Review Article

Laboratory Sciences Education and Training in Türkiye: A National and International Perspective

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ABSTRACT

Laboratory sciences education in Türkiye is structured across vocational, undergraduate, graduate, and medical specialization levels, reflecting the diverse institutional and regulatory framework of the country. At the undergraduate level, education is delivered mainly through health vocational schools and science faculties, with curricula covering anatomy, physiology, biochemistry, microbiology, hematology, pathology, and laboratory techniques. Postgraduate training includes medical residencies in biochemistry, microbiology, pathology, and genetics, as well as MSc and PhD programs in related fields. These pathways are regulated by the Council of Higher Education and the Ministry of Health's Medical Specialization Board. Alignment with the Bologna Process and the ORPHEUS framework has strengthened integration into the European Higher Education Area. Several universities have adopted ORPHEUS standards, requiring structured training and international publications for doctoral completion. Continuing professional development (CPD) is supported through national societies and international collaborations. The Turkish Biochemical Society, in partnership with EFLM, IFCC, FEBS, and IUBMB, plays a leading role by organizing specialized workshops and training courses. Key disciplines such as medical biochemistry, microbiology, molecular diagnostics, and immunogenetics are integrated across all levels of training. Education is delivered in both universities and Ministry of Health institutions, supported by modern laboratory infrastructure. This review highlights the organization, regulation, and international collaborations shaping laboratory sciences education in Türkiye. Particular emphasis is placed on curricula, reform processes, and professional development strategies, with attention to evolving global standards. These efforts aim to ensure a competent workforce, strengthen research capacity, and enhance the contribution of Türkiye's laboratory professionals to global health sciences.

Keywords: Biomedical education standards; Continuing professional development; Health sciences; Laboratory medicine specialization; Laboratory sciences education; Medical laboratory technician training; ORPHEUS

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Introduction

Türkiye's healthcare system relies on well-trained laboratory professionals to ensure accurate diagnosis, effective treatment, and robust biomedical research. Türkiye has a diverse and multi-tiered system of laboratory sciences education aimed at preparing qualified professionals for diagnostic, clinical, and research laboratories. This system includes vocational, undergraduate, graduate, and medical specialization pathways, each regulated under national frameworks established by the Council of Higher Education (YÖK) [1] and the Ministry of Health (MoH) [2]. Associate-degree health technician programs and university degrees form the basis of the workforce, while advanced clinical laboratory medicine is pursued through medical specializations and graduate studies.

Over the past decade, Türkiye has also sought to harmonize PhD education and specialist training with European standards through initiatives such as the ORPHEUS framework [3] and the European Federation of Clinical Chemistry and Laboratory Medicine (EFLM) Register of Specialists in Laboratory Medicine (EuSpLM) [4]. These reforms aim to balance educational capacity with workforce needs while elevating the quality of education and professional recognition.

This review traces the historical development and current structure of laboratory sciences education in Türkiye. It describes existing educational pathways at the undergraduate, graduate, and professional levels, with emphasis on key laboratory disciplines such as medical biochemistry, microbiology, pathology, molecular diagnostics, medical genetics, and tissue typing. The roles of universities versus MoH-run teaching hospitals are examined, along with the integration of ORPHEUS PhD standards and international collaborations. Finally, the review highlights evolving strategies for professional development and future directions in laboratory education.

Historical Overview

The roots of laboratory sciences education in Türkiye can be traced back to the 19th century, beginning with the establishment of the Imperial School of Medicine in 1827, later integrated into Istanbul University. However, structured training for laboratory technicians did not emerge until the 1960s, when vocational schools began to offer programs in laboratory practices.

The discipline gained academic recognition in the late 1980s, when specialized courses were introduced in university health sciences faculties. In 1989, a new higher-education law (Law No. 2880) formally established health vocational schools under universities. By the 1991–92 academic year, Atatürk University had launched one of the first associate-degree programs in "Medical Laboratory Techniques" [5]. This marked a transition from hospital-based vocational training to university-centered academic programs. During the 2000s, bachelor's programs in MLS (MLS) began to proliferate. Several universities such as Hacettepe and Istanbul pioneered standardized curricula aligned with European frameworks, thereby enhancing the recognition and academic standing of laboratory professionals. Today, the Council of Higher Education (YÖK) lists dozens of universities offering two-year Medical Laboratory Techniques programs under their Health Services Vocational Schools (Sağlık Hizmetleri Meslek Yüksekokulu) [6]. In parallel, "Health Vocational High Schools" (Sağlık Meslek Liseleri) at the secondary level have long provided an entry path into the profession, training medical laboratory technicians who may later pursue higher education.

The establishment of postgraduate programs in the 2010s, particularly in molecular diagnostics and public health, further underscored Türkiye's commitment to research-driven laboratory education. Figure 1 represents the historical milestones of medical laboratory education in Türkiye. These developments highlight the country's steady evolution from vocational

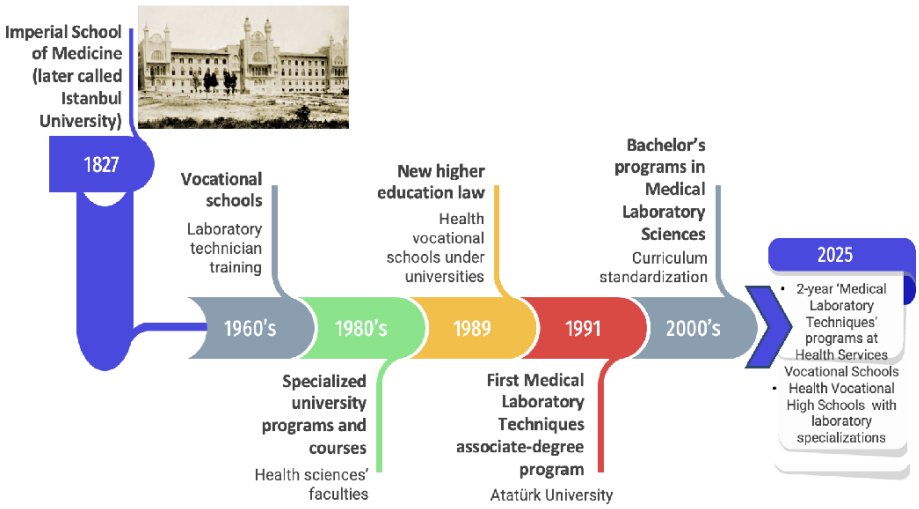

Figure 1. Historical overview of laboratory education in Türkiye.

training toward a comprehensive, university-based and research-oriented educational system.

Structure of Laboratory Sciences Education in Türkiye

Laboratory sciences education in Türkiye spans multiple levels, from secondary school to doctoral training.

Secondary Vocational Schools

Students may begin with four-year health vocational high schools (Sağlık Meslek Liseleri) offering medical laboratory programs. Graduates earn certification as "laboratuvar teknisyeni" (medical laboratory technicians) under regulations set by the Ministry of Education and the MoH. Nationwide, there are many such schools, both public and private, providing foundational training [7].

Vocational and Undergraduate Education in Laboratory Sciences

Associate Degree Programs: The most common entry-level qualification for laboratory professionals is the two-year associate diploma in "Medical Laboratory Techniques" (Tıbbi Laboratuvar Teknikleri), delivered by Health Services Vocational Schools (Sağlık Hizmetleri MYO) under state and private universities. More than 100 institutions currently offer this program. The curriculum blends theoretical courses (anatomy, physiology, chemistry, biochemistry, microbiology, parasitology, hematology, serology, pathology, biosafety) with intensive laboratory practice.

For example, Anadolu University's program includes biology, genetics, clinical microbiology, hematology, parasitology, and laboratory techniques across four semesters. Similar curricula are available at Hacettepe, Ege, Dokuz Eylül, Marmara, Lokman Hekim and Istanbul Atlas universities [8-13], all of which emphasize hands-on training through laboratory internships. Graduates are eligible for employment in public and private healthcare laboratories under the Ministry of Health's regulations.

Admission is typically through the national university entrance exam. Graduates may also advance into four-year bachelor's programs via the national Vertical Transfer Exam (DGS) organized annually by the Student Selection and Placement Center (ÖSYM) [14].

Bachelor's and Dual Degrees: In addition to a two–year technician training, several bachelor's programs provide a stronger theoretical foundation for laboratory careers. Many universities offer a 4-year undergraduate program (B.Sc) in fields such as Molecular Biology and Genetics, Biochemistry, Biotechnology, or Medical Laboratory Sciences (MLS). These degrees include extensive coursework in cell biology, biochemistry, immunology, instrumentation, data analysis, and laboratory methods. The Turkish Language and Social studies requirements apply to all undergrads. Notably, Selçuk University inaugurated Türkiye's first *Medical Laboratory Sciences* M.Sc program in 2014 (15) recognizing the need for advanced, research-oriented training. A few institutes (e.g., Health Sciences Institutes at major universities) now offer graduate degrees (MSc/PhD) in fields like clinical chemistry, molecular diagnostics, and hematology. While not specific to clinical settings, graduates from these programs often pursue laboratory-related careers in research institutes, industry, or hospital labs. Some institutions run specialized lab science programs; for instance, İstanbul Başkent University's curriculum integrates microbiology, clinical chemistry, hematology, and transfusion medicine components (including tissue typing and genetic lab work). In practice, such lab science majors complement the technician workforce by focusing on research and technical development. (Note: formal accreditation or national curriculum for these bachelor's programs is governed by university faculties of science or medicine and institutes of health sciences following YÖK regulations.)

Overall, undergraduate laboratory education in Türkiye blends theoretical science with practical skills. Faculty of Health Sciences (newly established under "Sağlık Bilimleri Üniversitesi (SBÜ)" – "the Health Sciences University") and traditional universities operate the vocational schools, sometimes in collaboration with nearby teaching hospitals. For example, SBÜ-affiliated schools (GATA, Etlik, etc.) ensure that students train in clinical laboratories of state hospitals during their internships. A recent review of Turkish associate-level health education noted that some fields are over-represented, indicating the need for policy alignment; medical laboratory programs would similarly be monitored under these workforce plans. Recent analyses of Turkish health education have raised concerns regarding the distribution and alignment of associate-level programs with national workforce needs. Özgül reported that several associate-degree health fields are oversupplied, while others remain underrepresented, indicating a lack of coordination between educational capacity and labor market demands [16]. This imbalance suggests inefficiencies in meeting the evolving needs of the healthcare system. Complementing this finding, Özdemir demonstrated that employment outcomes further exacerbate these discrepancies: bachelor's-degree graduates were nearly five times more likely than associate-degree graduates to secure public sector positions [17]. Together, these findings underscore the necessity of systematic workforce planning and policy alignment to optimize training capacity, ensure equitable distribution of health professionals across disciplines, and enhance the efficiency of human resource utilization in Türkiye's healthcare system.

Accreditation and Certification

All laboratory sciences education in Türkiye is regulated primarily by the Council of Higher Education (YÖK), which oversees all degree-granting programs. Program accreditation and quality assurance have been further strengthened with the establishment of the Higher Education Quality Council (YÖKAK) in 2015 [18]. YÖKAK evaluates institutional performance based on educational quality, research output, and alignment with the European Qualifications Framework (EQF).

Graduates of vocational or undergraduate laboratory sciences programs receive their diplomas through YÖK-accredited institutions, while licensure for professional practice is issued by the Ministry of Health (MoH). The MoH differentiates between technicians trained at vocational high schools, associate-level technologists, and bachelor-level graduates, defining their respective scopes of practice.

Clinical laboratories in Türkiye are increasingly encouraged to pursue ISO 15189 accreditation, ensuring quality and international recognition. Professional societies such as the Turkish Biochemical Society (TBS) provide workshops on quality management, ISO standards, and accreditation requirements, contributing to the professionalization of laboratory practice.

Graduate and PhD Education in Laboratory Sciences

Graduate education has become a cornerstone of Türkiye's effort to harmonize with international standards. MSc and PhD programs in medical biochemistry, medical microbiology, molecular biology, medical pathology, and medical genetics are offered through Institutes of Health Sciences at universities. These programs emphasize not only laboratory practice but also critical research skills, bioethics, and scientific communication.

A major development has been the adoption of the Bologna Process, which aligns Turkish graduate education with the European Higher Education Area (EHEA). Credit systems follow the European Credit Transfer and Accumulation System (ECTS) [19], and learning outcomes are aligned with the European Qualifications Framework (EQF) [20].

Postgraduate Education and ORPHEUS Implementation

At the postgraduate level, laboratory sciences education diverges into two main tracks: medical specialist training (for physicians) and academic graduate programs (for scientists, physicians and technologists). Figure 2 outlines the postgraduate educational structure of laboratory sciences in Türkiye.

The implementation of the ORPHEUS (Organization for PhD Education in Biomedicine and Health Sciences in the European System) standards in several Turkish medical faculties has enhanced the quality and comparability of Ph.D. training. ORPHEUS promotes transparent admission processes, structured supervision, transferable skills training, and regular progress evaluations, helping to ensure alignment with European doctoral education standards [21-23].

Academic Graduate Programs and Implementation of the ORPHEUS System in Türkiye

Universities offer MSc and PhD programs in laboratory-related fields (Biochemistry, Microbiology,

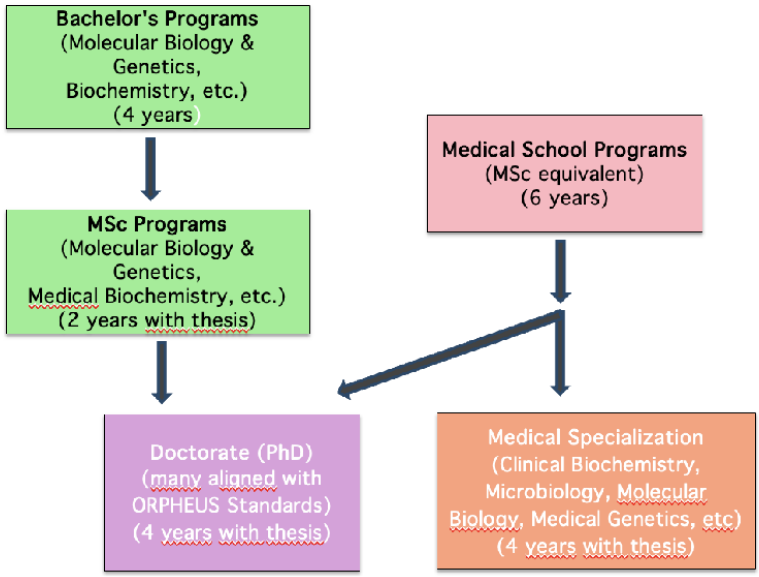

Figure 2. Postgraduate educational structure of laboratory sciences in Türkiye. Universities offer MSc and PhD programs in laboratory-related fields (Biochemistry, Microbiology, Molecular Biology, Molecular Sciences, Molecular Oncology, Immunology, Hematology, etc.), typically housed in graduate institutes (Institute of Health Sciences - Sağlık Bilimleri Enstitüsü).

Molecular Biology, Molecular Sciences, Molecular Oncology, Immunology, Hematology, etc.), typically housed in graduate institutes (Institute of Health Sciences - Sağlık Bilimleri Enstitüsü) or science faculty departments. Admission requires an undergraduate degree (or MSc) and a national exam score (ALES).

Türkiye has been an active participant in the ORPHEUS initiative. Following the Bologna Process and EU standards, Universities such as Hacettepe, Dokuz Eylül, Gazi, and Uludağ have adopted ORPHEUS standards for doctoral education. A pioneer in adopting ORPHEUS standards, under the leadership of Professor Gül Güner Akdoğan, Dokuz Eylül University initiated reforms between 2005 and 2010 to improve course structures and supervision. From 2010 to 2016, the university focused on internationalization, including hosting ORPHEUS conferences. Post-2016, efforts concentrated on safeguarding quality through supervisor training and aligning with ORPHEUS labeling criteria [24-27].

These reforms include:

- Structured supervision with clear roles and responsibilities.
- Transparent evaluation systems for doctoral theses.
- Requirements for publication in international peer-reviewed journals indexed in SCI/SCIE.
- Emphasis on transferable skills such as teaching, project management, and research ethics.

For example, Dokuz Eylül University restructured its PhD program to include mandatory publications, international mobility, and workshops in transferable skills. Hacettepe University's Graduate School of Health Sciences obtained the ORPHEUS label, signifying compliance with European best practices in PhD education.

Through ORPHEUS, Türkiye has positioned itself as a strong partner in European biomedical education, supporting internationalization, student mobility, and collaboration.

Further, the ORPHEUS 2024 Conference, held in Tbilisi, Georgia, focused on "Innovative Strategies and Concepts in Doctoral (PhD) Education in Biomedicine and Health Sciences." Turkish institutions actively participated, with presentations on strengthening PhD education and transferable skills [28-30].

In summary, Türkiye's postgraduate laboratory science programs increasingly embed ORPHEUS-style quality assurance, requiring international publications and standardized training for PhD students, indicating active harmonization with European PhD standards.

Regarding future directions, the integration of ORPHEUS standards into Turkish PhD programs is expected to:

- Enhance Research Quality: By emphasizing independent research and critical thinking.
- Improve Supervision Practices: Through structured training and adherence to international standards.
- Foster International Collaboration: Encouraging participation in global research networks and conferences.

These developments align with Türkiye's broader educational reforms aimed at elevating the quality of higher education and research.

Medical Specialization and Residency

In addition to academic degrees, physicians can pursue medical specialization (residency) in laboratory-related disciplines under the authority of the Ministry of Health's Medical Specialization Board (TUKMOS). Relevant specialties include:

- Medical Biochemistry
- Medical Microbiology
- Medical Pathology
- Medical Genetics
- Immunology and Tissue Typing

Admission to residency is through the Examination for Specialty in Medicine (TUS), a national exam administered by ÖSYM. Residency programs typically last four years, with structured curricula developed by TUKMOS. Training includes rotations in diagnostic laboratories, thesis preparation, and final board examinations. Residency programs emphasize competency-based training covering diagnostic accuracy, laboratory management, clinical consultation, and research methodology. Although challenges remain—such as heavy clinical workloads, disparities in institutional resources, and limited research time—efforts are underway to strengthen supervision, expand infrastructure, and align curricula with international standards [31]. Residency-trained laboratory physicians form the backbone of Türkiye's clinical laboratory leadership, often working as directors of hospital laboratories or as academic faculty.

Integration of New Technologies

In recent years, laboratory sciences education in Türkiye has expanded to include emerging technologies that are reshaping diagnostic and research practices. Traditional laboratory curricula have been enriched with courses on molecular diagnostics, genomics, proteomics, and bioinformatics. Techniques such as polymerase chain reaction (PCR), DNA sequencing, next-generation sequencing (NGS), and advanced immunoassays are increasingly emphasized, reflecting global trends in precision medicine.

Following the COVID-19 pandemic, digital tools gained prominence in laboratory training. Virtual microscopy platforms, online laboratory simulations, and e-learning modules enabled continuity of education during lockdowns. Many universities have since retained these tools as part of hybrid teaching models, ensuring broader access and flexibility in training.

Laboratory informatics, automation, and data science are also gradually being integrated into curricula.

Exposure to artificial intelligence (AI) and machine learning applications in diagnostics—such as digital pathology, automated image analysis, and predictive modeling—are becoming key competencies for future laboratory professionals. Research collaborations with EU-funded projects (e.g., Horizon Europe) foster innovation in genomic medicine and data analytics.

These innovations reflect Türkiye's efforts to align its workforce with international developments in laboratory medicine.

Continuing Professional Development (CPD) and The Significant Role of Turkish Biochemical Society

The Turkish Biochemical Society (TBS) has contributed substantially to the development of laboratory medicine education and continuing professional development (CPD) in Türkiye through scientific meetings, postgraduate educational programs, international collaborations, and professional networking initiatives. As one of the major national scientific associations in laboratory medicine, TBS has supported knowledge exchange and lifelong learning opportunities for laboratory professionals at all career stages.

In addition to its national educational activities, TBS has maintained active collaborations with international organizations, including IFCC, EFLM, FEBS, and regional scientific networks. These collaborations have facilitated alignment with international educational standards and increased participation by Turkish laboratory professionals in global scientific and training activities.

TBS regularly organizes national congresses, specialized symposia, workshops, webinars, and postgraduate courses covering various fields of laboratory medicine, including clinical biochemistry, molecular diagnostics, quality management, laboratory accreditation, bioinformatics applications, and emerging diagnostic technologies. These activities support the continuous updating of professional knowledge and competencies in response to evolving healthcare and laboratory practices.

Particular emphasis has also been placed on postgraduate and doctoral education through collaborations with universities and research institutions. Educational activities within the TBS Academy framework provide structured scientific training in areas such as scientific writing, research methodology, laboratory quality systems, and advanced laboratory technologies. These initiatives complement formal university-based education and strengthen the national CPD environment. Looking ahead, TBS Academy aims to expand its regional outreach through joint workshops with scientific societies in the Middle East and Central Asia and to develop accredited CPD tracks aligned with the EFLM CPECS® (32) and IFCC PROCEED® (33) frameworks.

The congresses and educational meetings organized by TBS also provide opportunities for interdisciplinary interaction among physicians, scientists, laboratory specialists, trainees, and students. Participation by international speakers and collaboration with international scientific organizations further support the global integration of laboratory medicine education in Türkiye.

Figures 3 in this manuscript presents selected example of scientific and educational activities organized within these frameworks and reflect the international and collaborative dimensions of laboratory medicine education and professional development initiatives in Türkiye.

Figure 3. The opening day of the FEBS 2025 Congress, which took place from July 5 to 9 in Istanbul, Türkiye.

Key Disciplines in Laboratory Medicine Education

Laboratory sciences education in Türkiye spans several major disciplines, reflecting the complexity of modern diagnostic medicine. Core areas include:

- Medical Biochemistry – foundational in clinical chemistry, enzymology, endocrinology, toxicology, and laboratory automation.
- Medical Microbiology – covering bacteriology, virology, parasitology, mycology, and antimicrobial resistance.
- Medical Pathology – focusing on histopathology, cytology, molecular pathology, and digital pathology.
- Molecular Diagnostics and Genetics – including PCR, sequencing, molecular oncology, cytogenetics, and immunogenetics. Genetics is taught as "Medical Biology and Genetics" in the early semesters. Some universities offer dedicated genetics B.Sc programs. Master's and Ph.D programs in genetics/molecular biology train graduates in molecular techniques (PCR, sequencing) for diagnostic and research labs. Türkiye has also launched graduate programs in genetic counseling. Specialists in medical genetics (MDs) and laboratory geneticists develop expertise in cytogenetics and molecular diagnostics.
- Immunology and Tissue Typing (HLA laboratories) – supporting transplantation medicine, autoimmunity, and immunogenetics. Some tissue-typing and HLA laboratories at universities and in private healthcare institutions in Türkiye participate in international quality-assurance and accreditation processes, including inspections and accreditation programs conducted by the European Federation for Immunogenetics (EFI). These activities help maintain international standards for histocompatibility and immunogenetics laboratory practices.

These disciplines are taught across vocational, undergraduate, and graduate programs, with residency specialization available for physicians. The integration of advanced diagnostic methods—such as flow cytometry, next-generation sequencing, and multiplex assays—ensures graduates are prepared for evolving healthcare demands.

Roles of Universities and Ministry of Health Institutions

Türkiye's laboratory sciences education is shaped by a dual structure, in which both universities and Ministry of Health (MoH) institutions play critical roles.

- Universities (state and private) are primarily responsible for academic education, from associate diplomas to PhD degrees. They provide foundational training, research opportunities, and international collaborations, often through Health Sciences Institutes. Universities also lead in adopting ORPHEUS standards for PhD programs and in integrating Bologna Process requirements.
- MoH Institutions are central to medical residency training. State hospitals and research-and-training hospitals provide the clinical laboratories where physician-specialists train in medical biochemistry, microbiology, pathology, and genetics. The MoH also regulates workforce deployment, laboratory licensing, and professional certification.

Thus, universities provide the academic framework and credentials, while MoH-affiliated institutions offer practical training environments. Collaboration between the two ensures that theory and practice are linked: a typical medical laboratory student might take classes at the university and train on equipment in a public hospital lab (e.g. pathology teaching slides or blood bank procedures).

To support educational advancement, universities and MoH-affiliated institutions organize joint research activities, meetings, and training programs that promote continuous updating of knowledge and skills.

Workforce Development and Continuing Education

Türkiye actively cultivates its laboratory workforce through both formal and informal channels. Beyond initial training, professional associations (e.g., the Medical Laboratory Technicians Association) and non-governmental organizations (NGOs) and industry partners offer workshops and conferences on new techniques. Continuing education plays a vital role in maintaining workforce competence. Universities, professional societies, and the MoH provide in-service training, online learning modules, and certification programs. These initiatives ensure that laboratory professionals remain updated on innovations in molecular diagnostics, bioinformatics, and laboratory automation.

For instance, a recent MoH notice announced a national certificate course in *Therapeutic Apheresis*, explicitly including laboratory technologists as eligible participants (shgmesdb.saglik.gov.tr). Similarly, quality and safety training (e.g., in ISO standards, biosafety) is mandated by regulations and usually delivered by accredited providers. These efforts reflect a push toward lifelong learning: as one official remark noted, health technicians are expected to adapt "to time's required scientific/technological developments" after their basic education (medikallabder.org).

Workforce planning is coordinated with the MoH's recruitment drives; for example, recent public-sector job postings have specified quotas for "*laboratuvar sağlık teknikerleri*," indicating steady demand.

International Collaboration and Support for Graduate and Postgraduate Laboratory Sciences Education

The TBS, a prominent national scientific organization, plays a pivotal role in advancing laboratory sciences education and training in Türkiye through its active membership and collaboration with major international bodies such as the European Federation of Clinical Chemistry and Laboratory Medicine (EFLM), the International Federation of Clinical Chemistry and Laboratory Medicine (IFCC), the Federation of European Biochemical Societies (FEBS), and the International Union of Biochemistry and Molecular Biology (IUBMB). These memberships have enabled Turkish scientists and trainees to access a wide range of resources, educational programs, and collaborative networks that significantly enhance both continuing professional development (CPD) and structured academic training at graduate and postgraduate levels.

Through its engagement with EFLM, the TBS actively promotes participation in the EFLM LabX initiative, which facilitates laboratory exchange opportunities across Europe. This program offers young laboratory professionals and postgraduate students in Türkiye the chance to gain hands-on experience in specialized European laboratories, fostering technical skills and international collaboration.

Similarly, the IFCC Professional Exchange Program (PEP) offers Turkish early-career scientists and trainees opportunities for short-term placements in IFCC-recognized laboratories worldwide. This not only supports knowledge transfer and capacity building but also strengthens global partnerships and the harmonization of laboratory practices.

Over the past decade, Türkiye (TBS) has proudly hosted several high-profile FEBS events (2002, 2006 and 2025 Congresses), reflecting the country's growing role in the European molecular life sciences community. Another notable event among these was the FEBS Education and Training Conference, the first of its kind in Europe, in 2024 at Antalya, which brought together international experts and regional educators to exchange innovative teaching practices and advance professional development in the molecular biosciences education. These events not only highlight Türkiye's capacity to organise world-class scientific meetings but also strengthen international collaborations and foster the next generation of researchers and educators in the region (Figure 4).

These initiatives provide valuable training in advanced methodologies, research ethics, and scientific communication, aligning well with the ORPHEUS framework's emphasis on research competence and internationalization in Ph.D education.

Moreover, interactions with IUBMB contribute to broadening the scope of biochemical education by facilitating Turkish participation in IUBMB-funded congresses, educational activities, and fellowships, thus fostering global scientific integration.

These international affiliations collectively reinforce the quality of laboratory science education in Türkiye by promoting excellence in teaching, facilitating global

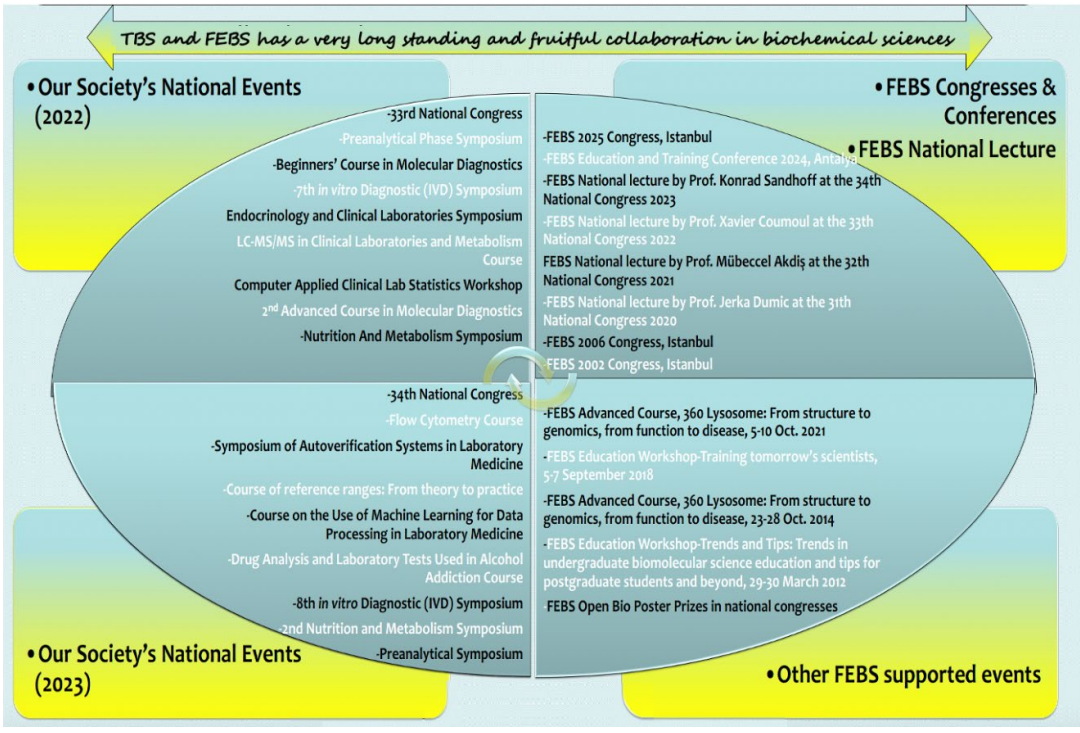

Figure 4. Recent joint events organised in Türkiye.

Table 1. Strategic Priorities and Opportunities for Advancing Clinical Laboratory Education and Practice in Türkiye.

Thematic Area	Description
Policy Reforms	Advocating for unified CPD/CE accreditation standards (e.g., EFLM CPECS® [32], IFCC PROCEED™ [33]) and raising awareness of continuing education credit value
Curriculum Modernization	Emphasizing emerging topics such as personalized medicine, big data analytics, AI integration, and interdisciplinary public health.
Global Collaboration	• Strengthening ties with global organizations (e.g., IFCC, EFLM, FEBS, IUBMB, ICRO) to harmonize competencies and research efforts. Enhance regional outreach (e.g., partnerships with societies in East and Central Asia, Middle East) through TBS Academy's strategy
Leveraging Conferences	Utilizing platforms like the International Clinical Laboratory Conferences in Türkiye to drive innovation and professional exchange.

networking, and ensuring alignment with international educational standards.

Future Directions

Looking ahead, experts identify several priorities. Türkiye's *Education Vision 2023* (Ministry of Education) emphasizes strengthening vocational education through enhanced quality assurance and industry partnerships. In lab sciences, this could mean tighter alignment of curricula with hospital requirements and EU standards. Graduates express a desire for more research training and soft skills (e.g., problem-solving), and planners are evaluating new bachelor's programs to create "laboratory technologist" roles. Global trends (e.g., personalized medicine) suggest a future need for bioinformaticians and genomics specialists; Turkish institutions are beginning to introduce related courses but may expand these offerings. Additionally, bolstering faculty expertise and lab infrastructure (biobanks, high-throughput sequencers) is on the agenda. Overall, the direction is toward harmonizing with international practices (Bologna Process, The European Qualifications Framework) and ensuring the workforce remains agile. As one recent review concludes, sustained investment in education and professional development is crucial: only a well-trained, continuously educated laboratory workforce can meet future health challenges.

Table 1 outlines key thematic areas that represent future directions in clinical laboratory science education and professional development in Türkiye. These priorities reflect expert recommendations for aligning educational programs with global standards, enhancing international collaboration, and modernizing curricula to meet evolving healthcare needs. Emphasis is placed on policy reforms, curriculum innovation, global engagement, and leveraging regional conferences to catalyze progress.

Conclusion

Türkiye has developed a comprehensive, multi-level educational structure for laboratory sciences that is supported by national regulatory frameworks, enriched through international collaboration, and continuously evolving. The integration of the ORPHEUS model in Ph.D education and the active involvement of national societies, particularly the Turkish Biochemical Society (TBS), in global scientific networks such as IFCC, EFLM, FEBS, and IUBMB, reflect Türkiye's commitment to aligning with international standards. Undergraduate programs in medical laboratory technology produce skilled technicians versed in all major lab disciplines. Graduate training combines medical specialty programs with MSc/PhD research tracks, now increasingly benchmarked against ORPHEUS standards.

Continuous efforts in Continuing professional development (CPD), research training, and international exchanges are essential to maintain the competitiveness and quality of Turkish laboratory professionals in a globalized biomedical landscape. CPD is well-supported by professional societies (e.g. TBS) and healthcare institutions. Key areas such as clinical biochemistry, microbiology, molecular science, genetics, and tissue typing are explicitly integrated throughout training. Universities and Ministry-affiliated hospitals jointly ensure practical laboratory exposure. While occasional workforce imbalances have been noted, Türkiye's ongoing commitment to standardizing curricula and embracing international best practices bodes well for the future quality of its laboratory science workforce. This forward-looking approach not only sustains national healthcare capacity but also enhances Türkiye's role as a respected contributor to the global laboratory sciences community.

Acknowledgment

This article draws on national education reports, professional society publications, and official institutional sources to synthesize current practices in Turkish laboratory sciences education.

Conflict of Interest

The authors declare that they have no conflict of Interest.

Abbreviations

ALES: Academic Personnel and Graduate Education Entrance Exam (Akademik Personel ve Lisansüstü Eğitimi

Giriş Sınavı), AMSE: Association of Medical Schools in Europe, CE: Continuing Education, CPD: Continuing Professional Development, DGS: Vertical Transfer Exam (Dikey Geçiş Sınavı), ECTS: European Credit Transfer and Accumulation System, EFI: European Federation for Immunogenetics, EFLM: European Federation of Clinical Chemistry and Laboratory Medicine, EQF: European Qualifications Framework, EuSpLM: European Specialist in Laboratory Medicine, FEBS: Federation of European Biochemical Societies, HLA: Human Leukocyte Antigen, ISO: International Organization for Standardization, IFCC: International Federation of Clinical Chemistry and Laboratory Medicine, IUBMB: International Union of Biochemistry and Molecular Biology, MLS: Medical Laboratory Sciences, MoH: Ministry of Health (Türkiye), MSc: Master of Science, NGO: Non-Governmental Organization, ORPHEUS: Organization for PhD Education in Biomedicine and Health Sciences in the European System, ÖSYM: Student Selection and Placement Center (Öğrenci Seçme ve Yerleştirme Merkezi), PCR: Polymerase Chain Reaction, PhD: Doctor of Philosophy, SBÜ: Sağlık Bilimleri Üniversitesi (Health Sciences University), SCI/SCIE/SSCI: Science Citation Index / Science Citation Index Expanded / Social Sciences Citation Index, TBS: Turkish Biochemical Society, TUKMOS: Turkish National Specialist Training Board (Tıpta Uzmanlık Kurulu Müfredat Oluşturma Sistemi), TUS: Examination for Specialty in Medicine (Tıpta Uzmanlık Sınavı), WFME: World Federation for Medical Education, YÖK: Council of Higher Education (Yükseköğretim Kurulu), YÖKAK: Higher Education Quality Council (Yükseköğretim Kalite Kurulu)

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