Challenges to laboratory hematology practice: Egypt perspective

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Abstract
Laboratory hematology is an integral part of all clinical laboratories along the extensive healthcare facilities in Egypt. The aim of this review is to portrait the laboratory hematology practice in Egypt including its unique socioeconomic background, blood disease pattern, education and training, regulatory oversight, and the related challenges. Current practice varies widely between different parts of the healthcare system in terms of the range of tests, applied techniques, workforce experience, and quality of service. The national transfusion service (NBTS) in Egypt has been recently upgraded and standardized according to the World Health Organization (WHO) guidelines. Formal postgraduate education roughly follows the British system. Laboratory hematology specialization is achieved through 2-3 years masters’ degree followed by 2-4 years doctorate degree in clinical pathology with training and research in hematology. Improvement of laboratory hematology education is recently undergoing a reform as a part of the modernization of higher education policy and following the standards developed by the National Quality Assurance and Accreditation Agency (NQAAA). Accreditation of medical laboratories is recently progressing with the development of the “Egyptian Accreditation Council” (EGAC) as the sole accreditation body system and training of assessors. Current laboratory system has many challenges, some are related to the inadequate system performance, and others are unique to laboratory hematology issues. The rapid technological advances and therapeutic innovations in hematology practice call for an adapting laboratory system with continuous upgrading.

KEYWORDS
laboratory hematology, Egypt laboratory practice, Egypt laboratory challenges, laboratory hematology education

INTRODUCTION

The role of the laboratory hematology extends throughout the patient care ranging from simple screening to advanced investigations in 3ry care service. It also involves services outside the laboratory including blood transfusion and bone marrow transplantation. Hematology laboratories also contribute to national public health programs targeting blood disorders and to specialized centers that provide integrated care for prevalent hematological disorders requiring multidisciplinary service and specialized experience.

Technological advances in hematology and the development of personalized medicine have increased the reliance on laboratory data and changed the role of the laboratory from a testing facility to a partner in health care. However, this is particularly challenging in resource-limited countries.

The aim of this review is to portrait the laboratory hematology practice in Egypt with its unique socioeconomic background, disease pattern, education and training, and regulatory oversight, together with the related challenges.
1.1 | Overview of current laboratory hematology practice in Egypt

1.1.1 | Organization of laboratory hematology service within the healthcare system

Laboratory hematology is an integral part of all clinical laboratories throughout the extensive healthcare system. The type of service provided, in terms of the range of tests, techniques, workforce experience and quality varies widely between different parts of the system, being generally more advanced in University Hospitals, large private laboratories, and specialized care centers than in government hospitals and primary care units.

1.1.2 | Laboratory hematology service in public health programs

National health programs involving laboratory screening for prevalent hematological disorders are frequently implemented often through collaborative projects with international agencies.

An outline of the common programs is given in Table 1.1,2

Although many of the communicable diseases in Egypt have been controlled, it is important to maintain training and laboratory capacity for their adequate diagnosis to ensure sustained control, especially in high-risk areas.3

1.1.3 | Specialized laboratory hematology services

Some blood disorders are particularly challenging to diagnosis, requiring a high level of expertise or an advanced technology not available in general laboratories. Others have a special public health concern due to high prevalence, serious consequences, or preventability.

Patients with these disorders are often first encountered in general hematology facilities and are ultimately referred to specialized centers, including stand-alone, specialized university departments, and private centers. Important examples of specialized hematology services include oncology, genetic diseases, blood transfusion, and hemopoietic stem cell (HSC) transplantation centers.

Hematologic malignancy laboratory service

The estimated incidence of hematological malignancies in 2013 was 5929/100 000 population, with NHL as the most frequent (5241/100 000 population and anticipated increase to 13 884 by 2050).4

The diagnosis of hematological malignancy is often provisionally made in general laboratories and patients are finally referred to a university or a specialized hospital for a comprehensive diagnosis including immunophenotyping, cytogenetic, and molecular tests, with some variability in capacity and expertise.

However, diagnosis is frequently delayed which could affect patient care. In a study of pediatric oncology patients at a large university hospital in Egypt, Abdel-Mabood reported an initial mis-diagnosis of referred patients with a median total delay of 37 days. These findings alert to the need for increasing the diagnostic yield of general hematology laboratories especially in remote areas.5

Many large oncology centers with advanced facilities are developed in Egypt, notable examples include the National Cancer Institute (NCI), with affiliated centers in some governorates and a newly established facility, oncology departments in all public universities, the Children Cancer Hospital Foundation-Egypt (57357) (CCHE) which also provides a fellowship training and cancer

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TABLE 1  Laboratory hematology role in some common public health programs

| Disorder | Laboratory hematology service | Diagnostic challenges |
|----------|-------------------------------|-----------------------|
| Micronutrient screening programs: Iron deficiency is the commonest cause of anemia with 30% prevalence | Tests are widely available: iron profile, automated full blood count with red cell indices | Subclinical and mild deficiency may be missed with inadequate experience |

Communicable blood disorders

| HIV: currently has a low prevalence (<1%) <0.1%. Program continuing to maintain control | 100% testing of collected blood |
|-----------------------------|-----------------------------|

Malaria: Currently controlled, and maintained in “the prevention of reintroduction phase” of the control program. Small high-risk foci, for example, “Al-Fayoum governorate” are present.

| Adequate malaria microscopy and Rapid tests | Sensitive molecular screening using 18 S ssrRNA Plasmodium gene.2 | Malaria is inadequately diagnosed in common hematology laboratories due to insufficient experience, especially for new laboratory hematologists. This is critical with low parasite load and subclinical infection and requires building experience with malaria microscopy and recent sensitive techniques especially for those working in high-risk areas |

Neglected tropical diseases: Cutaneous Leishmaniasis: Residual small endemic foci of cutaneous leishmaniasis are still present in Sinai

| Microscopic diagnosis | Diagnosis can be easily missed by inexperienced hematologist and with low parasite density |
research, and Fakkous Center for Cancer and Allied Diseases in the delta region (http://egyptcancernetwork.org/about/our-partners/fakkous/), etc.

In addition, the NCI has established a comprehensive National Cancer Registry Program which has 4 associated peripheral registries and plays an important role in cancer epidemiology studies in Egypt.4

Genetic and hereditary blood disorders service
Hereditary hematological disorders are the second common hereditary diseases in Egypt with an estimated frequency of 18.48%.6,7 Diagnosis may be suspected in 1ry and 2ry pediatric clinics or hospitals and patients are often finally referred to a university specialized pediatric clinic, a genetic center, or a specialist private pediatric clinic. A common problem in diagnosis of genetic disorders is the substantial delay in referral due to inadequate experience and complexity of many genetic disorders. The Organization of genetic centers and the diagnostic service provided are outlined in Figure 1. Some advanced molecular techniques may not be available at some centers due to lack of advanced technology and/or special experience, in addition to the incurred costs.

An overview of the current status of the common hereditary blood diseases practice is given in Table 2.8-14

In addition to the regular service, support is also provided by other organizations, for example, the Egyptian thalassemia association (ETA), the Egyptian Red Crescent (ERC), and the National Hemophilia center.

The economic burden of some hereditary disorders is enormous as to warrant national prevention plan and improvement of diagnostics. For example, the estimated average management cost of thalassemia is about $10 million/year and is on the increase.10

Specialized genetics certification in universities and integration of genetics into the mainstream of clinical practice were suggested to enhance early identification of cases.8

The successful model of thalassemia control in some Mediterranean countries, for example, Cyprus which reduced the carrier rate from 14% to only one child/year mainly through a national premartial plan is worth trying in Egypt.

Blood transfusion service in Egypt
The Ministry of Health and Population (MOHP) policy for blood transfusion service was implemented since 2007 to ensure safety and adequacy of the blood supply as an integral part of the national healthcare system, with all blood banks regulated and financed by the MOHP.15 The ERC also supports transfusion service and has 5 transfusion centers across Egypt including a special pediatric center. Blood banks are distributed across different health facilities including MOHP Hospitals (>250 facilities), Specialized Medical Centers, Teaching Hospitals, Curative Care Hospitals, Health Insurance Organization Hospitals, and the Egyptian Company for Production of Vaccines, Sera, and Drug (VACSERA. http://www.vacsera.com/).16

The national transfusion service (NBTS) in Egypt is divided into 12 regions, each having 1 or more regional transfusion center (RTC) (totally 10 large and 7 small) in addition to 6 district blood banks (DBB) serving remote areas and overseen by regional centers.

The NBTS follows standards and procedures of the WHO and relies mainly on voluntary nonremunerated donations.17 Collected blood constitutes only about 30% of the country requirements with an estimated total of 1.21% of the population in 2011, barely reaching the minimum 1% needed to meet the basic needs.18 In a recent comprehensive situation analysis of blood transfusion services in 18 Eastern Mediterranean countries, the WHO (2017) reported variable
| Genetic disorder Group | Disease type | Estimated prevalence | Diagnostic facilities | Current diagnosis | Diagnostic challenges | Standard Diagnostic care Requirements | Prevention measures |
|------------------------|-------------|----------------------|-----------------------|------------------|----------------------|---------------------------------------|-------------------|
| Thalassemia and hemoglobin disorders | β-Thalassemia | >1000 new cases/yr, Carrier rate 9-10%, Gene frequency 0.03 | University hospitals, National Research Center, private laboratories, School Medical Insurance Hospitals, Ministry of Public Health (Medical Council), MOHP (792) thalassemia care centers | Automated full blood count, cell morphology, iron profile, general hemolytic tests, hemoglobin analysis (electrophoresis, HbA2 micro-column chromatography, HPLC, capillary electrophoresis in few centers. Molecular testing is for 1ry family diagnosis using e.g. ARMS-PCR technique | Difficult implementation of service within the public health system, lack of public awareness of the specific service, unavailability of genetic services in many governorates, costs, and lack of insurance coverage for many patients | 1. Early diagnosis and treatment to avoid complications 2. Routine molecular diagnosis for all cases | Voluntary individual prevention including: 1. Limited premarital screening 2. Early neonatal screening | Highlight importance of countrywide epidemiologic studies and possibility for targeted prevention program |
| | α-Thalassemia | Carrier rate 9.25%, Gene deletion frequency 0.08 | | | | | |
| Sickle-cell disorders | Overall 2%. Small foci, for example, Siwa Oasis has 18% carrier rate and 6% disease rate | | | | | | |
| Hereditary bleeding disorders | Hemophilia A | 6.26% | | | | | |
| | Others | | | | | | |
| Rare hereditary disorders | Gaucher disease (mainly type II) | 10 968 patients registered at Cairo University Children Hospital | Variable diagnostic accuracy in general hematology laboratories. Confirmed diagnosis is mainly in advanced hematology laboratories | Microscopic, Enzyme assay in some centers, Genotyping in special cases and in research | Delayed diagnosis at primary centers and in referral | Early diagnosis to avoid complications and improve therapeutic outcome which is currently available in Egypt | None |
| | Inherited bone marrow failure syndromes and cancer susceptibility | Very limited data. At Cairo University pediatric clinic, they represent about 25% of all aplastic anemia cases | Confirmed diagnosis is only available in specialized experienced centers | Based mainly on the exclusion of acquired etiology and few basic tests, for example, karyotyping, chromosomal breakage, metabolic tests | Awareness of the disease complexity and early suspicion Complete genetic testing using available panels for common mutations and sequence analysis for unknown mutations | 1. Lack of comprehensive genetic testing 2. Lack of adequate experience 3. High costs of complete test panels 4. Inadequate data about common genetic abnormalities | None |
gaps in key elements of the blood transfusion system. A summary of the main findings in Egypt in 2013 is outlined in Table 3.

**Hemopoietic stem cell transplantation (HSCT) service**
The overall transplant rate in Egypt is about 2.8 per million. Financial constraints and adequate professional experience are the main challenges for the expansion of this service. The average cost of a single transplant in Egypt is about 15 000 USD which is currently covered by the MOHP and medical insurance.19 Transplantation centers with specialized laboratories are developed in Governmental facilities, university hospitals, and some oncology centers.

Cord Blood (CB) banking is a promising source of stem cell transplantation SCT in Egypt and other Arab countries,20 with some implementing related policies including Egypt. Currently, there are 7 banks, mostly private. They are also regulated by the MOHP based on international regulations and are overseen by the National Blood Transfusion System.15

A National Stem Cell Committee was initiated in 2011 by the MOHP to establish regulations for research and therapy. Some stem cell research centers have been established, for example, in few public universities and in “Zewail City of Science and Technology”.21 The latter is also partnering with Assiut University for a public CB bank establishment in Upper Egypt. However, public CB banking in Egypt is limited due to the high costs incurred, estimated by one private bank as an initial $1600 fee and $140 annual maintenance/unit.22 Some biological factors in the Arab region may favor the support of regional public CB banking especially public- and family-directed donation programs, including the common genetic background.11

Establishing national CB registries and regional networking could be an economical solution for countries with limited resources.23,24

### 1.2 Laboratory hematology education, training, and licensure

Formal postgraduate education in Egypt roughly follows the British system except for the specialty diploma before a masters’ degree in the UK. Career progression in academia is closely tied to these qualifications. Further specialization in the MOHP is established

| Item | Criteria | 2013 |
|------|----------|------|
| Number of blood centers | | |
| Stand-alone | 24 |
| Hospital-based | 70 |
| Total | 94 |
| Estimated % of blood donations | 33% |
| Voluntary nonremunerated donations (VNBD) | | |
| Total | 272 829 |
| Paid donation | 150 194 |
| Screening donated blood for transfusion-transmissible infections (TTIs) | | |
| HV1 + 2 | Antibody and antigen (enzyme-linked immunosorbent assay (EIA) and nucleic acid amplification test (NAAT)) |
| HBV | HBs antigen, anti-HBc antibody |
| HCV | Antibody and antigen (enzyme-linked immunosorbent assay (EIA) and nucleic acid amplification test (NAAT)) |
| Syphilis | Yes (enzyme-linked immunosorbent assay (EIA)) |
| Malaria and Chagas disease | No |
| Blood centers performing laboratory screening of blood donations 2011-2013 | | |
| Total number | 28 |
| Number participating in the EQAS for TTI | 17 |
| Proportions of donations screened for TTI | % | 100 |
| Component preparation 2011-2013 | | |
| Number of centers | 24 |
| The proportion of donated whole blood | 99.8% |
| Clinical use (2011-2013) | | |
| Number of governmental hospitals performing a blood transfusion | 400 |

**TABLE 3** Key elements of the Egyptian National Blood System (2013) (Summarized from the WHO report, 2017)18
Laboratory pathology, specialization is achieved through 2-3 years masters’ degree followed by 2-years doctorate degree in clinical pathology with training and research in hematology. In addition, professional subspecialty certification programs are offered by many universities, for example, the professional transfusion medicine program at Cairo University. An analogous blood transfusion diploma is administered by the MOHP. However, an important constraint for graduate laboratory training is the limitation of resources, especially with the advanced technology.

Currently, continuous professional development (CPD) is optionally provided by many organizations including; medical schools, the Egyptian Medical Syndicate (EMS), national hematology organizations e.g. (the Egyptian Society for Laboratory Medicine-ESLM, the Egyptian Society of Hematology, the Egyptian Society for Hematology and Research, the Egyptian Thalassemia Association, Egyptian Committee for Pathology Training working in partnership with the Royal College of Pathologists, etc. as well as international organizations. Another channel for experience in laboratory hematology is the increased interaction in international settings through conferences, short training visits, partnership with international societies, and mentorship programs offered by many international universities and professional associations.

On the other hand, only few training channels are available for laboratory technicians. One eminent program in Egypt is the "Certified Medical Technologists" provided by the American University in Cairo and accredited by the American Society of Clinical Pathology (ASCP). Graduates can optionally complete the international certification. However, this is considered an expensive option for many technicians. Recently, few private universities developed a college degree in health science. Technologist training, however, is still inadequate.

The main findings of the UK general medical council (GMC) report comparing medical regulatory systems of 10 countries including Egypt are summarized in Table 4.26

Improvement of laboratory hematology education is a recent endeavor developed as a part of the modernization of higher education policy and follows the national standards developed by the National Quality Assurance and Accreditation Agency (NQAAA). This agency is currently being evaluated as a national accreditation body as a step for national universities accreditation.28

1.3 Laboratory hematology service regulation and quality

The Egyptian Accreditation Council (EGAC) is the sole accreditation body in Egypt initiated in 2006 and is currently a member of the International Laboratory Accreditation Cooperation (ILAC) and the International Accreditation Forum (IAF). It is also recognized by the Arab Accreditation Council (ARAC) and the African Accreditation Council (AFRAC). In the medical laboratory system, EGAC is responsible for setting up the evaluation system for assessment bodies, issuing accreditation certificates, maintaining continuous surveillance of accredited bodies and upgrading their services according to the international criteria, encouraging the exchange of experience among different bodies, and representing the state in international activities. Currently, the EGAC accreditation scope covers: Testing and Calibration Laboratories (ISO/IEC 17025), clinical Laboratories (ISO 15189), Certification Bodies (QMS, EMS, FSMS) ISO/IEC 17021, and Inspection Bodies (ISO/IEC 17020).20

A collaborative project with the British Standards Institute (BSI) and the Swedish Board for Accreditation and Conformity Assessment (Swedac) "Building the capacity of the EGAC to deliver accreditation services” assisted EGAC in training assessors. The agency also collaborated with the Society for Promotion of Quality Assurance in Medical Laboratories, e.V. “INSTAND” of Germany to develop a proficiency testing programs based on EQAS (External Quality Assessment Services).35

Although laboratory accreditation is not currently a regulatory mandate, 27 governmental laboratories were certified at 2017 and an increasing number in other sectors. Moreover, university hospitals are currently funding projects for accreditation of hospital laboratories. Through 2017, a number of Cairo University Hospital laboratories have been ISO 15189 certified including the central chemical pathology laboratory, the main microbiology laboratory, and 2 specialized laboratories; molecular biology and bone marrow pathology. The central general hematology laboratory is currently being prepared.

According to ISO 15189 standards, all pathological results are verified by a competent professional. Comparable to most countries, in Egypt, a medical staff is responsible for this step and also for communicating results with the clinician.

1.4 Research in hematology laboratories

Research in universities and academic centers laboratories in Egypt is mostly applied and includes graduate student thesis and investigator-initiated research. The later includes small laboratory studies and large projects supported by national and international grants. Most studies involve hematology clinical diagnostic or prognostic parameters while very limited research involves laboratory hematology practice performance or standards.

Clinical investigations of industry-sponsored clinical trials are often performed in the hosting institute or other large laboratories in Egypt, while more advanced studies including genetic and pharmacogenomics studies are conducted in the sponsor’s central laboratory.

All institutes and research centers in Egypt have implemented research regulations systems.

Initiatives for research promotion are proposed by governmental and nongovernmental agencies, for example, increased national research funding, and collaborative agreement with international academic centers and organizations. Research capacity building, researcher training, and technology transfer are some of the themes of recent grant calls. In addition, universities also promote quality
**TABLE 4** Comparison of regulatory aspects of Medical Education and Licensure in 10 countries (modified from the GMS report, 2009)\(^{27}\)

| Item | Description | UK | Egypt | Germany | Greece | India | Italy | Nigeria | Pakistan | Poland | Spain | South Africa |
|------|-------------|----|-------|---------|--------|-------|-------|---------|----------|--------|-------|--------------|
| Regulatory structure | Centralized | + | + | + | + | + | + | + | + | + | + | + |
| | Decentralized | | | | | | | | | | | | |
| Registration/licensure | Separate | + (MOHP, EMS) | + | + | + | + | + | + | + | + | + | + |
| | Combined | + | + | + | + | + | + | + | + | + | + | + |
| Type of registrations | Once for life | + | + | + | + | + | + | + | + | + | + | + |
| | Renewable | + | + | + | + | + | + | + | + | + | + | + |
| Revalidation | No | +\(^a\) | + | + | + | + | + | + | + | + | + | + |
| | Yes | + | + | + | + | + | + | + | + | + | + | + |
| Regulatory and QA bodies | Single | + | + | + | + | + | + | + | + | + | + | + |
| | Shared by: medical councils, local authorities, ministries of health/education | + | + | + | + | + | + | + | + | + | + | + |
| Activities: | Variable between countries (curricula, entry examinations, issuing degrees, inspections of and issuing accreditations to medical schools, and other duties. Egypt\(^c\)) |
| Continuous professional development (CPD) Yes | + | + | + | + | + | + | + | + | + | + | + | + | + |
| No | +\(^e\) | + | + | + | + | + | + | + | + | + | + | + | + |
| Number of GMC registrants | - | 2755 | 3672 | 1682 | 26589 | 1731 | 3192 | 7340 | 1937 | 1082 | 7167 |

\(^a\)Countries developing their revalidation systems.

\(^b\)Except small autonomous areas.

\(^c\)Currently setting of curricula is the preserve of individual medical schools with growing calls from international bodies, for example, the World Health Organization (WHO) to centralize some of the functions of medical education.

\(^d\)CPD is primarily by random audits of about 10% of all doctors/yr to check compliance with the South African CPD requirements.

\(^e\)A proposed system by the MoHP is based on credits points.
| Challenges                                                                 | Main impact                                                                 | Possible solutions                                                                                                                                 |
|---------------------------------------------------------------------------|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Lack of local practice standards which have some differences from the western | Unrealistic reference ranges and critical thresholds for the local population | Large population studies to develop national standards                                                                                             |
| 2. Lack of nationally developed cost-effective diagnostic guidelines.      | 1. Incomplete diagnosis in some cases  
2. High diagnostic error rate.  
3. Inconsistent selection of available diagnostic tests | 1. Development of real-world evidence guidelines involving cost-effectiveness measures to optimize context-tailored guidelines without compromising diagnostic outcome |
| International guidelines with large panels may not be feasible due to financial and/or technical limitations |  |  |
| 3. Inadequate experience and/or diagnostic capabilities for some diseases, for example, complex genetic disorders and some hematologic malignancies | Incomplete diagnosis and suboptimal patient care and outcome | 1. Building and updating professional experience to the identified diagnostic gaps  
2. Directing funding to capacity building of deficient areas |
| 4. Inadequate data on the real magnitude and demographics of some disorders due to inadequate data collection and population-based epidemiologic studies | Poor planning of screening and preventive measures of some diseases, for example, high prevalence disorders as thalassemia | 1. Promoting population-based epidemiologic studies and data collection  
2. Building disease registries and biorepositories especially for rare and complex genetic disorders |
| 5. Delayed development of technical and professional expertise comparable to the rapid advances in laboratory and analytical technology | Progressive loss of diagnostic competence relative to the therapeutic needs of modern hematology practice | Expanding the scope of specialty training and promoting continuous professional updating and competency revalidation |
| 6. Inadequate laboratory-clinician communication and collaboration which is essential in modern hematology practice | 1. Delayed diagnostic process  
2. Possible misinterpretations of diagnostic test | 1. Implementing regular communication channel in routine work, for example, timely case review meetings or one to one case discussion  
2. Use of modern communication technology to enhance collaboration |
| 7. Increased referral of cases to 3ry and specialized hematology laboratories due to inadequate diagnostic capacity at lower care levels which overloads resources at referral centers | 1. The high workload at referral centers  
2. Increased diagnostic errors  
3. Delayed patients diagnosis  
4. Overutilization of resources at referral sites | 1. Promoting diagnostic capacity and competency at 1ry and 2ry care laboratories  
2. Enhancing consultation and communication between different levels of care with the use of innovative technology such as digital pathology platform which could facilitate microscopic diagnosis, consultation, quality control and teaching, especially with the recent FDA approval, and CAP recommendations  
3. The system could also provide other capabilities, for example, development of algorithms and research resources |
| 8. Limitation of using reflex testing without a clinician order due to reimbursement issues | 1. A delayed patient diagnosis which could have a serious implication  
2. Redundant use of laboratory tests due to inconsistent test selection. | 1. Building consensus about common disease diagnostic flow and test ordering between laboratory experts and clinicians |
| 9. Limited utility of POC due to:                                         | 1. Delayed diagnosis in cases which might need a prompt service  
2. Waste of resources when complex test process is used for initial patient triage instead of a rapid simple screening. | 1. Identifying and limiting use to specific indications with a prior calculation of cost-effectiveness  
2. Personnel training, with the exact test to apply with regular oversight  
3. Ensuring prompt verification and transfer of results, otherwise, it will not be of value |
| i. Not cost-effective  
ii. Noncompliance and overload of nonlaboratory staff  
iii. Poor information system  
iv. Inappropriate indication, for example, bypassing central laboratory process, or convenience |  |  |
| 10. Inadequate number and expertise of advanced laboratory technicians    | 1. Increased diagnostic errors and technical faults  
2. Delayed and sometimes inefficient laboratory processes | 1. Promoting laboratory technologist formal education programs especially in public universities  
2. Continued training programs for laboratory technicians  
3. Incentivizing technician education updating |
research and international publications through funding international publications, conferences travel, and postgraduate research.

1.5 | Challenges to laboratory hematology practice in Egypt

Current laboratory system in Egypt is challenged with many roadblocks which impede adequate performance in relation to the range and nature of the population health status and disease burden. Furthermore, the rapid advances in diagnostic technology and novel therapeutics increase the demand for a rapidly adapting laboratory system with continuous upgrading of methodology and expertise. In addition, laboratory hematology and hematopathology diagnosis is a complex multifaced area which requires the integration of many technologies and diagnostic skills.

The previous discussion of the laboratory system organization, services provided and disease patterns in Egypt, point to some general challenges that could adversely impact hematology diagnosis. In addition, the capacity for hematologic diagnosis has its unique difficulties that could compromise performance and impede future advancement in laboratory hematology. A simple analysis of the main challenges in laboratory hematology practice is given in Table 5.

However, assessment of the real magnitude of these problems needs more accurate evaluation in large quantitative studies to develop appropriate evidence-based improvement plan.

It has been recommended by Futrell that improvement in a limited number of critical laboratory issues will produce a great impact on the whole system performance which is worth considering in resource-limited countries. The most important of these issues are:

1. Eliminating waste which can save up to 30% of total healthcare spending
2. Monitoring test utilization and developing “Best-practice” ordering guidelines to reduce redundant testing, save laboratory resources, and provide appropriate test orders. Effective utilization of laboratory services will also reduce diagnostic errors.
3. Use of diagnostic algorithms for appropriate test selection.
4. Integration of point-of-care (POC) tests in a cost-effective way to certain critical tests.

2 | CONCLUSION

The laboratory hematology service in Egypt ranges from simple screening in primary care to routine disease investigations in general hematology laboratories to advanced specialized tests in large laboratories and specialized centers. The infrastructure, quality, and expertise of the service vary widely between different sectors and laboratory types being generally more advanced in university hospitals, large private laboratory corps, and specialized centers than in government hospitals and primary care units. In addition to routine investigations, the hematology laboratory participates in screening and prevention programs for some blood disorders with public health concern, for example, the highly prevalent nutritional iron deficiency, and common hereditary diseases such as thalassemia.

Specialized centers with advanced hematology laboratories and experienced consultants provide diagnostic service to patients with certain blood disorders that are particularly challenging to diagnosis, have a high prevalence, serious consequences, or are preventable. These centers are also important resources for epidemiologic data and disease registries and contribute to building the required specialized laboratory workforce. The population characteristics and hematologic disease pattern are important considerations in service planning and resource deployment.

A policy to ensure safety and quality of blood transfusion service in Egypt was implemented since 2007 in collaboration with the WHO with a measurable improvement according to the set criteria including, 100% screening for infectious diseases using stringent test techniques, better oversight and management of transfusion facilities, and training of the specialized workforce, etc. An important challenge in Egypt is the low voluntary donation rate which is still below the expected for the country needs. The HSC transplantation service and cord blood banking are similarly regulated by the MOHP.

Laboratory hematology education and training are essential elements of a quality service. Formal postgraduate education is currently undergoing a major reform as a part of modernization and future accreditation of higher education in Egypt.

Accreditation of health laboratories in Egypt is progressing with the initiation of the “Egyptian Accreditation Council” (EGAC) as the sole accreditation body, training of assessors, and preparation for ISO 15389 accreditation in many laboratories both governmental and private.

The hematology laboratories, mostly in universities and academic centers, are involved in applied clinical research with very sparse research on laboratory practice or test evaluation and almost no basic research.

Many challenges are currently facing laboratory hematology practice in Egypt. Laboratory hematology and hematopathology diagnosis is a complex multidisciplinary area which requires the integration of advanced technologies and diagnostic skills and close collaboration with clinicians. Inadequate expertise in selecting diagnostic pathways and decisions will adversely affect patient care. Furthermore, the rapid advances in diagnostic technology and novel therapeutics increase the demand for a rapidly adapting laboratory system with a continuous upgrading. Overcoming these hardships and facilitating the cost-effective seamless integration of laboratory hematology into the healthcare system requires an overlook and collaboration of all stakeholders.

3 | FUTURE PERSPECTIVES

The reshaping of hematology practice in the recent era of technology evolution and innovative therapeutics require reconsideration of the architecture and scope of medical laboratories. Hematology is a part of the laboratory which may be especially affected by the
modern practice changes, requiring a laboratory hematologist to be a partner in healthcare decisions. The evaluation of a laboratory test is wider than its performance criteria but also embraces its impact on the patient care and outcome. The concept of the laboratory hematology profession similarly needs to transform and keep in tune with the changing field. Laboratory professionals and scientific associations have a central role in changing the traditional view to healthcare laboratories.

The recent global initiative for Sustainable Development emphasized universal health coverage by 2030 in low- and middle-income countries as a central development focus. Achieving this goal will require planned strategic improvement of the laboratory system as an indispensable element of the healthcare system as discussed in a series of articles\(^{38-40}\). The authors identified 4 critical barriers to adequate laboratory performance namely workforce, infrastructure, education and training, and quality assurance. A global framework for their solution was recommended to be integrated within a nationally tiered laboratory system, together with crucial high level actions for deployment namely a national strategic laboratory plan, adequate financing, and a leadership role to advocate for laboratory centrality. However, this proposal is not a "one solution fits all," but should be tailored to individual country contexts based on adequate local needs assessment. It was also emphasized that improvement in a single issue would not be effective in absence of other components. It could be a promising start for improving laboratory hematology system in Egypt but will require long effort and collaboration of all stakeholders.

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