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LETTER TO THE EDITOR

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The need to establish and recognize the field of clinical laboratory science (CLS) as an essential field in advancing clinical goals

To The Editor,

Clinical laboratory science (CLS) must be addressed in the current world of new diseases. Although it is important to maintain academic integrity, it is even more important to implement a standardized curriculum to accurately diagnose the clinical objective. In today's society, a medical diagnostic laboratory relies on three critical elements: advanced equipment, essential materials, and most importantly, a human employee capable of monitoring performance and quality, interpreting and reporting results; phone call regarding critical values. The CLS plays an important role in the education and training of scientists and other Healthcare professionals.[1,2] Another point is medical/healthcare professionals depend on the CLS with laboratory equipment and technology to ensure rapid access to results for patients.[3] CLS is an important axis of modern health care for fast, correct, accurate, and timely disease diagnosis; innovative medical research; and ensuring the safety and effectiveness of medical treatments.[4–6]

The COVID-19 pandemic has emphasized the overarching role of the CLSs. The rapid development of diagnostic tests for diseases ranging from diabetes, and metabolic syndrome to rheumatism, and cancer, viral mutation tracking, point-of-care tests, and vaccine research depends on the expertise of laboratory scientists[7–12] (Table 1). To attain the best benefits of laboratory science, we propose a comprehensive and multifaceted academic program that should be designed and implemented as the knowledge and its applications are beyond the defined geographical barriers (Table 2). The program should include a bachelor's degrees in laboratory science, master's degrees in laboratory science, and the doctorate or professional doctorate in CLS. In addition, a two-tiered system, consisting of a PhD in Clinical Laboratory Science and a Bachelor of Laboratory Science, has undergone a clear career progression. Individuals can start with a bachelor's degree, gain practical experience, and gradually progress to achieve a laboratory science doctorate. This structure has been successful in countries such as Iran, where laboratory science programs have thrived.

In addition, the All India Institute of Medical Sciences, New Delhi, is the initiator and provider of a postgraduate course in laboratory medicine for holders of a Bachelor of Medicine and Bachelor of Surgery (MBBS) degree in India. The 3-year residency program in a specialty following the MBBS leads to a corresponding postgraduate MD degree. A DM/MCh degree can then be obtained through a 3-year residency program. Pathology, microbiology, biochemistry, and laboratory medicine are among the specialization courses in CLS offered in India.[13–16]

CLS differs significantly from traditional medical training paradigms. Unlike medicinal chemistry, which focuses on theoretical principles, clinical biochemistry in CLS emphasizes practical applications in diagnostic and prognostic testing and patient care. Specialized training is essential for CLS and requires specific programs. In CLS, the curriculum is tailored to bridge the gap between laboratory testing and clinical practice, with an emphasis on the seamless translation of laboratory results to bedside treatment. While traditional degree programs suggest continuity from general biology to specialized fields, CLS emphasizes the importance of the clinical perspective in laboratory analysis for effective patient outcomes. While both fields aim to improve patient outcomes, clinical laboratory scientists specialize in bridging the gap between laboratory and patient care. Laboratory scientists participate in clinical work focusing on the practical aspects of health care. This approach expedites communication between the laboratory and healthcare providers, facilitating faster diagnosis and treatment decisions.

Just as nurses are trained in the fundamentals of health care, laboratory scientists must have basic knowledge of key disciplines, including hematology, immunology, microbiology, parasitology, virology, mycology, and biochemistry. In addition, they should be trained in quality control and quality assurance. To cultivate a workforce of clinical laboratory scientists, we propose to offer an additional 5-year study period for those who have completed their bachelor's degree. This culminates in a Ph.D in Clinical Laboratory Science, further strengthening their expertise and allowing them to take on laboratory leadership roles.

Therefore, the recognition and establishment of laboratory science as a core discipline in healthcare has long been important. Clinical Laboratory professionals, as described in Table 1&2, play a

TABLE 1 Comprehensive laboratory diagnostic tests and their clinical significance in various fields of clinical laboratory science.

Laboratory science field	Associated diseases	Diagnostic tests	Clinical indications	Sample types	Diagnostics/monitoring importance
Hematology	Hematologic malignancies, and anemia hemoglobinopathies	Complete blood count (CBC), hemoglobin electrophoresis, peripheral blood smear, molecular tests, and flowcytometery	Unexplained fatigue, pale, weakness, respiratory complications, bleeding, chronic infections, and fever	Blood (EDTA/citrate) and body fluid	Blood disorders, pre/postsurgery monitoring, coagulopathy, ESR, and histopathology
Immunology	Autoimmune diseases, infertility, and immunodeficiency	Antinuclear antibody (ANA) test, rheumatoid factor (RF) test, infertility tests, molecular tests, and flowcytometery	Joint pain and pregnancy	Blood, serum and body fluid	Immune system disease and pregnancy
Biochemistry	Diabetes, liver or kidney disease	Blood glucose test, serum creatinine test, lipid profile, and liver function tests	Diabetes, kidney dysfunction, and digestive complications	Blood, urine, and body fluid	Metabolic and renal health
Genetics	Genetic disorders	Genetic DNA testing and genetic counseling	Congenital defects	Blood, tissue, and body fluid	Genetic mutations
Parasitology	Malaria and giardiasis	Microscopic examination of blood, and serology	Travel history and diarrhea	Blood and stool	Parasitic infections
Virology	HIV, influenza, HBV, HCV, HEV, HTLV, and CMV	HIV viral load test, influenza rapid test, molecular tests, flowcytometery, and serology	High-risk behavior and flu symptoms	Blood and nasal swab	Viral infections
Mycology	Candidiasis and aspergillosis	Fungal culture and microscopic examination	Persistent infections	Tissue and swabs	Fungal pathogens
Bacteriology	Tuberculosis and staph infections	Tuberculosis culture and Gram stain test	Cough and skin infections	Sputum and tissue	Bacterial infection
Microbiology	Various infections	Bacterial culture and microscopic examination	General infections	Body fluid, blood, urine, sputum, stool, animal tissues, and plant tissues	Various bacterial pathogens

Abbreviations: CMV, cytomegalovirus; ESR, erythrocyte sedimentation rate; HBV, hepatitis B virus; HCV, hepatitis C virus; HEV, hepatitis E virus; HIV, human immunodeficiency virus; HTLV, human T-lymphotropic virus type 1.

TABLE 2 Laboratory science programs in selected countries: An international overview.

Country	University	Program name	Duration (years)	Curriculum highlights	Clinical internships*
United States	XYZ	Bachelor of Science in Medical Laboratory Science	4	Clinical rotations in various laboratory departments Hematology, Microbiology, Immunology	Yes (12 months)
United Kingdom	UVW	BSc Biomedical Science	3–4	Pathology studies	Yes (You can choose a 4-year sandwich pathway or traditional 3-year pathway in internship program)
Canada	LMN	Bachelor of Medical Laboratory Science	4	Diagnostic testing - Laboratory management	Yes (clinical practicum)
Australia	PQR	Bachelor of Laboratory Medicine	4	Clinical microbiology - Molecular diagnostics	Yes
Iran	Ahvaz Jundishapur	Bachelor of Laboratory Sciences	4	Core courses in Hematology, Microbiology, Immunology	16 Units (hospital)
Germany	GHI	Master of Science in Medical Biotechnology	2	Biotechnology applications - Research projects	No
India	Jai Prakash Narayan Trauma Centre	MD Laboratory Medicine	3–4	Clinical pathology, hematology microbiology, biochemistry, and laboratory medicine	3 Years in the main Department of MD Laboratory Medicine

*Clinical internships in laboratory science courses often involve students working in diagnostic or clinical laboratories under the supervision of experienced laboratory professionals. This hands-on experience allows students to gain valuable skills, apply their theoretical knowledge, and become familiar with the daily operations of a clinical laboratory. The internship is an essential part of their education and prepares them for a future career in laboratory science.

crucial role in healthcare innovation through their extensive training programs and career paths. They not only play a role in diagnosis and research, but also contribute significantly to the overall health care system. Their expertise and knowledge is invaluable in guiding healthcare professionals, including physicians, through the complexities of modern medicine. It is time to recognize their importance and maneuver them to the forefront of healthcare innovation.

AUTHOR CONTRIBUTIONS

Mojtaba Aghaei: Investigation; writing—review and editing. **Reyhane Khademi**: Writing—review and editing. **Seyed Sobhan Bahreiny**: Writing—review and editing. **Najmaldin Saki**: Supervision; validation.

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The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

ETHICS STATEMENT

This article does not contain any studies with human participants or animals performed by any of the authors.

TRANSPARENCY STATEMENT

The lead author, Najmaldin Saki, affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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