Mini Review

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Current status and future perspectives on standardized training for laboratory medicine resident physicians in China

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Abstract: This paper offers a comprehensive examination of the current landscape of standardized training for laboratory medicine resident physicians in China. It explores key elements including training objectives, methodologies, content, and evaluation criteria. Based on a critical analysis of existing strengths and limitations within the current system, targeted recommendations are proposed to guide the cultivation of highly qualified professionals in laboratory medicine. These suggestions aim to improve the overall quality of residency training and address growing clinical demands and evolving trends within the discipline.

Keywords: standardized training; laboratory medicine; China; achievements

Introduction

Laboratory medicine plays a fundamental role in modern healthcare, with its data chain spanning the entire continuum from early disease screening, diagnostic classification, and treatment monitoring to prognosis evaluation. With the rapid development of technologies such as mass spectrometry, flow cytometry, next-generation sequencing (NGS), and AI-based data interpretation, the scope of laboratory medicine has evolved from a traditional "testing room" to a "data center plus clinical decision support" hub. This transformation places dual demands on laboratory physicians – they must function both as precise testing engineers and as interdisciplinary clinical consultants [1, 2].

In China, over 95 % of clinical laboratories are located in large general hospitals, where laboratory physicians move daily between the bench and the bedside. They must ensure internal quality control, validate methodologies, and assess new technologies, while also being familiar with the diagnostic thinking, medication strategies, and disease progression in specialties such as respiratory medicine, hematology, and critical care. This breadth of skills is essential to convert "cold data" into "actionable information" that can be immediately adopted at the bedside. Precisely because of these complex demands, standardized residency training has been established as a cornerstone of medical education. Its goal is not merely to produce "technical operators," but to cultivate dual-competence professionals who bridge the laboratory and the clinic [3, 4]. Since the nationwide implementation of Specialist Physician Standardized Training in China in 2014, including specialist training of medical doctors in laboratory medicine [5, 6], A "1 + 2" tiered framework has taken shape: one year of general rotation allows trainees to participate in multidisciplinary rounds (MDT), interpret imaging and pathology, and understand comprehensive disease management; two additional years focus on re-evaluating the clinical significance of laboratory tests, translational research, and doctor–patient communication. This system has continuously produced professionals capable of aligning laboratory results precisely with individualized treatment pathways, driving laboratory medicine's shift from a "cost center" to a "value center."

Fundamentally, this specialist training of medical doctors in laboratory medicine approach addresses the emerging demands of an aging population, precision medicine, and multidisciplinary collaboration. It also serves as a national strategic initiative to improve healthcare quality and ensure patient safety. By deeply integrating clinical relevance, technical proficiency, research thinking, and

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lifelong professional development, it lays a broad runway for Chinese laboratory physicians to move seamlessly from the bench to the bedside and toward population health, establishing a solid foundation for the continued modernization of laboratory medicine.

Current status of standardized training of medical doctors in laboratory medicine

Training objectives

Rooted in the national standards for residency education and shaped by six core competencies. The six core competencies required in specialist physician standardized training include: professionalism; medical knowledge and skills; patient care; communication and collaboration; teaching ability; lifelong learning and self-improvement. The program aims to produce laboratory physicians who can independently and proficiently manage clinical responsibilities. Residents are expected to master both clinical and laboratory medical knowledge, perform key laboratory procedures, interpret test results with precision, and provide expert diagnostic and therapeutic consultations. Additionally, ethical conduct, humanistic values, research literacy, and teaching capabilities are emphasized as integral components of professional development.

Basic conditions of the training base

The hospital must have at least 1,500 beds in total and an annual outpatient volume of no less than 1,000,000 visits. The average daily number of specimens tested should be no less than 2,000. The Department of Laboratory Medicine should include the following subspecialties: Clinical Hematology and Body Fluids, Clinical Biochemistry, Clinical Immunology, Clinical Microbiology, and Clinical Cytology and Molecular Genetics.

The types of diseases covered by the clinical departments for rotation must comply with the requirements specified in the Standards for Standardized Residency Training Bases and the Standards and Requirements for the Content of Standardized Residency Training in Laboratory Medicine. The variety and volume of laboratory tests performed, as well as the corresponding instruments and equipment, must meet the detailed requirements for Laboratory Medicine outlined in the Standards for Standardized Residency Training Bases.

The training base must be equipped with demonstration classrooms, digital projection equipment, and full-text databases and retrieval platforms for Chinese and English electronic journals.

Training methods

The training spans 36 months and adopts a rotation-based structure covering both clinical and laboratory disciplines (Figure 1):

Clinical Rotations (12 months): Residents rotate through internal medicine subspecialties, such as cardiology, nephrology, respiratory medicine, gastroenterology, endocrinology, and hematology, to build foundational clinical skills.

Laboratory Rotations (21 months): Training encompasses clinical hematology and body fluids, biochemistry, immunology, microbiology, and molecular genetics, with residents gaining practical experience in core laboratory techniques and quality assurance.

Flexible Rotations (3 months): These are tailored for specialized learning or supplementation.

Throughout the program, residents engage in diverse activities – patient care, laboratory practice, theoretical sessions, case discussions, and teaching rounds. Junior residents guide interns, while senior residents mentor juniors, creating a collaborative and hierarchical learning environment.

Training content and progression

Year 1: Focuses on developing clinical proficiency in internal medicine. Residents are trained to understand the diagnostic and therapeutic workflows of prevalent diseases, including related laboratory investigations.

Year 2: Residents begin formal training in laboratory medicine, acquiring basic laboratory techniques under the supervision of experienced mentors. Rotations span key laboratory subspecialties.

Year 3: Emphasizes integration of clinical and laboratory knowledge. Residents take part in ward rounds, case reviews, and multidisciplinary consultations. Rotations include advanced topics such as cytogenetics and molecular diagnostics.

Training courses

According to the guidelines for standardized residency training teaching activities, specific requirements are set for

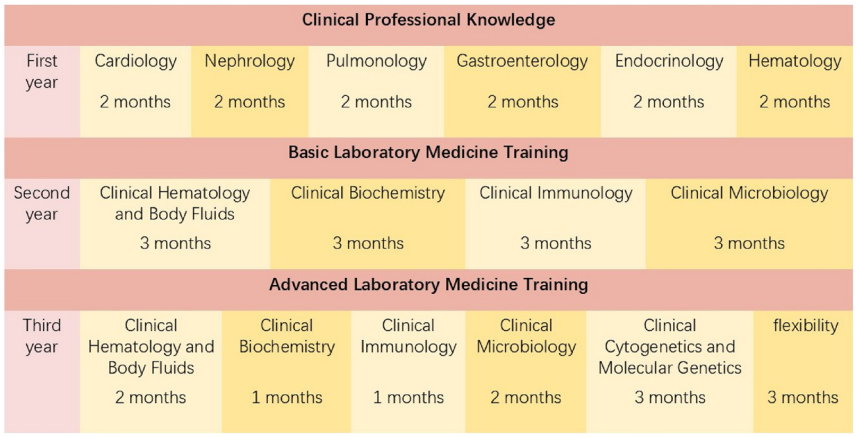

Figure 1: Clinical laboratory physician training program rotation schedule.

the frequency and format of training courses. The training includes departmental orientation and rotation induction, image reading sessions, case discussions, laboratory report interpretation, and mini-lectures.

Departmental orientation and rotation induction

The purpose is to standardize the induction process for new residents entering the specialty base, covering topics such as the discipline background, rules and regulations, training objectives, training content and rotation plan, as well as the clinical diagnosis and treatment skills and procedures that residents are expected to master during rotations. This is organized and implemented by designated personnel. Similarly, the rotation department induction includes orientation on department-specific information, discipline, training plans and requirements, medical ethics, and doctor-patient communication. Training and assessment requirements should reflect the essential needs of the department's positions and be organized by designated staff. This must be conducted once before residents enter each base or department.

Image reading sessions

These sessions focus on teaching using medical imaging data (pictures or scans) of clinical cases. Under the guidance of supervising physicians, residents actively participate through interactive teaching, combining theoretical knowledge with clinical cases and imaging interpretation. This activity is required to be held once every two weeks.

Teaching case discussions

Teaching case discussions center around real patients in a multidisciplinary on-site teaching format. Residents present medical histories, laboratory results, and imaging findings. Supervising physicians guide residents in evidence-based analysis of diagnosis, differential diagnosis, and treatment strategies, integrating guideline interpretation, ethical considerations, and demonstrations of doctor-patient communication. Real-time Q\&A and thought-process summaries aim to cultivate residents' skills in clinical decision-making, teamwork, and lifelong learning. These discussions are required once every two weeks.

Mini-lectures

Mini-lectures are concise teaching sessions delivered by supervising physicians focusing on knowledge gaps identified among residents. Lasting 15–20 min, each lecture targets a specific laboratory item or disease-related topic, using evidence-based guidelines, the latest literature, and representative cases, along with flowcharts and quality control charts. On-site Q\&A and interaction help residents quickly build knowledge frameworks, update technical understanding, and integrate theory with clinical practice. Mini-lectures are required once a week.

Laboratory report interpretation

In these sessions, supervising physicians guide residents through step-by-step analysis of laboratory data, interpreting abnormal values in the context of patient history, medication use, and physiological variations. They demonstrate how to identify interferences, extract diagnostic clues, and develop treatment recommendations while simultaneously training clinical reasoning, communication skills, and awareness of quality management. This activity is required once every two weeks.

Training trainer

Supervising instructors must hold a medical undergraduate degree or above and possess at least three years of experience as an attending physician (or senior laboratory technician) with a professional technical title. They must have at least five years of working experience in the Department of Laboratory Medicine and a minimum period of practice in the relevant subspecialty they supervise, such as at least four years in Clinical Hematology and Body Fluids, three years in Clinical Biochemistry and Immunology, five years in Clinical Microbiology, or three years in Clinical Cytology and Molecular Genetics.

Each resident must be assigned a dedicated supervising instructor as their mentor, who is responsible for providing full-process guidance throughout the training period. Before starting their role, supervising instructors must participate in institution-level faculty training, with a 100 % training completion rate, and must hold a valid faculty certification. They are also required to continuously engage in continuing education to enhance their teaching abilities. An annual evaluation of each supervising instructor's teaching performance must be conducted at least once every year.

Training evaluation

A comprehensive evaluation system is employed, including daily assessments, periodic reviews, and annual examinations. Routine assessments include evaluation of medical ethics and professionalism, clinical professional conduct, attendance, clinical practice competence, completion of training indicators, participation in academic learning activities, as well as the implementation of formative evaluations. Relevant records and original documentation must be complete, authentic, and properly maintained. Rotation assessments must have detailed implementation guidelines. The assessment content should cover both theoretical knowledge and practical skills, reflect the specialty's characteristics and competency requirements for the position, and align with the concept of progressive training by levels. The assessment format must be standardized, with complete original documentation, and must be reviewed and signed by the teaching group and the group leader of the specialty base. Annual assessments must have implementation guidelines that align with the specialty. The content should include personal summaries, theoretical knowledge, practical skills, and comprehensive evaluations, providing an accurate and thorough reflection of the resident's annual training performance, while highlighting the specialty's characteristics and the progressive training requirements by level.

The assessment matrix covers theoretical knowledge, clinical competencies, and case-based performance. Upon successful completion of all required training rotations and assessments during the standardized residency program, residents must pass the National Medical Licensing Examination, which evaluates their comprehensive medical knowledge and clinical competence. In addition, they must pass the final exit examination organized by nation, which typically includes a theoretical exam and a practical clinical skills assessment, ensuring that trainees meet the required standards of independent practice in their specialty.

After passing both the national licensing exam and the program's final certification assessment, residents are awarded a nationally recognized Residency Completion Certificate and the National Medical Practitioner Qualification Certificate (medical license). Holding this license is mandatory for registration on the national medical practitioner registry, which is a legal prerequisite for practicing medicine independently in China. Only registered physicians listed in the national database are authorized to provide medical services, and assume full responsibility for patient care (Figure 2).

Achievements

Standardized framework

Since 2014, a unified structure for training objectives, curricula, and evaluation methods has promoted consistent national standards. This has helped ensure equitable development across institutions and improved the overall quality of training nationwide.

Workforce development

Thousands of residents trained through this program now serve in diverse healthcare settings, contributing to improved diagnostic accuracy, enhanced patient care, and better treatment outcomes.

Academic and research contributions

The training program encourages active participation in research, publications, and academic activities. These initiatives foster innovation and elevate China's global presence in the field of laboratory medicine.

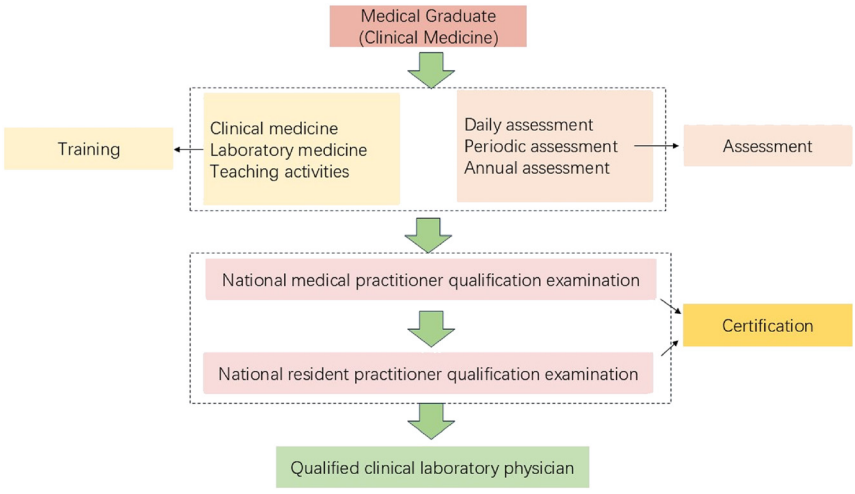

Figure 2: Assessment and certification process for clinical laboratory physician training program.

Challenges

Disparities across training bases

Training quality varies significantly due to unequal resource distribution. Grassroots institutions often lack advanced equipment, experienced faculty, and complex case exposure, which can hinder training effectiveness.

Outdated curriculum and clinical relevance

Rapid innovations in diagnostics often outpace curriculum updates. Moreover, current training may insufficiently address interdisciplinary collaboration or critical thinking – both essential in the era of precision medicine.

Faculty shortages

There is a lack of well-trained educators proficient in both clinical practice and teaching methodologies. Many instructors focus primarily on clinical responsibilities and lack formal pedagogical training.

Inconsistent evaluation standards

Although a multi-level assessment system is in place, the emphasis often skews toward theoretical knowledge, with less focus on clinical reasoning or decision-making. Regional inconsistencies in evaluation practices further impact fairness and reliability.

Future directions

Strengthening training bases

Invest in infrastructure and faculty at grassroots institutions.

Foster partnerships between tertiary hospitals and community facilities.

Implement regular audits and dynamic evaluation systems to maintain training quality.

Curriculum modernization

Regularly update content to reflect cutting-edge technologies and clinical practices.

Integrate multidisciplinary learning to encourage broader clinical thinking and collaboration.

Faculty development

Establish structured faculty development programs focused on teaching methodologies.

Promote innovation in education through pedagogical research and problem-based learning.

Assessment reform

Align assessments with practical decision-making and clinical integration.

Standardize evaluation criteria and ensure fair implementation nationwide.

Technology integration

Develop digital platforms for training, assessment, and resource sharing.

Leverage telemedicine and e-learning to enhance flexibility and accessibility.

Conclusions

Over the past decade, standardized training for laboratory medicine in China has achieved significant progress by cultivating a highly skilled and clinically relevant workforce. At present, China's standardized residency training is still undergoing continuous improvement, drawing inspiration from mature systems abroad. Such as, similar to Europe's competency-based training frameworks and Australia's emphasis on workplace-based assessments, China has gradually strengthened formative and summative evaluation, clinical rotations, and competency requirements. However, there are also differences in the length of training, rotation models, and assessment methods across countries. For example, Europe and Australia often include more emphasis on supervised subspecialty training pathways and board examinations, while China places strong focus on bridging laboratory practice with direct patient care through extensive clinical rotations. After completing the three-year standardized training for resident physicians (a national requirement), the clinical laboratories of various hospitals will conduct another three-year training that is more detailed and specialized. This is another training system. For instance, for physicians specializing in laboratory biochemistry, it will enable them to become more proficient in biochemistry. Addressing these challenges through systemic reforms in infrastructure, curriculum, faculty development, evaluation, and technology will be essential for elevating training quality and sustaining the discipline's growth.

Research ethics: This study was approved by the Ethics Committee of the Peking University People's Hospital according to the ethical guidelines of the Declaration of Helsinki (1975).

Informed consent: Informed consent was obtained from all the participants.

Author contributions: Shanshan Li and Shujing Liang drafted the manuscript. Hui Wang and Hongbin Chen provided critical revisions. All authors reviewed and approved the final version. Shanshan Li serves as the guarantor for the overall content.

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