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Review Article

Clinical Laboratory Sciences in Iran: Historical Evolution and Educational Structures

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ABSTRACT

Clinical Laboratory Sciences, also known as Medical Laboratory Sciences, constitute a fundamental component of modern healthcare systems, playing a critical role in patient care by providing vital diagnostic information derived from the analysis of clinical specimens. This article presents a historical review of the development of Clinical Laboratory Sciences education in Iran, tracing its origins from the mid-nineteenth century to the present educational framework. Drawing upon primary historical sources, archival documents, and official curriculum records from the Ministry of Health and Medical Education of Iran, the article examines the key milestones that have shaped the profession over more than a century. This trajectory began with the establishment of Darolfonoon in the 1850s and the contributions of European physicians who founded the first chemistry and biochemistry laboratories in Iran. The evolution of laboratory sciences education progressed significantly with the founding of the Pasteur Institute of Iran (1918) and the Razi Institute (1924), followed by the establishment of the Central Laboratory of the Ministry of Health (1936) and the laboratories of the Tehran Faculty of Medicine (1939). Subsequent development included a one-year postgraduate course for laboratory directors (1952), the specialist in laboratory sciences program (1958), bachelor's degrees in Medical Laboratory Science (1968), the doctoral program in Clinical Laboratory Science (1984), and, most recently, the Fellowship in Clinical Laboratory Science (FCLS) in 2017. The current educational structure comprises Bachelor of Laboratory Science (BSc) program, postgraduate degrees (MSc and PhD) in specialized disciplines such as Clinical Biochemistry, Hematology, Immunology, etc., residency program in pathology and the FCLS program. In addition, this article reviews the current structure of clinical laboratories in Iran, which includes more than 8,200 laboratories across hospital-based, private, and public laboratories.

Keywords: Iran; Clinical Laboratory Science; Education; History

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Introduction

The discipline of Medical Laboratory Sciences (MLS), which is offered and known by other names such as Clinical Laboratory Sciences (CLS), Medical Laboratory Technology (MLT), Laboratory Medicine, and Biomedical Science in universities around the world, is a field of medical science and is an essential discipline within the healthcare field that plays a pivotal role in diagnosing diseases, monitoring treatments, and ensuring patient well-being. Clinical laboratory scientists are responsible for performing a wide range of laboratory tests on clinical specimens such as blood, urine, tissue samples, and other bodily fluids, ensuring the quality and reliability of test results, interpreting and correlating laboratory findings with clinical conditions, and evaluating test performance and diagnostic validity. Clinical laboratory sciences programs aim to graduate professionals who possess advanced skills and competencies, capable of pursuing a career in diverse areas of professional practice. In this article, we aim to review the state of clinical laboratory sciences education in Iran.

History of Clinical Laboratory Sciences in Iran

The history of laboratory training in Iran can be traced back to the 1850s when physicians and pharmacists from European countries entered Iran. In 1850, a modern-type institute for higher education called "Darolfonoon" was established in Tehran, including a medical sciences school. Dr. Edward Jacob Polack, an Austrian surgeon, was in charge of the medical school and started his work in 1851. Mohammad-Hasan-Khan Ghajar and Mirza-Hossein-Khan Afshar served as his assistant/translator. Dr. John Schlimmer and Dr. Focchette were among the physicians invited and had a significant impact on the development of the medical school. Dr. Focchette established the first chemistry, biochemistry, and analytical chemistry laboratories in Iran in 1857. In the following years, a number of other foreign physicians joined the Darolfonoon and contributed to both instruction and natural experiments. Additionally, several Iranian physicians and pharmacists played a significant role in collaboration with them. One of Focchette's students, Mirza-Kazem Mahallati (Chimi), and his son Dr. Mahmood Chimi, and later, Dr. Gagik Howakemian and Dr. Aramtis Vartany, continued Focchette's work (1-3).

Despite all the efforts made during these years, what is certain is that the era of laboratory science transformation in Iran based on scientific routes began with the establishment of the Pasteur Institute of Iran in 1918, and the Hesarak Institute (later called the Razi Institute) in 1924. In 1936, the medical diagnostic laboratories of the Pasteur Institute, which had provided valuable services to patients and doctors for many years, were closed and their activities were transferred to new laboratories established by the Iranian National Health Office (later called the Central Laboratory of the Ministry of Health). The Institute of Health comprised various departments, including the Serology Department under the supervision of Dr. Hossein Mashoof and Dr. Hassan Mirdamadi, the Microbiology Department under the supervision of Dr. Hossein Sohrab and Dr. Mehdi Zolreyasatein, the Parasitology Department under the supervision of Dr. Asadullah Sheibani and Dr. Gholamkhan Amidzadeh, the Pathology Department under the supervision of Dr. Mostafa Habibi-Golpayegani, and the Chemistry Department under the supervision of Dr. Gagik Howakemian and Dr. Hamid Mahmoodzadeh. This laboratory performed all laboratory diagnostic procedures for patients in Tehran hospitals, private doctors, and charitable institutions, and was a consultant to the country's health and medical institutions on quarantine and epidemiological matters and health programs. It also established branches in some provincial centers to implement these programs (1-4).

Until 1939, when the new structure of the Tehran Medical School was established by Professor Charles Oberling, the laboratories of the Medical School only had an educational role and did not provide any service activities. In 1939, most of the specialists in various laboratory disciplines who served in the Institute of Health were transferred to the Tehran Medical School. As a result, the medical school laboratories underwent significant development and became well-equipped organizations that, in addition to providing diagnostic services for patients in the medical school's hospitals and clinics, offered scientific research and laboratory science education to students. The establishment of well-equipped laboratories in hospitals affiliated with the Faculty of Medicine and the establishment of new specialized laboratories in the fields of immunology and biological chemistry were among the activities carried out at the Faculty of Medicine in these years (1, 2).

In order to help complete the laboratory staff need of hospitals, in 1952, through the efforts of Dr. Nasser Ansari, professor of Parasitology and head of the Institute of Malariology at Tehran Medical School, a one-year supplementary course in laboratory sciences was established for those with laboratory work experience. Accordingly, the holders of a doctorate in medicine, veterinary medicine, pharmacy, or biochemistry who had served for a period of time in one of the government medical diagnostic laboratories could become the director of the clinical diagnostic laboratory after completing a one-year supplementary course. This program was implemented for 8 periods. During the years 1955 to 1956, the Pasteur Institute of Iran also played an effective role in training laboratory

Table 1. Historical milestones in clinical laboratory sciences in Iran

Year	Milestone
1850	Establishment of Darolfonoon
1918	Establishment of the Pasteur Institute of Iran
1936	Establishment of Central Laboratory of the Ministry of Health
1939	Establishment of Tehran Medical School Laboratories
1952	Establishment of One-year supplementary course in laboratory sciences for holders of a doctorate in medicine, veterinary medicine, pharmacy, or biochemistry
1958	Establishment of specialist in laboratory sciences program
1968	Establishment of bachelor degrees in medical laboratory sciences
1974	Clinical pathology course was launched
1979	Merged program of Clinical and Anatomical pathology was launched
1984	Establishment of doctoral program in clinical laboratory sciences (DCLS)
2017	Establishment of fellowship program in clinical laboratory sciences (FCLS)

technicians. The institute trained laboratory technician job applicants for a six-month period (1, 2).

In 1958, the laboratory sciences specialty training program began with a well-established curriculum including theoretical, scientific, and practical courses at Tehran Medical School. The training period was two years for physicians and three years for holders of doctoral degrees in pharmacy, veterinary medicine, and biological chemistry. Each year, 20 students were selected to participate in this program, and all educational programs were administered by professors from the School of Medicine, and internships were conducted in hospitals and laboratories affiliated with the School of Medicine. Graduates of this course were given a certificate of specialization in laboratory sciences, which allowed them to direct a clinical diagnostic laboratory. This educational program was discontinued in 1982 (1, 2).

In 1936, the first pathology laboratory was established at the Institute of Health under the supervision of Dr. Mustafa Habibi. This Laboratory was transferred to the Tehran Medical School in 1939, and the Department of Pathology was established to continue its previous service to patients and to teach pathology scientifically and practically to medical students. In 1943, pathology became a separate department from embryology and histology. At that time, the curriculum only included anatomical pathology, and general practitioners were trained in a three-year program. In 1974, the clinical pathology course was launched in several universities and residents underwent a 3- to 4-year training course. In 1979, the two departments of clinical and anatomical pathology were merged. As a result, the three-year training program was expanded to four years, and residents were trained in both anatomical and clinical topics (1-4).

In 1984, due to the urgent need for directors in many laboratories in the country, a professional doctoral program in laboratory sciences (Doctor of Clinical Laboratory Sciences, DCLS) was implemented and this program continued until 1993. According to this program, the holders of an associate degree in laboratory sciences would become a laboratory director after completing a 5-year training course. 1,250 people were trained under this training program (2, 5-7).

In 1968, for the first time, bachelor's degrees in medical laboratory sciences were established in some universities across the country, such as Tehran, Ahvaz, Isfahan, Tabriz, and Shiraz. In 1978, the associate degree program in laboratory sciences began as a two-year educational program. Admissions to the associate degree in laboratory sciences program were discontinued in 2008, however, due to the need for laboratory personnel, the program was offered without an entrance exam between 2014 and 2017. Currently, laboratory sciences education is only available at the bachelor's degree level (1, 5, 8).

After the Islamic revolution of Iran in 1979, and in order to meet the specialized needs of the laboratory field, master (MSc) and doctoral (PhD) degree programs in Clinical Biochemistry, Hematology and Blood Transfusion, Medical Bacteriology, Medical Immunology, Medical Virology, Medical Mycology, Medical Parasitology, and Medical Genetics were launched in many universities. PhD graduates in the mentioned programs, in addition to educational and research activities, can be the director of their own specialized departments in the clinical laboratory (9).

In 2017, a fellowship program in clinical laboratory sciences (FCLS) was launched at 6 universities and this program is currently ongoing. According to the curriculum, the holders of a PhD degree in one of the fields of laboratory sciences can become the director of medical diagnostic laboratories after completing a two-year training course (10, 11). More details about the training courses currently available in Iran will be discussed in the next section. Historical milestones in clinical laboratory science in Iran are presented in Table 1.

Structure of Clinical Laboratories in Iran

Clinical laboratories in Iran are organized within a centralized, multi-layered healthcare network under the Ministry of Health and Medical Education. Currently, Iran has over 8,200 active clinical laboratories across various healthcare levels (12). These laboratories can be

broadly categorized into three main types:

1. Hospital-Based (Public and University) Laboratories

These laboratories operate in public, private, and academic hospitals and provide diagnostic services to inpatients and outpatients. Some medical universities have established networks of hospital laboratories and have integrated several hospital laboratories under a single management to provide coordinated and standardized services. The number of hospital-based laboratories is approximately 1400 (13).

2. Private Laboratories

Private laboratories range from small local facilities to large multi-specialty centers offering diverse diagnostic services. The private sector accounts for approximately 3,300 laboratories in the country. While private labs deliver the majority of outpatient diagnostic tests, public hospital labs primarily serve hospitalized patients (13).

3. Public Health Laboratories

Integrated into the national public health system, these laboratories provide population-based services such as disease screening, health monitoring, and surveillance of infectious and non-communicable diseases. The number of public health laboratories is approximately 3,500 (12).

Educational Programs in Clinical Laboratory Sciences in Iran

Undergraduate (BSc degree)

Applicants to study in this field must have a certificate for completing a high school graduation diploma in the field of experimental sciences, and admission is possible only through the National University Entrance Exam. At present, there are about 60 universities of medical sciences that admit students (1493 students in 2025) in this field. The duration of the course is four years, and the total number of study credits is 130 credits according to the latest curriculum approved by the Supreme Council for Medical Sciences Planning in 2019 (14, 15). Graduates of the BSc degree in clinical laboratory sciences in Iran have a wide range of career options. Many can work in hospitals, clinics, or diagnostic laboratories. Others can join the factories producing laboratory equipments and kits. Another part of the graduates can be involved in education at the universities.

Post-graduate MSc and PhD degrees

Graduates who have completed their BSc in Laboratory Sciences have the option to pursue further studies in non-continuous MSc and PhD programs in a variety of sub-fields within clinical laboratory sciences. These sub-fields in Iran include Clinical Biochemistry, Medical Immunology, Hematology and Blood Transfusion Sciences, Medical Mycology, Medical Microbiology, Medical Virology, Medical Genetics, and Medical Parasitology. The Ministry of Health is responsible for admitting candidates to universities in these programs through a national entrance exam held for the MSc program and a two-stage process national entrance exam (written and interview) for the PhD program. The MSc program typically lasts for 2-3 years and usually requires completion of 30-32 credits for different subfields, including 18-22 credits of core (compulsory) courses, 2-6 credits of non-core (elective) courses, and 6-8 thesis credits (16, 17).

The PhD program typically takes 4-5 years to complete and is divided into two stages: an educational stage and a research stage. The educational stage begins when the student is admitted to the entrance exam and ends with the comprehensive examination. The research stage starts after the educational stage and ends with the defense of the thesis. The PhD usually requires 42-50 study credits, including 17-27 credits of core courses, 2-6 credits of non-core courses, and 18-20 thesis credits. Graduates who hold PhD degrees are eligible to work as laboratory directors in their respective fields of study in clinical diagnostic laboratories. For instance, a graduate with a PhD degree in Clinical Biochemistry can serve as the director of the Clinical Biochemistry division in a clinical diagnostic laboratory (16, 18, 19). In 2025, the number of universities accepting PhD students as well as the number of students in each field were 10 universities and 38 students for the Clinical Biochemistry, 8 universities and 38 students for Medical Genetics, 6 universities and 18 students for Medical Virology, 5 universities and 18 students for Medical Mycology, 6 universities and 30 students for Hematology and Blood Transfusion, 8 universities and 38 students for Medical Bacteriology, 7 universities and 25 students for Medical Immunology and 5 universities and 19 students for Medical Parasitology, respectively (20). Here, the doctoral curricula of clinical biochemistry is introduced as an example (Table 2).

Fellowship in Clinical Laboratory Sciences (FCLS)

This program aims to enhance the knowledge and skills of graduates of specialized doctoral programs (PhD) in various fields of clinical laboratory sciences. This program is open to candidates with a PhD degree in one of the clinical laboratory sciences fields, including Clinical Biochemistry, Medical Genetics, Medical Immunology, Hematology and Blood Transfusion Sciences, Medical Mycology, Medical Microbiology, Medical Virology, and Medical Parasitology. Admission to the program is conducted by the Ministry of Health through a two-stage entrance exam: a written exam and an interview. The training course lasts for 24 months. Graduates with a PhD degree in one of the clinical laboratory sciences fields are required to complete 23 credits of laboratory science courses, 14 credits of pathophysiology of the disease's courses, and a 12-month hospital internship (Table 3). At the end of

Table 2. Clinical Biochemistry PhD Curriculum

Row	Title	No. of Credits	
		Theoretical	Practical
	PhD Core Course		
1	Clinical Biochemistry 1	2	-
2	Clinical Biochemistry 2	2	-
3	Clinical Biochemistry 3	2	-
4	Laboratory Management & Quality Control	1	-
5	Inherited Metabolic Disorders	2	-
6	Biochemistry of Cancer and Tumor Markers	2	-
7	New Methods of Molecular Diagnosis of Diseases	2	-
8	Specialized Seminar	0.5	0.5
9	Clinical Laboratory Internship	-	6
10	Thesis	-	18
	Total	38	
	PhD Non-Core Course *		
1	Bioinformatics	1	1
2	Cell Culture	1	1
3	Trace Elements Biochemistry	2	-
4	Biological System & Bio-signaling	2	-
5	Monitoring of Poisons and Drugs	2	-
6	Advanced Diagnostic Methods	1	1

* The student must choose and pass 4 units of optional courses with the approval of the supervisor and the approval of the graduate education council of the university

Table 3. Fellowship in Clinical Laboratory Sciences Curriculum

Row	Title	No. of Credits	
		Theoretical	Practical
1	Pathophysiology of the Digestive System	2	-
2	Pathophysiology of the Cardiovascular System	2	-
3	Pathophysiology of the Endocrine System and Metabolism	2	-
4	Pathophysiology of Blood Disorders	2	-
5	Pathophysiology of Respiratory Diseases	2	-
6	Pathophysiology of Kidney Diseases	2	-
7	Pathophysiology of Rheumatic Diseases (Autoimmune)	2	-
8	Clinical Biochemistry	3	1
9	Laboratory Hematology & Transfusion Sciences	3	1
10	Medical Immunology	2	1
11	Medical Bacteriology	2	1
12	Medical Virology	0.5	0.5
13	Medical Parasitology	2	1
14	Medical Mycology	0.5	0.5
15	Management Principles in Clinical Laboratories	2	-
16	Evidence-Based Laboratory Medicine	2	-
	Total	37	
17	Clinical Laboratory Internship (Hospital)	12 months	

the training course, students take part in a national exam (theoretical and practical). After achieving the passing score in the final exam, graduates are eligible to direct general Clinical Pathology laboratories (21). In 2025, 32 students at 8 universities were accepted to study the FCLS program after two stages of written and oral exams (22).

Pathology Residency

Pathology is a medical specialty that includes anatomical and clinical pathology. In Iran, individuals who hold a degree in Doctor of Medicine are eligible to participate in the pathology residency program by taking a written exam held by the Ministry of Health yearly. The pathology residency program lasts for four years and is designed to cover all major components in both clinical and anatomic areas so that the resident can be exposed to both main areas during this period. The educational program for clinical pathology involves monthly rotations or specialized blocks, with each block lasting for one month. Table 4 outlines the pathology residency program curriculum. Also, some medical universities offer fellowship courses in Gastrointestinal Pathology, Dermatopathology, Cytopathology, Hematopathology, Transfusion Medicine, Gynecological Pathology and Molecular and cytogenetics for pathology graduates, which usually last between 12 and 18 months (23). In 2025, 147 students were accepted to study the Pathology Residency program at 18 universities (24).

Table 4. Pathology Residency Curriculum

Row	Title	Duration (month/block)
	Clinical Pathology course	
1	Hematology, Coagulation, and Hematopathology block	5
2	Bacteriology block	4
3	Mycology block	1
4	Urine Laboratory block	1
5	Parasitology & Stool Test block	1
6	Virology block	1
7	Biochemistry block	4
8	Serology & Immunology block	3
9	Transfusion medicine, immunohematology, and Stem Cells block	2
10	Molecular Pathology and Cytogenetics block	2
11	Laboratory Management block	68 hours
	Total	24 months
	Anatomic Pathology course	24 months
	Total	48 months

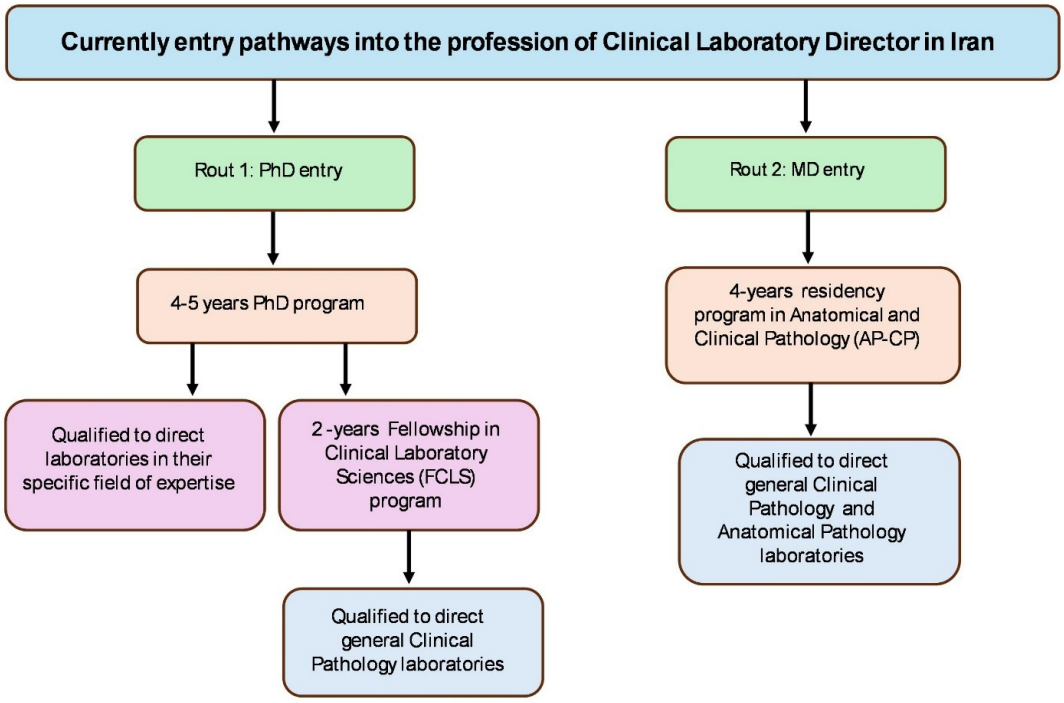


Figure 1. Currently Laboratory Director entry Pathways in Iran

Education program for Clinical Laboratory Directors

Entry pathways into the profession of clinical laboratory directorship in Iran are shown in Fig. 1 and Fig. 2. According to current regulations, there are three main professional pathways to obtain laboratory directorship (25).

Route 1: PhD entry

Individuals holding a doctoral degree (PhD) in disciplines such as Clinical Biochemistry, Hematology, Medical Immunology, Medical Genetics, Medical Bacteriology, Medical Virology, Medical Mycology, and Medical Parasitology are only authorized to serve as directors of the specialized section corresponding to their field of expertise. In other words, their responsibility is limited to their own discipline and does not extend to general laboratory directorship.

Route 2: PhD-FCLS entry

This advanced training pathway provides eligibility for general laboratory directorship. Holders of the Fellowship in Clinical Laboratory Sciences (FCLS) degree are qualified to direct and assume full responsibility for all departments of a clinical laboratory, including biochemistry, hematology, microbiology, immunology, molecular pathology, and other departments.

Eligibility pathways for laboratory directors in Iran	
Pathways for MDs	MDs with combined specialties in Clinical Pathology and Anatomical Pathology: Qualified to direct general Clinical Pathology and Anatomical Pathology laboratories
Pathways for Scientists	Specialties in Clinical Laboratory Sciences: Qualified to direct general Clinical Pathology laboratories. (closed to new applicants since 1982)
	Doctorate holders in Clinical Laboratory Sciences: Qualified to direct general Clinical Pathology laboratories. (closed to new applicants since 1998)
	Clinical Scientists with PhD degree in Clinical Biochemistry, , Hematology and Blood transfusion, Medical Immunology, Medical Bacteriology, Medical Parasitology, Medical Mycology, Medical Genetics, and Medical Virology: Qualified to direct laboratories in their specific field of expertise
	Clinical Scientists with post-doctoral Fellowship in Clinical Laboratory Sciences (FCLS): Qualified to direct general Clinical Pathology laboratories

Figure 2. Laboratory Director eligibility pathways in Iran

Table 5. List of clinical laboratory societies involved in CME in Iran

Name of the Society	Address
Iranian Society of Biochemistry (IFCC full member)	https://www.biochemiran.com
Iranian Association of Clinical Laboratory Doctors (IFCC affiliated member)	https://www.iacld.com
Iranian Society of Pathology	https://iranpath.org
Iranian Scientific Association of Clinical Laboratory	https://isaclcong.ir
Iranian Association of Clinical Pathologists	https://isacp.ir
Iranian Society for Immunology and Allergy	http://isiaonline.org
Iranian Society of Virology	https://isv.org.ir
Iranian Association of Laboratory Hematology	-
Iranian Society of Blood Transfusion	-
Iranian Society of Medical Mycology	-
Iran Society of Medical Genetics	-
Iranian Society of Parasitology	-
Iranian Society of Trace Elements	-

Route 3: MD entry

Pathologists are also eligible to serve as general laboratory directors. Similar to FCLS fellows, they are authorized to direct all departments of a clinical diagnostic laboratory and hold full managerial and scientific responsibility.

Laboratory Accreditation in Iran

Accreditation of clinical laboratories in Iran has developed as part of the country's efforts to ensure high-quality diagnostic services and patient safety. The process is primarily overseen by Reference Health Laboratory (RHL) of the Ministry of Health and Medical Education which set regulatory frameworks and quality standards aligned with international guidelines. In Iran, Ministry of Health has divided the country to 50 regions each of which is under supervision of its dedicated medical university. There is an office of laboratory affairs in each university that is responsible for supervising the laboratories in that province. This office is responsible for licensing, defining regulations, and laboratory inspection.

Iranian clinical laboratories are encouraged to comply with standards analogous to ISO 15189, the internationally recognized benchmark for medical laboratories, which covers both management and technical requirements. Accreditation involves systematic evaluation of laboratory processes, including pre-analytical, analytical, and post-analytical phases, alongside personnel competency, equipment calibration, and quality assurance programs. The Iranian Society of Biochemistry, Iranian Association of Clinical Laboratory Doctors and Iranian Society of Pathology have played advisory roles in providing training programs and workshops to familiarize laboratory staff with quality management systems. Laboratories that meet these standards are officially recognized and listed as accredited by National Accreditation Center on Iran (NACI) (26).

Continuing Medical Education for Clinical Laboratory Professional

Continuing Medical Education (CME) is a fundamental component of maintaining professional competence, ensuring quality laboratory services, and patient safety in clinical laboratory sciences. Iran has established a nationally regulated CME system for healthcare professionals, including clinical laboratory

directors. CME activities for clinical laboratory professionals in Iran are regulated and supervised by the Ministry of Health and Medical Education through its national CME office. Participation in CME programs is mandatory for all licensed healthcare professionals, including laboratory directors. Clinical laboratory professionals are required to obtain a minimum of 25 CME credits annually. These credits must be earned through officially approved educational activities, including national and regional scientific congresses, workshops and short courses and e-learning and online modules (27).

The delivery of CME programs in clinical laboratory sciences is largely carried out by professional scientific societies, with particularly active engagement from the Iranian Society of Biochemistry, the Iranian Association of Clinical Laboratory Doctors, and the Iranian Society of Pathology, while other related societies also make essential and complementary contributions to CME activities. A list of the professional societies involved in CME is provided in Table 5. In parallel with the societies, academic departments at the universities of medical sciences play an influential role in the execution of CME programs in Iran.

Conclusion

The evolution of clinical laboratory sciences in Iran demonstrates a successful integration of education, research, and clinical services. The establishment and progressive development of key institutions, hospitals, specialized laboratories, medical universities, and diverse academic programs, from undergraduate degrees to MSc, PhD, FCLS, and residency have provided a path for training specialized and highly qualified professionals nationwide.

The current structure of laboratories, including hospital-based, private, and public health laboratories, along with the supervisory role of the National Reference Laboratory, enables the provision of high-quality diagnostic services and the standardization of procedures. Professional routes for laboratory directorship (PhD, PhD-FCLS, and pathology residency) ensure both scientific expertise and managerial competence of graduates. This integrated system is an example of the sustainable and professional development of laboratory sciences in Iran, which continuously improves the public health outcomes and the quality of diagnostic services.

Despite recent challenges in the timely supply of kits and laboratory equipment, the field of laboratory sciences in Iran remains dynamic and continues to play a pivotal role in advancing healthcare services. Rapid scientific developments, particularly in emerging technologies such as omics, genomics, personalized medicine, big-data analytics, and artificial intelligence, highlight the urgent need to update educational programs. Equipping students and laboratory professionals with practical skills, data analysis capabilities, and critical thinking is essential to address future challenges. Strengthening accreditation standards, developing modern laboratory infrastructure, and emphasizing professional ethics and quality control are also crucial to ensure diagnostic accuracy and public trust.

Conflict of Interests

The authors declare that they have no conflict of interests.

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