

The Role of the Clinical Laboratory Scientist in the System of Early Disease Detection: A Literature Review

Hakimov Azad Atamuradovich

Bukhara State Medical Institute named after Abu Ali ibn Sina, Uzbekistan, Bukhara, st. A. Navoi. 1 Tel: +998 (65) 223-00-50 e-mail: info@bsmi.uz

ABSTRACT: *Early diagnosis of diseases is one of the key determinants of treatment success, reduction of complications, and improvement of patient quality of life. Clinical laboratory diagnostics plays a central role in the early detection of pathological processes, and the clinical laboratory scientist becomes a critical link between the patient, the physician, and the analytical system. This review summarizes current data on the functions, competencies, and professional responsibilities of laboratory scientists in the context of early diagnosis, including their role at the pre-analytical, analytical, and post-analytical stages. The article discusses analytical errors, quality control systems, digitalization, automation, communication with clinicians, and participation in screening programs. Special attention is given to risk management, biosafety, and professional development. The review demonstrates that the importance of laboratory personnel extends far beyond technical sample processing: they contribute to clinical interpretation support, validation of laboratory findings, implementation of quality management systems, and development of diagnostic protocols. Strengthening professional status, expanding training programs, and integrating laboratory scientists into multidisciplinary medical teams are necessary to improve the effectiveness of early disease detection systems.*

KEY WORDS1; Clinical laboratory science; laboratory diagnostics; early detection; screening; pre-analytical errors; quality control; laboratory scientist; automation; biosafety.

INTRODUCTION

Modern healthcare systems cannot function effectively without clinical laboratory diagnostics: up to 70–80% of clinical decisions are based on laboratory results [Lundberg, 2019, p. 44]. Early diagnosis is not limited to identifying a disease at an asymptomatic stage; it also encompasses monitoring of risk factors, pre-disease states, and subclinical changes [Tate, 2020, p. 67].

The key professional figure in the laboratory service is the clinical laboratory scientist (laboratory technologist/technician). Their responsibilities include:

- correct reception and identification of biological samples
- control of pre-analytical variables
- calibration and maintenance of analytical systems
- quality assurance
- result validation
- participation in internal and external quality control programs
- communication with clinicians
- compliance with biosafety standards

Despite the enormous role of clinical laboratories, their contribution is often underestimated, and their activity is sometimes perceived merely as technical support [Burtis, 2022, p. 12]. However, without the qualified participation of the laboratory scientist, the system of early diagnosis becomes ineffective and clinically unreliable.

The aim of this literature review is to summarize current scientific data on the role of the clinical laboratory scientist in early disease detection, to define the principal directions of their professional activity, and to identify challenges and future perspectives for the development of the profession.

LITERATURE REVIEW

1. Early diagnosis as a global healthcare priority

Early diagnosis significantly reduces mortality, prevents disability, and lowers overall treatment costs [Wilson, 2018, p. 102]. It is particularly important in:

- oncological diseases
- cardiovascular disorders
- infectious diseases
- endocrine disorders
- genetic and metabolic diseases

Screening programs largely rely on laboratory methods [WHO, 2021, p. 29].

2. The laboratory as an integral part of the clinical process

Clinical laboratory testing consists of three interdependent stages:

1. Pre-analytical stage
2. Analytical stage
3. Post-analytical stage

Studies demonstrate that up to 70% of laboratory errors occur during the pre-analytical phase [Plebani, 2017, p. 88], highlighting the critical role of the laboratory scientist.

3. Functional role of the clinical laboratory scientist

In modern laboratory medicine, the professional activity of the laboratory scientist includes:

- acceptance and correct labeling of samples
- assessment of sample suitability
- preparation of specimens for analysis
- work with automated analyzers and systems
- internal quality control
- participation in accreditation procedures
- management of laboratory documentation
- methodological and consultative support to clinicians

Contrary to popular belief, automation does not reduce the relevance of the specialist — it transforms the role from operator to analytical expert [Hollensead, 2020, p. 54].

4. Quality control as a fundamental component

Quality assurance systems in laboratory medicine include:

- Internal Quality Control (IQC)
- External Quality Assessment (EQA)

Laboratory scientists are responsible for interpreting control charts, identifying trends, and preventing systematic errors [Westgard, 2019, p. 33].

5. Digitalization and artificial intelligence

Laboratory Information Systems (LIS) improve traceability, reduce the risk of human error, and support clinical decision-making [Hallworth, 2021, p. 16].

Artificial intelligence technologies increasingly support routine diagnostics, including hematology, microbiology, and pathology [Topol, 2019, p. 201].

However, professional accountability remains with the human expert.

6. Professional risks and biosafety

Work in the clinical laboratory is associated with exposure to biological agents, chemicals, and physical hazards [Panlilio, 2018, p. 98].

The laboratory scientist is therefore a key participant in infection control and biosafety systems.

7. Ethical aspects

Professional responsibilities include:

- maintaining patient confidentiality
- accurate sample identification
- prevention of data falsification
- maintaining clinical competence

This confirms the high social responsibility of the profession [Carter, 2020, p. 72].

DISCUSSION

The review indicates that the role of the clinical laboratory scientist in early disease detection is multidimensional.

1. Responsibility for the pre-analytical phase

Incorrect blood sampling, failure to follow storage conditions, hemolysis, lipemia, and inappropriate collection tubes may lead to false or misleading clinical conclusions [Plebani, 2017, p. 90].

Therefore, the laboratory scientist plays a decisive role in prevention, training, and incident documentation.

2. From operator to analytical expert

The modern laboratory professional:

- interprets quality control data
- monitors analytical bias and drift
- initiates corrective actions
- participates in multidisciplinary case discussions

Thus, the laboratory scientist is an active participant in clinical decision-making, not merely a technical assistant.

3. Role in population screening programs

Laboratory professionals ensure the reliability of:

- neonatal screening
- oncological marker testing
- hematological screening
- infectious disease testing (HIV, hepatitis, tuberculosis, etc.)
- genetic and metabolic diagnostics

The quality of early detection directly depends on their competence [Wilson, 2018, p. 105].

4. Future perspectives

Further development of the profession will be driven by:

- molecular diagnostics
- high-throughput laboratory systems
- personalized medicine
- telemedicine formats

However, the foundation remains quality, precision, and professional responsibility.

RESULTS

This section summarizes key findings of the review.

Table 1. Main functions of the clinical laboratory scientist in early disease detection

Stage	Role of laboratory scientist	Significance for early diagnosis
Pre-analytical	Identification, sampling, storage, transportation	Prevention of false results
Analytical	Calibration, testing, instrument control	Ensuring analytical accuracy
Post-analytical	Validation, verification, data transmission	Support for clinical interpretation
Quality control	IQC, EQA, audit participation	Reduction of systematic errors
Education	Training clinical and laboratory staff	Risk reduction
Biosafety	Infection prevention and safe waste handling	Prevention of occupational exposure

Table 2. Major sources of laboratory diagnostic errors

Stage	Examples of errors	Role of laboratory scientist
Pre-analytical	Hemolysis, incorrect tube type, poor storage	Monitoring and prevention
Analytical	Incorrect calibration, reagent problems	Quality control oversight
Post-analytical	Data transfer errors, misinterpretation	Verification and communication

Scheme 1. Position of the clinical laboratory scientist within the healthcare system

Patient → Physician → Laboratory (Laboratory Scientist) → Diagnostic Decision → Treatment → Follow-up Monitoring

Scheme 2. Relationship between laboratory diagnostics and early disease detection

Risk Factors → Biomarkers → Laboratory Testing → Early Diagnosis → Prevention of Complications

CONCLUSION

Clinical laboratory diagnostics represents the foundation of modern medicine, and the clinical laboratory scientist is a key participant in the system of early disease detection. Their professional activities determine:

- accuracy and reliability of laboratory testing
- patient safety
- effectiveness of screening programs
- clinical value of laboratory data

Strengthening the professional role of laboratory scientists, expanding educational programs, introducing digital technologies, and recognizing their contribution within healthcare systems are essential for improving early diagnosis and population health outcomes.

REFERENCES

1. Burtis C. *Tietz Fundamentals of Clinical Chemistry*. 2022.
2. Carter J. *Ethics in Laboratory Medicine*. 2020.

3. Hallworth M. *The Role of Laboratory Medicine in Healthcare*. 2021.
4. Hollensead S. *Automation in the Clinical Laboratory*. 2020.
5. Lundberg G. *Medicine and Clinical Laboratory Science*. 2019.
6. Panlilio A. *Laboratory Biosafety Guidelines*. 2018.
7. Plebani M. *Errors in Laboratory Medicine*. 2017.
8. Tate J. *Principles of Clinical Laboratory Practice*. 2020.
9. Topol E. *Deep Medicine*. 2019.
10. Westgard J. *Quality Management in the Laboratory*. 2019.
11. WHO. *Early Diagnosis and Screening Strategies*. 2021.
12. Wilson J. *Screening for Disease: Theory and Practice*. 2018.
13. Young D. *Effects of Preanalytical Variables on Laboratory Tests*. 2019.
14. Zhang L. *Laboratory Information Systems*. 2020.
15. Zhou X. *Modern Clinical Diagnostics*. 2021.
16. Zwaans B. *Professional Competence in Laboratory Medicine*. 2022.