratory automation in non-analytical steps over 25 years has contributed to the reduction of pre- and post-analytical errors, improved workflow, and increased operational efficiency.	The study highlights that
Implementation of automatic release criteria Feitosa, MS; of results of biochemistry in a University Public Hospital	Leão, GS; Silva, CM; Oliveira RS laboratory of	2016	of automatic release criteria for laboratory routines. faster release of results aiming for reduction increase of manual and laboratory errors, and reduced processing time. to release and ensure greater and safety of the laboratory results.	Automation has contributed to improving the implementation allowing for better test results, the efficiency in the testing process, increase productivity of the standardization

Source: Prepared by the author, 2026

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4. DISCUSSION

Laboratory automation has become an essential strategy for modernizing...
clinical laboratories, providing significant gains in efficiency, quality and safety of
Automated systems allow for the reduction of human error and the standardization of processes.
Analytics and workflow optimization contribute to more reliable results. These
These advancements have a direct impact on the daily routine of biomedical professionals, who can now dedicate themselves to other activities.
more analytical, focused on interpreting results and making technical decisions, elevating their role to
a more strategic level in the laboratory (Antonios; Croxatto; Culbreath, 2021).
The concept of Total Laboratory Automation (TLA) integrates a technological system across different areas.
stages of the laboratory workflow, from receiving and preparing samples to analysis and release of results.
results highlighting that full automation increases sample traceability and reduces variations.
between operators and improves the time it takes to release results. Automating the steps does not
Analytics also helps to minimize errors, strengthening the security and standardization of processes.
Laboratory technology is not limited to analytical processes; it also impacts...
directly impacts workflow management, improving exam turnaround times (Yu *et* al., 2019).
Production processes in the laboratory have been benefiting from technological innovations, developing
further enhances laboratory medicine and positively impacts the healthcare chain, making available a
Faster prevention, with early diagnoses and greater effectiveness of therapies (SBPC/ML, 2018).
The integration of advanced technologies enhances analytical precision and laboratory efficiency.
Zayas-Cabán, Haque and Kemper (2021) show that automation experiences adapted from other
Industrial technologies can be applied to healthcare to reduce rework, organize processes, and increase efficiency.
productivity. Enabling the biomedical professional to have fewer manual interventions and the possibility of monitoring and
To oversee the operation of the systems, contributing to safety and reliability. This demonstrates that...
The need for continuous professional updating and training makes the role of the biomedical professional increasingly important.
even more strategic.
At the same time, it demands specialized technical knowledge from the biomedical professional.
In this way, the implementation of automation in healthcare institutions also improves the patient experience.
patient. Maintaining loyalty through value delivery, in clinical indicators, and also looking at
The employee experience. This scenario reinforces the need for continuous training and skills development.
clear technique and protocol development (Salvagno; Danese; Lippi, 2020).
National guidelines, such as those from SBPC/ML, recommend careful planning in the implementation of
automation, considering the appropriate selection of systems and continuous management to ensure efficiency,
Standardization and safety. It is emphasized that the biomedical professional needs to have a deep understanding of...

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laboratory principles, which allows for the correct application of technologies and interpretation of results.
safely.

Knowledge in laboratory medicine has been constantly evolving and becoming increasingly...
complex, demanding even more from the biomedical professional. Some clinical situations require
knowledge of specific diagnostic methods and the development of more complex protocols, which
This reinforces the need for continuous training. In this context, laboratory automation acts as...
an important support tool, in conjunction with the professional (SBPC/ML, 2019).

The automation of laboratory systems not only optimizes analytical processes, but also...
This transforms the routine and role of the biomedical professional, who now needs greater technical training to...
Operate automated systems, interpret complex data, and work with newly integrated technologies.
in the laboratory environment. Gruson, Zima and Plebani (2026) reinforce that automation is an element
central to value-based laboratory medicine, increasing operational capacity,
promoting better clinical outcomes and enabling biomedical professionals to contribute to safety,
The quality and reliability of the results.

Therefore, the integration of advanced technologies, continuous professional training, and efficient management are key.
These findings represent a breakthrough for clinical laboratories , solidifying the role of the biomedical professional as a key player in...
The excellence of laboratory services. Biomedical practice, which is no longer focused solely on...
The manual execution of exams now involves the supervision of automated processes and the control of
Quality, critical analysis of results, and management of laboratory technologies. The professional
A biomedical professional becomes a manager, supervisor, and critical analyst in the laboratory. This requires adaptation between the...
Human knowledge and technological innovation to ensure efficiency and safety in services.
laboratory.

FINAL CONSIDERATIONS

Laboratory automation is establishing itself as a transformative element in clinical laboratories.
promoting greater efficiency, standardization, and safety in analytical processes. The process of
Implementing a laboratory automation model generates important benefits, mainly
By providing greater safety in healthcare, laboratory medicine plays a role .
fundamental and, increasingly, a source of information with an impact on clinical decision-making. Its implementation
It not only reduces human error and optimizes workflow, but also allows the biomedical professional...
focus on strategic activities, such as critical analysis, interpretation of results and
Supervision of processes, strengthening their role in ensuring the quality of examinations.
Technology for clinical analysis laboratories enables the growth of analyses, with

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Reproducibility and accuracy. Therefore, it is a strategic enabler of value-based care.

By combining technological innovation with human expertise, automation improves precision,

Capacity and clinical relevance throughout the testing process.

Investing in advanced systems, coupled with continuous professional training, contributes not only to the need for continuous training of professionals, but also to the need for continuous training of professionals.

not only for more accurate and reliable results, but also for safer clinical practice.

efficient and strategic, consolidating the biomedical professional as a key player in laboratory excellence.

clinical.

In addition to the impacts directly related to laboratory processes, the professional's role

The biomedical field has undergone profound transformations. In this context, the biomedical professional now performs various functions.

more strategic, related to the supervision of automated processes, analytical validation, and control

of quality and critical interpretation of results, reinforcing the importance of technical and scientific updating.

Constantly adapting to technological changes in laboratory medicine.

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