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Shaping the future of medical laboratory practices in Somaliland: a review of the current standards

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Abstract

Medical laboratory science has an acknowledged pivotal role in evidence-based practices and patient-centered care, informing clinical decision-making for precise diagnosis and treatment. Laboratory practices' advancements in sub-Saharan Africa indicate several challenges and limitations, where progress remains slow, hindered by limited accredited laboratories, weak governance, and inadequate national health policies. This review presents the current status of medical laboratory practices in Somaliland, emphasizes the urgent need for reform and adherence to international standards, and provides actionable recommendations for transforming the healthcare system. While strides have been made toward aligning laboratory practices with international standards, inadequate compliance underpins challenges in Somaliland's medical laboratory practices, highlighting suboptimal management performance and the urgent need for adherence to international benchmarks that fit Somaliland's laboratory landscape and the gap that pertains. This review discusses the Total quality management (TQM) approach, emphasizing a dual focus on quality of management and management of quality, which is vital for ensuring reliable, high-quality services. While compliance with international standards demonstrates significant outcomes, quality management is the key role guiding this compliance and ensuring service quality. Findings demonstrate that quality management and efficient leadership are critical for a successful pre-accreditation and post-accreditation process, indicating the dual focus as the main strategy to ensure Somaliland's medical laboratories meet global standards of excellence in terms of diagnostic accuracy, operational efficiency, patient outcomes, resilience and sustainability. Finally, effective compliance with international benchmarks that promote the quality management and management of quality standards can ensure the implementation of the dual focus and maintain TQM. International collaboration are necessary for knowledge sharing, resources, and guidance as current practices' data and information available. Consultation for effective compliance is highly recommended to navigate the challenges of simultaneously considering and implementing the proposed dual focus to obtain accreditation. It promotes continuous evaluation to achieve the targeted improvements and growth.



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Keywords Medical laboratory, Somaliland, Diagnosis, Laboratory accreditation, Quality management

Article highlights

Challenges, constraints and limitations that medical laboratories face in Somaliland and how compliance to international standards represented as a key solution as a comprehensive approach in addressing the complexities and challenges persist. Evaluation on the existing frameworks of standards internationally and recommendations for new as comprehensive frameworks matching the context of Somaliland with applicability to be adopted; where Total quality management (TQM) can be ensured in medical laboratory practices.

Discussion on local prudent financial options to minimize over-reliance on international aid and funding; in addition to guidance and recommendations for strategic implementation and accreditation maintenance; ultimately transforming the healthcare system with optimized services and better delivery in term quality, accuracy, reliability, availability and accessibility for optimal outcomes.

1 Introduction

The healthcare system is a collaborative field where each aspect mutually influences the other based on the practices pertained. Patient-centered care has recently been accepted internationally; thus, medical laboratories have become increasingly vital in ensuring quality healthcare services and delivery. This acceptance promotes the role of medical laboratory science as a pivotal and fundamental aspect to function as a focal point between clinicians and patients to foster collaborative healthcare [1]. Evidence-based practices play an essential role in all clinical decisions and are critically relevant to the quality of healthcare services [2]. The importance of medical laboratories in evidence-based practices is represented by their role in embracing new sources of information and communication with each stakeholder group, clinicians, and patients for knowledge management, provision of educational information, and support [1, 3]. Clinical experts and physicians from the US and Germany, including oncologists and cardiologists, identified a significant contribution of diagnostic procedures for patient management, demonstrating the role of laboratory diagnostics as essential to patients' management and decision-making with a significant role in medical practices. Approximately 66% of decision-making is based on in vitro diagnostics [4]. While 70% of clinical decisions are influenced by medical laboratory output, this percentage still indicates the importance of medical laboratories in fostering decision-making via evidence-based practices [2]. However, advanced technologies such as artificial intelligence (AI) and machine learning (ML) have become substantial globally in the medical laboratory field, which highly improves decision-making. Medical laboratory practices have evolved in sub-Saharan Africa (SSA) as well, but mainly in a slower mode of progress than countries in the West since the integration of these technologies is a challenge [5].

In contrast, most countries in SSA do not have sufficient accredited laboratories. In 2014, A survey showed the existence of 380 accredited laboratories, whereas 91% of them are located in South Africa, and 9% were distributed among 11 countries, including Kenya, Namibia, Botswana, Uganda, Ghana, Nigeria, Ethiopia, Mali, Mauritius, Tanzania, and Zimbabwe [6]. The reason for having only a few accredited laboratories in

this region is the existence of a standard gap that compromises the implementation of healthcare policy initiatives. In 2017, an analysis study of national health policies and plans valid throughout and beyond 2010 across 39 countries in SSA revealed that key factors contributing to the scarcity of reliable, accurate, and accredited diagnostic laboratories include misalignment between policies and plans, underdeveloped financial strategies and monitoring frameworks, lack of reference points to identify gaps and shortages, and inadequate governance structures [7]. It further showcased that suboptimal performance in compliance with national and international standards hinders policy implementation. While these countries have barriers to effective healthcare represented by clinical misdiagnosis, limitations within laboratory capability, weak diagnostic accuracy, and inadequate healthcare infrastructure, laboratory infrastructure suffers the most from not being prioritized within the healthcare systems to be addressed. Most healthcare professionals; including physicians, policymakers and decision-makers, fail to realize the importance of prioritizing and allocating more resources for medical laboratories to provide effective healthcare, as many claim for more resources to help prevent and treat complex healthcare challenges that persist [8]. In 2025, a study aimed to analyze the capacity of national tiered laboratory network from 14 countries in SSA found that only 675 (1%) out of 53,000 laboratories are equipped for bacterial testing, where less than 50% of population in seven countries having accessibility to antimicrobial susceptibility testing (AST). Whereas 87–88% of these laboratories have access to basic utilities like power and water, only 23% are ISO15189 accredited, and just 13% are using electronic information systems; indicating a significant gap in the quality and readiness. The study demonstrates that only 20% of the proposed interventions in 12 out of 14 national action plans were implemented to strengthen laboratory's capacity; indicating a lack of prioritization and investment in laboratory capabilities [9]. Conversely, national reference and private laboratories tend to perform better in terms of AMR readiness compared to district and government laboratories, which intend to serve a larger portion of the population [9, 10]. Accordingly, this disparity highlight that the lower-tier laboratories are particularly under-resourced.

The three strategies to unlock the potential of healthcare services in SSA doesn't promote the prioritization of laboratories to be allocated with resources in the approach provided. As reported by World Bank Blogs in 2023, this approach promotes resources allocation that offer substantial value such as cost-effective interventions, immunizations and task-shifting from doctors, nurses and community health workers to be prioritized by policymakers first. The report claims the need by governments to employ the provided approach to increase funding and investment, indicating the lack of resources as a major issue need to be primarily addressed [11]. However, the lack of sufficient public funding to laboratory facilities also includes lack of awareness on prioritizing and allocating resources for laboratory.

A systematic review demonstrates a significant portion of healthcare financing in SSA relies on direct-out-of-pocket payments, which is more than 30% of total health expenditures in many countries [12]. The reason behind the absence of adopting efficient healthcare financing model lays on the perception of healthcare professionals, policy and decision-maker as a qualitative study aimed to assess barriers and enablers in SSA found a low perception among of physicians and healthcare executives in Ethiopia [13]. Historically, medical laboratories have been neglected as a significant component of health

systems in SSA to receive adequate attention in national health policies and strategic plans. A study aimed to review national laboratory policies and plans in 39 SSA countries found that financial and budgetary considerations for laboratories were mentioned in less than 5% of national health policies reviewed [14]. The collective findings and evidence demonstrate a significant gap in the prioritization and allocation of resources for medical laboratories in SSA, which hinder the overall effectiveness and quality of healthcare services and delivery. This also indicate lack of perception and awareness among healthcare professionals and policy and decision-makers. Despite that, it is important to note that the availability of resources is often obtainable but unreliable, and inaccurate medical laboratory practices with limited experience in resource management and compliance with international standards and regulations are considered the major problem.

In Somaliland, a self-declared independent region in northern Somalia since 1991, medical laboratories face similar challenges to those in SSA [15]. The future of these laboratories depends on adopting harmonized standards and the strict implementation of standardized development methodologies. Effective policies and plans are crucial for setting improvement targets, which can only be achieved with strong governance and adherence to international standards to enhance the quality of decisions [7, 16]. Overall, adherence to standards and addressing compliance issues are essential for ensuring that laboratories are accredited, support medical decision-making, and play a key role in addressing health crises through prevention and treatment. This review presents the current status of medical laboratory practices in Somaliland, emphasizes the urgent need for reform, and provides actionable recommendations for transforming the healthcare system.

2 Current status of medical laboratory landscape

2.1 Overview of laboratory infrastructure and the existing standards

In Somaliland, 46 primary health facilities exist, including 10 referral health centers, 20 district hospitals, 279 maternal and child health centers, and 131 primary health units [17]. The medical laboratory landscape has evolved, which is featured by its pledge to enhance service quality, accuracy, and reliability [18, 19]. They had a prominent role in detecting and managing infectious diseases such as non-communicable diseases, malaria, and tuberculosis, which are prevalent in the region, as well as in providing essential health services such as blood transfusion and prenatal screening. The current practices of the laboratory embrace a wide range of diagnostic tests and services, including hematology, microbiology, biochemistry, immunology, and molecular diagnostics [17, 20, 21]. Additionally, the Quality Testing Laboratory and the metrology laboratory were established by the Strategic Quality Control Commission (SQCC) in Somaliland but are still under development [22].

The Ministry of Health has developed a national framework for supervising, licensing, and ensuring compliance with minimum standards regarding health facility infrastructure, equipment, staff qualifications, and operational protocols. Furthermore, a significant step has been made in establishing the National Health Profession Commission (NHPC), which provides technical assistance and enhances competencies by training medical laboratory personnel in different specialties, including data management and equipment maintenance [20, 23, 24].

However, the framework of national practices and accreditation must be enhanced, crucial for maintaining the integrity of laboratory results and effective roles in morbidity

and mortality. Accordingly, there are intensive efforts to align local practices of medical laboratories to international guidelines and regulation standards. This includes attempt for compliance in term of implementation while enhancing the framework to match the context of Somaliland. For instance, the compliance of local practices to those set forth by the World Health Organization (WHO), World Bank Environment and Social Standards (ESSs), and the International Organization for Standardization (ISO) [25]. Additionally, encouragement for accreditation, which involves rigorous quality assurance processes, inter-laboratory testing comparisons, and regular quality control activities to ensure the accuracy and reliability of test results, has been escalated by local health authorities and other partners including ministry of health development, NGOs and International bodies such as WHO and Finnish Institute of Health and Welfare (THL) [17, 22]. The integration of laboratory management systems has been prioritized to ameliorate the collection, analysis, and reporting of data, hence supporting evidence-based decision-making for public health management. This includes establishing specimen referral networks, which facilitate the safety and efficiency of sample transportation and ensure timely diagnosis, treatment, and prevention control. While the integration of laboratory management systems has been prioritized as a commitment to expand their use across all laboratories in Somaliland; including plans to standardize practices and ensure that all health facilities can effectively utilize these systems for better public health outcomes, it is important to clarify that not all laboratories currently use such systems uniformly. The current extent of laboratory management systems indicates a varied implementation across different laboratories. For instance, larger and urban laboratories have adopted more advanced systems than smaller or rural laboratories, whose may still rely on traditional methods for data management [17]. However, ongoing efforts are aligned to enhance public health management by focusing on capacity-building, overcoming challenges, and expanding access to these systems across all laboratories in Somaliland.

Several critical issues in current medical practices continue to affect the quality of services in Somaliland. A study conducted in 2023 in Hargeisa; the country's capital, aimed to identify factors contributing to patients' mistrust of the healthcare system and inform future policy development. The study found that patients' lack of trust in physicians was primarily due to local healthcare services' unreliability and poor accuracy. Key issues identified include financial barriers, diagnostic accuracy, drug use, equipment quality, the role of laboratories, doctors' knowledge and skills, medical ethics, governance, the reputation of local doctors, and the overall quality of available services. However, analyzing current practices and assessing compliance with international standards to restore patient trust can bridge the mentioned gaps [26].

2.2 Challenges of medical laboratory procedures in Somaliland

Somaliland's current medical laboratory practices and standards exhibit a complex landscape characterized by distinguished strengths and significant weaknesses. On the prominent side, there is a rise in commitment from local practices to meet international guidelines. The compliance is evident in a remarkable increase in medical laboratories pursuing accreditation and ongoing efforts to improve the overall quality of care [27]. Nevertheless, there is no internationally accredited laboratory yet. Several weaknesses persist within the existing standards that hamper the advancements of the medical

laboratory landscape in obtaining international accreditation [18, 28]. Medical laboratory procedures in Somaliland face many challenges and limitations, which remain critical concerns to their effectiveness and reliability. This includes infrastructure issues, lack of human resources and training, operational challenges, and policy framework. [19, 28].

The primary challenge includes the suboptimal conditions of laboratory facilities that lack essential infrastructure, modern equipment, and technology in many laboratories. Whereas some facilities have made strides in alignment with international benchmarks, others still have weaknesses, particularly in the public sector. Consequently, variability in testing accuracy and reliability within the healthcare system landscape persists [19]. The inadequacy among laboratories hampers the performance on having a comprehensive range of quality diagnostic tests nationwide; leading to inaccuracy and delays in obtaining results and ultimately escalating patient safety risks. These issues are exacerbated by outdated equipment and lack of proper maintenance, calibration, and validation of laboratory instruments, where indicators of these factors vary from facility to another. Consequently, there is inconsistencies in laboratory outputs, which increase disparities among private, public, urban, and rural areas [29–31].

The absence of a validated tool necessary to diagnose acute appendicitis at Hargeisa Group Hospital indicated the development of diagnostic validity of the Modified Alvarado Score, a clinical diagnostic supported by laboratory tests that include evidence-based practices to diagnose acute appendicitis. Furthermore, findings suggest the applications of a validated tool to diagnose acute appendicitis and recommend the importance of validating diagnostic tools to increase the accuracy of laboratory tests. However, critical issues relevant to the reliability and usage of laboratory equipment highlight the need for tool validation, demonstrating the absence of effective evidence-based practices due to outdated equipment [32]. Similarly, the oncology care at Needle Hospital in Hargeisa provides some oncology services such as solid tumors, palliative care, follow-up, and cancer health education. The oncology departments face considerable limitations, such as financial constraints on patients for investigation and management, the presentation of cancer at an advanced stage, and diagnostic capacity restriction, for example, in the immunohistochemistry technique [33].

Another challenge includes insufficient training and qualifications for laboratory personnel, with many staff members lacking formal education in relevant fields [28]. The education gap is compounded by limited accessibility to ongoing professional development opportunities. Consequently, there is a notable disparity in the competencies of laboratory staff, particularly among rural–urban and public–private laboratories, and a limited number of specialized and qualified laboratory personnel [28, 31]. Despite implementing initiatives to improve laboratory staff's skills, a lack of access to a comprehensive training program that covers the latest diagnostic techniques and quality management practices is still needed [34]. Accordingly, the existing gap hinders the impactful implementation of quality assurance measures and compromises the overall quality of laboratory services at different levels [31].

A notable survey revealed significant gaps in the capacity of healthcare facilities in Somaliland to manage and prevent non-communicable diseases effectively. Among nine hospitals from different levels across selected regions, including Hargeisa, Burao, Odywene, Aynaba, Salaleh, and Gebileh, the survey found that while all hospitals had basic laboratory facilities for tests such as hemoglobin, lipid profile, urinalysis, complete

blood count, and liver and renal function tests, their capabilities were limited for more advanced diagnostics. For example, while some laboratories could perform prostate-specific antigen tests, they lacked the capacity for electrolyte tests, urine microalbumin tests, and cancer diagnostics like cytology and fecal occult blood tests. Approximately 75% of hospitals reported a deficiency of reagents, and 51.7% could not run cancer diagnostic tests. All hospitals conducted only essential microbiology and hematology tests, with about 71.4% also performing basic immunology and blood transfusion tests. Medium-level immunology tests were available in just 28.6% of hospitals, and none offered hemoglobin electrophoresis tests [21]. While 71.4% of hospitals could measure blood lipid levels and 57.1% calculated body mass index, essential services like prostate cancer screening, cytology/pathology screening, palliative care, chemotherapy, radiotherapy, physiotherapy, and tracking family history of NCDs were absent in all surveyed hospitals. Therefore, none of the hospitals adhered to WHO-PEN standards for human resources, equipment, and medicines needed for effective NCD management. The findings underscore the urgent need for comprehensive training programs, the acquisition of advanced diagnostic equipment, updated clinical guidelines, and improved referral systems to address these gaps and enhance healthcare delivery in Somaliland [21, 35].

The insufficiency and inefficiency of the available education and qualifications in providing effective practices for laboratory personnel is considered a daunting hurdle. Most university laboratories have inadequate chemical safety procedures, poor record-keeping and inventory management of chemicals, non-compliance with chemical waste management protocols, and insufficient understanding and awareness of chemical laboratory safety rules. The pressing need to address issues such as meagre facilities, equipment, and personal protective equipment to ensure chemical safety is paramount [35]. Nonetheless, chemical management safety procedures in labs should be improved by creating a standard curriculum for continuing education, giving employees and students proper training and supervision, and putting explicit chemical safety regulations in place.

Financial constraints are a significant barrier; many laboratories rely on external aid and donations. This dependence creates instability in covering supplies and equipment as funding is inconsistent, exacerbating the operational challenges and imposing limitations on them. For instance, cost-related issues raise supply chain challenges and often lead to a shortage of critical reagents and consumables, where disrupted laboratory workflows and testing delays are remarkable [19]. Another operational manner includes inconsistent quality control practices, leading to many laboratories not complying with established standard protocols that ensure reliability, ultimately undermining the trust in local services [17, 25]. A study utilized a theory-informed mixed-method approach to evaluate the feasibility and acceptability of a new fluorescence microscopy technology for tuberculosis (TB) diagnosis in fragile states to enhance accessibility to good quality care (diagnosis and treatment) for TB patients. Findings include a weak relationship between light-emitting diode fluorescence microscopy (LED) technology usage and increased TB case detection.

Furthermore, the staff attitudes were largely negative toward the future introduction and implementation of new technologies for routine utilization without improving the systematic and programmatic readiness of the existing health system. In contrast, limited resources and structural and environmental constraints have been identified as factors affecting facilities' operations. Additionally, the study indicated some operational

issues. For instance, the highest proportion of specimens with inconclusive test outcomes were reported not being examined, which is attributed to inadequate intervention guidelines used by laboratory technicians [36].

The existing policy framework governing medical laboratory practices often faces challenges that are required to bridge the gaps that the health sector is experiencing. Despite the establishment of NHPC to improve oversight and accountability of laboratory services, inconsistent applications of regulatory standards across different laboratories remain to enforce these regulations. Additionally, the policy is still in its nascent regulation stage [30]. Notably, medical complications account for 17.9% of indirect obstetric causes of death due to inadequate interprofessional collaboration, which is an indication of inconsistent applications and limited adherence to the existing regulation standards and guidelines [37]. Hence, a robust mechanism and policy change are essential to determine priorities, set clear standards for internal and external practices, and ensure compliance, adherence, and accountability, along with an integrated approach that involves local and international collaboration, as well as the inclusion of the emerging technologies for the improvement of medical laboratory procedures [17, 25, 38]. Using the building blocks of the healthcare system, the key issues and the limitations are explicitly consolidated in Table 1 [20, 39].

3 Discussion

The issues related to medical laboratory practices stem primarily from inadequate compliance with regulatory standards and guidelines, including those concerning financial resources. While financial limitations are undoubtedly a concern, they are not the sole barrier. Therefore, strict adherence to international benchmarks is essential to address these challenges and ensure effective management of available resources. Moreover, the performance of management departments at various levels within the laboratory structure and related bodies reflects a suboptimal ability to implement policies. A joint external evaluation report revealed that the health ministry sought technical support from the Finnish Institute of Health and Welfare to enhance compliance with international health regulations, underscoring the need for urgent improvement [27]. Achieving compliance with international standards requires efficient, effective, and reliable management at all levels of the health sector. To ensure adequate adherence to these standards, the quality of management and the capabilities of those responsible for policy implementation must be prioritized and addressed first.

The answer to both questions within the context of Somaliland requires a comprehensive conceptual framework for Total quality management (TQM). As an overview of how to shape the future of medical laboratories, it is essential to note that management of quality is different from the quality of management [16]. The quality of management is about indicators of top management's capability and capacity at all laboratory structure levels. It pertains to the effectiveness of leadership and organizational practices within the laboratory setting, including how well management structures support staff, allocate resources, and foster a culture of quality and accountability among personnel. It also determines what roles and responsibilities are necessary to promote interoperability within the healthcare system. Quality of management can assist governments in ensuring that the national health policy and plan can be implemented effectively in the determined timeline, as it provides an imaginary landscape for medical laboratories' future

Table 1 A comprehensive overview of the current limitations

Building blocks of healthcare systems	The key issues	A descriptive summary of the current limitations
Governance	Weak governance hinders policy implementation. This includes the unavailability of some regulations and laws that represent the key to healthcare provisions, human resources, pharmaceuticals, transparency in decision-making, and equity issues. Furthermore, unavailability of some of the sub-policies and strategies [20]	The governance structure in Somaliland presents another significant challenge and formidable limitations for the medical laboratory sector. This includes limited leadership capacities at regional and district levels. Consequently, poor regulations across service delivery in both the public and the private clinics, a largely unregulated private sector, and poor alignment and harmonization of external assistance to the health sector remain major limitations of the health system governance function [20]. Weak governance hinders the effective implementation of policies and oversight necessary to ensure that laboratory practices meet established standards. The absence of a cohesive national health research policy and a lack of coordination among stakeholders further exacerbate the situation, leading to fragmented efforts in improving laboratory services. This weak governance framework limits the capacity to enforce regulations and standards that could enhance the quality of laboratory practices and health services in Somaliland [40].
Infrastructure	Infrastructure gaps such as power outages and outdated equipment. This includes a lack of proper maintenance, calibration, and validation of laboratory instruments [30]	Infrastructure deficiencies, including frequent power outages and outdated equipment, significantly impact the functionality of medical laboratories in Somaliland. Many laboratories operate with unreliable power sources, which can disrupt operations and compromise the integrity of test results. Furthermore, the prevalence of outdated equipment limits the ability to perform a wide range of diagnostic tests accurately and efficiently [32, 41]. Addressing these infrastructure gaps is essential for enhancing the reliability and quality of services [17].
Human resources	Resistance from personnel to adopt new technologies and practices. Graduates from weak training institutions and irrational distribution of healthcare professionals create several obstacles indicating that the human resources don't meet the needs for the delivery of the essential package; as many health workers do not feel accountable to communities. The key issues are typically related to the availability of capacities that guide policies, workforce planning, financing, and managing the workforce (pre and in-service, hiring, and performance) [20]	Currently, there are no clear realistic, and indeed needs-based plans for health workforce development. In contrast, many medical and nursing schools do not exercise the required training standards and lack even basic teaching aids and equipment. All institutions can't provide the necessary skills in basic, clinical, technical and management domains. Accordingly, there is an inappropriate skill mix of the various categories for human resources in the health sector. Notably, performance assessment is weak and salaries are extremely low. Supervision, support, accreditation, workforce compensation, occupational risks, and their life-long learning and professional development represent the major issues at the management level as well [17, 20]. Moreover, resistance from personnel to adopt new technologies and practices poses a substantial barrier to the advancement of medical laboratory services. Many laboratory staff may be accustomed to traditional methods and may be hesitant to embrace innovative technologies that could improve efficiency and accuracy. This resistance can stem from a lack of training, fear of the unknown, or a perceived threat to job security [36]. Overcoming this resistance is crucial for the successful integration of modern practices and technologies in the laboratory setting.

Table 1 (continued)

Building blocks of healthcare systems	The key issues	A descriptive summary of the current limitations
Financing healthcare	Financial constraints may delay infrastructure upgrades and training The existing domestic and foreign funds are inadequate to meet the extensive healthcare demands. Approximately 53% of the budget designated by the government in 2021 for the health sector was allocated to salaries, and the attempts to mobilize domestic resources were not sufficiently strong due to limited advocacy and support at higher levels [20]	Financial limitations are a critical barrier affecting the medical laboratory services in Somaliland. The government's funding for the health sector has gradually risen over the past ten years, now totalling 5.23% of the national budget for 2021–18. The financing issue, however, is worsened by the ongoing pandemic and the crisis that has significantly affected all socioeconomic facets of every nation [20] Accordingly, insufficient funding restricts the ability to upgrade laboratory infrastructure and procure modern equipment necessary for accurate diagnostics. Additionally, financial constraints impede the training and development of laboratory personnel, which is essential for maintaining high standards of practice and adapting to new technologies. The reliance on external funding sources often leads to delays in implementing necessary improvements, as these funds may not be consistently available or aligned with local needs [17, 38] Overall, inadequate funding and the division of limited resources hinder the establishment of a fully operational system
Health Information	Limited availability of data due to the lack of a clear policy that explicitly consolidates the health management information system (HMIS) throughout the country This includes the absence of a national health research centre in Somaliland [38]	The presence of health data and information in Somaliland reveals significant shortcomings that must be tackled. This encompasses the deficiencies that exist in the ability to analyze and interpret data across all levels. Various data collection systems promoted by vertical programs and supporting agencies still need a clear policy to unify the HMIS system nationwide. The data currently accessible, primarily from facility-based sources, must be integrated with other information sources, including regular health and demographic surveys, ongoing health and nutrition assessments, and research data [20] Conversely, personnel at research centres were poorly prepared to carry out research and emphasized the necessity for national health research oversight. The creation of a national health research institute, formulation of a national health research policy and priorities, provision of adequate and sustainable funding, enhancement of staff capacity, and fortification of national health research governance in health research systems encounter significant challenges that require attention [38]
Public–private sectors and service delivery	Lack of information, poor-quality provision, weak regulatory framework, and lack of understanding of the private sector	The role of the private sector in service provision is huge populations seek health care from the largely unregulated private sector, which includes pharmacies, clinics, hospitals, and traditional healers. However, there is a general lack of understanding regarding the roles and responsibilities of private healthcare providers, which further complicates the landscape of healthcare delivery in Somaliland. In contrast, there is a significant gap in data regarding private healthcare service quality and availability, which also complicates effective planning and intervention strategies [39] The rapid growth of the private sector, coupled with weak regulatory oversight, has led to varying quality levels in healthcare services. Consumers often rely on informal networks for treatment recommendations, which can perpetuate the use of substandard providers. Furthermore, the lack of effective regulatory enforcement allows for a proliferation of unqualified providers, posing risks to patient safety and overall healthcare quality. Therefore, to reduce the existing gaps, urgent action has to be taken given all these essential components in service delivery [39]

in delivering high-quality services. Still, only compliance can guarantee the accomplishment of desired outcomes [42].

In contrast, quality management is about indicators related to service quality. It refers to the systematic procedures and techniques that guarantee that laboratory services fulfil set standards and produce accurate, dependable findings. This includes quality assurance procedures, protocol adherence, and continuous improvement programs designed to improve the overall quality of laboratory outputs [42]. The quality of management further promotes adequate compliance with regulation standards and guidelines, ensuring effective practices, communications, and policy implementation with capabilities to tackle internal and external issues. Thus, quality management can be ensured and maintained, which enhances the quality of services and substantiates the reliability and efficiency required for accreditation. Furthermore, the quality of management developed by top management of health sector entities and the Ministry of Health can ensure the adherence of all departments' practices to standards and provide services with high quality effectively.

To ensure high quality of the healthcare system, TQM is required. Within this article, we define TQM as a dual focus on quality management and management of quality needed to provide high-quality and reliable services. The physician and founder of the study of quality in health care and medical outcomes research and the creator of the Donabedian model of care proposed the triad use to ensure TQM, including structure, process, and outcomes to assess healthcare quality [43].

As Donabedian proposed, the dual focus is the key to promoting total quality management and ensuring reliability, assurance, and responsiveness. If so, the seven pillars of quality as presented by Donabedian, are efficacy, efficiency, optimality, acceptability, legitimacy, equity, and cost can be achieved [42, 44]. A dual focus allows laboratories to implement robust quality control measures and cultivate an environment where staff are empowered and motivated to uphold these standards. Furthermore, prompting a culture for continuous improvement, where feedback is actively sought and utilized to refine processes and practices. For example, the success rate of implementing TQM was 8.3% in Isfahan University Hospitals. Findings include 75% of hospitals having mechanistic structures and 25% having organic structures. The success of TQM in hospitals with organic organizational structure and medium organizational culture was higher than in hospitals with mechanistic and bureaucratic hospitals having weak organizational cultures. Successful implementation of TQM needs the most focus on process management, customers, leadership, and management but less focus on suppliers, performance results, strategic planning, and focus on material resources [45]. Quality-oriented organizational culture supported by senior management commitment and involvement, organizational learning and entrepreneurship, teamwork and collaboration, risk-taking, open communication, continuous improvement, customer focus (both internal and external), partnership with suppliers, and monitoring and evaluation of quality are urgently needed to ensure TQM [45, 46].

Simultaneously, guidance from external bodies ensures compliance with standards, gap analysis, and recommendations-based practices, which are considered a fundamental pillar for the successful implementation of TQM. It is essential to have an external body inspect and accredit the quality of the healthcare system to ensure the successful implementation of TQM. Approximately 70% of the variance in implementing TQM

can be achieved by following the principles of TQM, such as continuous improvement, teamwork, training, top management commitment, and customer focus. Continuous improvement was the most significant factor in explaining variance and implementing TQM successfully. Furthermore, obtaining international accreditation indicates the availability of services with high-quality reliability [46].

3.1 Constraints and barriers faced by medical laboratory

In Somaliland, the medical laboratory department is confronted with multifaceted barriers and significant limitations that hinder its effectiveness and ability to provide quality healthcare services. While Somaliland has made significant progress toward quality healthcare services, the authorization body suffers from a lack of funding, personnel, and support from the judiciary system, along with a weak regulatory framework and limited enforcement capacity [39]. The key issues and the limitations are explicitly consolidated in Table 1.

It is important to note that the existing limitations within laboratory practices include considerable variations and disparities between the public and private sectors. The organization, planning, and packaging of services, service quality, patient-centered care; the continuum of care, collaboration between the public and the private, and availability of UHC vision are the current issues in Somaliland. The public sector tends to focus on comprehensive healthcare delivery but struggles with resource limitations, leading to inconsistencies in service quality. In contrast, the private sector, while offering flexibility and a variety of services, often prioritizes profitability, which can result in compromised care quality [39]. Limitations between public and private sectors include disparities in terms of governance, infrastructure, human resources, financing healthcare, and the availability of data and information, all of which impact service delivery. The key issues of both sectors are summarized in Table 2.

Table 2 Description of the key issues and the existing disparities of limitations of the health public–private sector [39]

The key issue	Descriptions
Governance	While there is a regulatory framework intended to govern private sector participation in healthcare, adherence is low due to inadequate dissemination and understanding of these regulations. Regulatory agencies lack sufficient manpower and resources to enforce policies effectively, resulting in a fluid healthcare market characterized by low entry and exit barriers
Infrastructure	Both public and private sectors suffer from infrastructure gaps, such as unreliable power sources and outdated equipment. However, private providers often have more flexibility in service delivery and pricing, which can lead to disparities in service quality and accessibility
Human resources	The private sector faces significant challenges, including a shortage of qualified personnel. In contrast, public facilities may have better-trained staff but are often overwhelmed by demand and underfunded, affecting the quality of care delivered
Financing healthcare	Financial constraints are a major barrier across both sectors. Public facilities struggle with inadequate funding for infrastructure and personnel training, while private providers face difficulties accessing capital for expansion and operational costs. Consequently, healthcare delivery often prioritizes profitability over patient needs, leading to potential inequities in care
Availability of health data and information	Limited data on private healthcare providers hampers effective planning and analysis of health interventions. A lack of comprehensive health service mapping prevents stakeholders from understanding the service landscape, which is crucial for improving healthcare delivery. Additionally, consumer behavior is driven by factors such as price, proximity, and perceived quality, often leading families to rely on informal treatment options before seeking formal care

3.2 Expected outcomes from compliance with international standards

The expected outcomes from aligning medical laboratory practices with international standards include credibility, effectiveness, accuracy, and reliability in providing high-quality services in Somaliland. As a result, further funding and support from international organizations and donors can be obtained, and medical facilities can receive accreditations. The robust infrastructure will be better equipped to respond to such challenges, ensuring that healthcare providers and patients can access reliable, accurate, and timely diagnostic tools and information [42, 44]. Such alignment fosters the overall efficiency of laboratory operations and plays a vital role in resource-limited settings. By adhering to established protocols, laboratories can improve their diagnostic accuracy, reduce errors, and streamline workflows, ultimately leading to better patient outcomes and increased satisfaction with healthcare services [42]. Evaluating the accreditation's influence on the performance of laboratories regarding the International Standards Organization/International Electrotechnical Commission (ISO/IEC 17025) revealed a statistically significant relationship between accreditation, customer satisfaction, and financial returns. Therefore, the accreditation in the Nano Center for Measurement and Calibration has improved the performance of laboratories to achieve the desired outcomes. The accreditation promoted evidence-based practices and the quality of services since it has positively influenced the results' validity, the staff's performance and efficiency, customer satisfaction, and financial returns to laboratories [47].

The benefits of adherence extend beyond immediate operational improvements; such compliance contributes to the long-term sustainability of the healthcare system in the country, facilitates the integration of laboratory services and new technologies into broader public health initiatives, and promotes effective surveillance and response strategies to health crises [48]. Moreover, fostering a culture of quality and compliance with standards can make the healthcare system more resilient, sustainable, and better prepared to face future challenges, such as emerging infectious diseases and outbreaks. This resilience is critical in such settings with limited resources, which can reduce the burden on healthcare facilities and improve health outcomes across the population [49]. Such compliance is necessary to obtain accreditation, which can assist laboratories in Somaliland to overcome the limitations within the healthcare building blocks, such as human resources not being accountable to communities. For instance, accredited laboratories had twice the number of staff complement when compared with non-accredited laboratories in the South African National Laboratory. A study indicated that 98% of employees in the South African National Health Laboratory believe that they are a critical resource for the organization, as they see themselves continuing in their work for more years. They also recommended the National Health Laboratory Service (NHLS) as a great place to work. Moreover, about 94% believe that laboratory accreditation is necessary as they know their role in accreditation [50].

Evidence on the impact of accreditations demonstrates the capability of medical laboratories to achieve the expected outcomes in Somaliland. A longitudinal study aimed to evaluate the impact of accreditation on health care services performance in the Kiryandongo district in Uganda and found that laboratories were positively impacted by accreditation. The result showcased that the accredited facility was also more likely to receive referral samples (OR = 1.67) as compared to the nonaccredited public and private not-for-profit facilities. This impact translated into increased healthcare performance

at the accredited facility compared to the non-accredited facilities. However, the study indicates the attainment of accreditation comes with several requirements, which may include facility upgrades, building personnel capacity, establishing functional equipment management programs, and participation in external quality assurance programs. These requirements often form facilitators for resource-limited settings to realize accreditation, especially if the value for investment is demonstrated [51]. Another case study aimed to investigate the impact of ISO/IEC 1705 laboratory accreditation in sub-Saharan Africa and found that a higher level of quality compliance was exhibited for laboratories during the post-accreditation years 2013 up to 2017, which indicates the need for awareness of the accreditation impact and promotes compliance. The findings also indicate that the ISO/IEC 1705 accreditation of the quality control laboratory resulted in well-improved reliability of test reports and enhancement of the laboratory quality systems [52].

3.3 Local prudent financial options

Due to uncertainties on the future funding from international organizations like USAID, this manuscript also discusses the local prudent financial options as alternative for Somaliland as well [53, 54]. Over-reliance on international aid can create vulnerabilities, particularly when funding is inconsistent or subject to geopolitical changes [55, 56]. Thus, providing a comprehensive approach with effective strategies is critically needed to increase funding and secure sufficient investment aimed at enhancing Somaliland's healthcare system and obtaining accreditations. To ensure that medical facilities and laboratories can secure a sufficient investment, establishing public–private partnerships between the government and private sector is required to mobilize resources for healthcare improvements [57]. Such strategy for collaboration not only brings additional funding but also enhances service delivery through the application of private sector efficiencies and allow for shared responsibilities and risk. For instance, collaborating with private sector entities allows the government to share investment costs and risks associated with upgrading medical facilities and laboratories [57–59].

Implementing community-based health insurance schemes for mobilizing resources, where local communities will cover healthcare costs and contribute financially to their needs, can provide a sustainable funding source [60]. These schemes can involve pooling resources to create a fund that covers healthcare costs, making services more accessible and reducing the burden on public financing [61]. The scheme also encourages community engagement and ownership of health initiatives. Hence, community health financing strategy can ensure that accessibility to laboratory services is improved without relying solely on external aid [62]. Since laboratory accreditation and efforts are required to enhance overall healthcare infrastructure, the approach that introduce modest taxes or levies on specific goods, such as tobacco and alcohol, can generate revenue dedicated to healthcare funding [63]. This approach can help the financing process of accreditation for laboratories in Somaliland, where the generated revenue streams must be allocated specifically to support laboratory improvements and other essential health services, thereby reducing reliance on external sources [64, 65].

Promoting engagement among local businesses and affluent individuals in philanthropic initiatives can foster a culture of giving [66]. Local philanthropy and corporate social responsibility to urge donations is another effective strategy that can be directed

toward healthcare projects, including laboratory improvements [67]. By fostering a culture of giving, Somaliland can tap into local resources to support healthcare projects, including laboratory accreditations [68, 69]. Additionally, investing in training programs for local healthcare professionals can enhance their skills and create a more self-sufficient healthcare workforce. A skilled workforce is more likely to attract local investment, as it demonstrates a commitment to quality care and sustainability [70, 71]. Although this approach represents indirect strategy, where a well-trained workforce can attract private investment that potentially led to improved services and delivery, cost reduction and effective allocation of resources is required [72–74]. Such strategy requires a cost reduction of services while improving access to healthcare [75]. In such case, leveraging technology like telemedicine and mobile health applications is crucial to do so as a parallel approach that promote effective allocation of resources to attract further funding and investment [76–79]. The utility of such technologies can reduce operational costs and expand access to healthcare services. Implementing the indicated two strategies parallelly can ensure the creation of new revenue streams and increase efficiency within medical facilities effectively [80–85].

However, the suggested strategies aimed to increase local funding and investment need transparent processes to build trust among stakeholders. Transparency and accountability measures can build trust, encouraging local entities to contribute financially to health initiatives [86]. Accordingly, enhancing governance and accountability in health financing are required, which promote the attraction of more investment and increase funding from local sources as the donors are confident in the effective use of the funding [87–91]. Overall, it important to note that the implementation of the suggested strategies as a comprehensive approach requires gradual steps in reducing over-reliance on international aid. This includes balancing between the increase of local funding while decreasing the international aid of funding and investment. The diversification of sources for funding and reducing over-reliance on international aid, Somaliland can create a more resilient healthcare system. The indicated local financial options can not only promote sustainability but also empower the community to take an active role in improving their healthcare services. It is a proactive essential approach in navigating the uncertainties of future funding from international organizations.

3.4 Total quality management (TQM) & future directions

It is important to note that TQM prioritizes quality management and facility leadership as the most important factors in improving laboratory practices and the quality of its services, as well as guiding the facility to gain accreditation and ensure its sustainability. A cross-sectional survey aimed to investigate the effect of accreditation on service quality in medical laboratories and the factors that explain how accreditation affects service quality through laboratory staff's viewpoints in Dokuz Eylül University Hospital Central Laboratory in Turkey found that the most important factors were quality management, benefits of accreditation, accreditation staff involvement, quality results and human resource utilization with the proportions 52.0%, 7.7%, 6.7%, 4.6% and 4.0% of the total variance, respectively. The quality management factor, which had nine scale items addressing leadership, human resource utilization, planning, and management features of accreditation, was indicated as the most significant factor that influences the service quality of medical laboratories, with the largest proportion of 52.0% of the total variance. The findings showcased that

accreditation is particularly necessary to improve the safety culture and increase test indicators of service quality [92]. However, the survey demonstrated that the establishment and execution of an efficient quality management system is important for the accreditation process and its sustainability, whereas quality management and encouragement from the administration play a crucial role in achieving organizational goals.

While compliance with ISO standards demonstrates significant outcomes, barriers and challenges may arise to limit the capability to obtain accreditation. A systematic review of the quality management of Ethiopian Medical Laboratories indicates that Inadequate Support from Management Bodies and Problems Associated with laboratory professionals are the biggest challenges to ensuring quality and obtaining accreditation [93]. Furthermore, a research study aimed to examine quality assurance initiatives and organizational performance of the Ethiopian Standards Agency in Addis Ababa revealed major challenges in implementing ISO 9001:2015 quality management systems. The challenges in the course of quality management systems implementation processes include low engagement of people, lack of motivational package, lack of QMS awareness, knowledge, skill, attitude, and shortage of available resources. Moreover, the absence of continuous, comprehensive monitoring and evaluation was identified as the key quality assurance and organization performance implementation challenge [94]. Another case study aimed to explore the influence of staff motivation, laboratory practices, and management support to achieve the South Africa National Laboratory Accreditation and demonstrates that problems associated with laboratory professionals are raised by quality management and leadership limitations. 82% stated that there is no work recognition for good performance and 77% indicated that management decisions do not regard quality as the top priority. The study highlights inadequate management support and leadership as the main cause of the slowness of implementing accreditation in medical laboratories [50]. The findings of these studies demonstrate that the quality management lack is associated with other relative issues, including improper provision of information, lack of commitment, poor professional skill, poor communication, poor internal quality control practice, and inadequate utilization of laboratory documents. Poor quality management and ineffective leadership hinder the capacity to navigate these challenges within the laboratory landscape, which prevents facilities from gaining accreditation. This evidence highlights concerns around business management performance and demonstrates the need for standards to ensure the quality of business management activity and its executive decisions.

Whereas several international standards address the needs and basic requirements for quality, environment, risk, and safety management, no ISO standards prescribe the need for the quality of the business management activity and its executive decisions by which such standards can be applied [16]. Yet, there are no universally accepted standards for organizational planning and management systems. Meanwhile, a cross-reference with ISO9001:2015 highlights the importance of considering a new version of business management standards entitled “BMS75000:2020” for quality management, which seeks to provide a means for executive decisions and gives the same degree of credibility and assurance that ISO9001 offers for a product or a service simultaneously [95, 96]. TQM is a comprehensive approach aimed at improving the quality of products and services through ongoing refinements in response to continuous feedback, where BMS75000: 2020 is highly recommended in promoting TQM within a landscape like Somaliland

effectively. The importance and benefits of TQM to be obtained require a strengthened accreditation authority in Somaliland Table 3. Summarizes the key importance of having a local accreditation authority as a successful TQM require; along with the challenges that hinder its implementation and outcomes.

To achieve TQM, Somaliland needs to strengthen its local accreditation by ensuring that laboratories comply with the necessary standards, in which compliance accordingly has a significant impact on laboratory operations and healthcare outcomes. We hereby provide a comprehensive framework composed of strategies, considerations and way forward to contextualize effective and efficient TQM's implementation that enabling the transformation of healthcare system entirely in Somaliland. See Supplementary Table 4, a comprehensive framework to strengthening local accreditation bodies and overall TQM in Somaliland. By implementing these strategies, considering local contexts, and following through with targeted recommendations, Somaliland can eventually enhance the quality of laboratory services and improve healthcare outcomes for its population.

Table 3 Key significance and challenges of local accreditation authority for TQM

Key benefits & significance	Description	Challenges
Ensures compliance with international standards	Strengthening local accreditation processes helps laboratories align with international standards such as ISO17025 and BMS75000: 2020, which is essential for ensuring the accuracy and reliability of test results. This compliance is crucial for building trust in laboratory services among healthcare providers and patients [95–102]	Limited resources: Many laboratories lack the necessary resources to meet accreditation requirements, including funding for training and infrastructure improvements
Enhances quality management systems	A robust accreditation framework promotes the establishment and maintenance of effective quality management systems within laboratories. This includes regular internal audits, staff training, and adherence to quality policies, which are vital for achieving TQM [103, 104]	Awareness and training: There is a need for increased awareness among laboratory personnel and stakeholders about the importance of accreditation and TQM principles
Facilitates continuous improvement	Accreditation encourages laboratories to engage in continuous improvement practices. By regularly assessing their processes and outcomes, laboratories can identify areas for enhancement, leading to better service delivery and patient care [105–109]	Regulatory framework: The existing regulatory framework may need strengthening to support the accreditation process effectively
Promotes accountability and transparency	Strengthening local accreditation fosters a culture of accountability and transparency within laboratory operations. This is essential for ensuring that laboratories are held to high standards and that any deviations from quality norms are promptly addressed [86–91]	Conflict of interest in embracing a particular standard framework: Whether a particular framework of standards demonstrated its applicability and benefits or not, a conflict of interest in embracing a particular one may raise due to the existence of several frameworks. Evaluation and approval is required to select the most suitable framework of standards for Somaliland's landscape
Supports national health goals	By enhancing laboratory accreditation, Somaliland can better support its national health goals, including the effective management of diseases and the implementation of public health initiatives. Accredited laboratories are better equipped to provide reliable data that inform health policies and interventions [110–112]	Ineffective support for the establishment of agencies when adopting a framework of standards: When adopting standards framework, the establishment of agencies that provide consultation and facilitate accreditation for local entities, organizations or institutions require support to streamline the agency mission locally

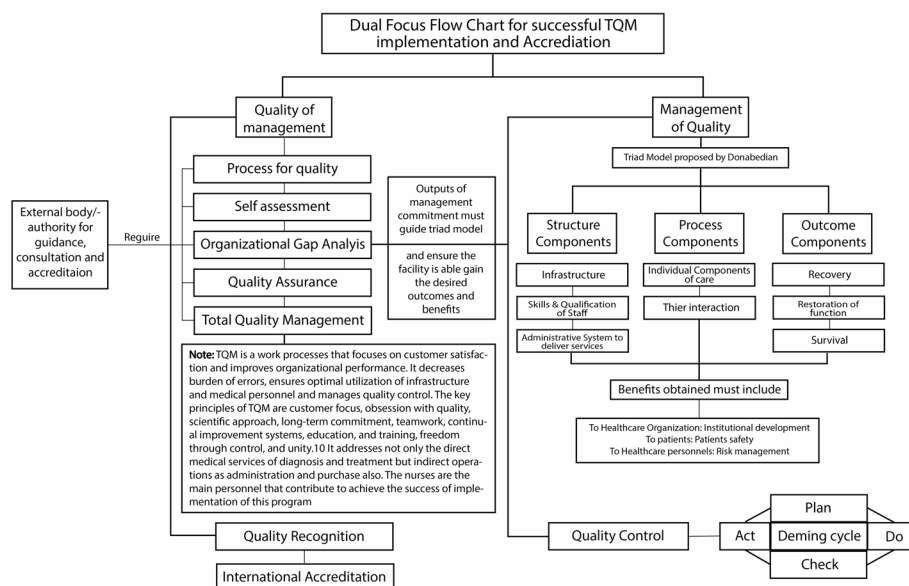


Fig. 1 Flowchart of successful TQM

To shape the future of medical laboratory practices, the healthcare system needs some reforms, including a new action for quality to achieve TQM, which is considered a need and challenge but represents the future directions toward accreditation. Findings from a study on the quality and resilience of clinical laboratories in Rwanda emphasize the significance of instituting a laboratory quality plan and sustainable strategies, along with regular assessments, as policy directives to uphold and enhance quality standards, which benefits both local and global communities, given the pivotal role of laboratories in patient treatment, disease prevention, and surveillance [113]. However, policy change, implications, and implementation are significant in obtaining the desired outcomes. For policy implication and implementation, we suggest a dual focus strategy, as clarified in the flowchart below, that is designed to be applicable and relevant to Somaliland's context or similar settings. As shown in Fig. 1.

This flowchart can be used by all policy or decision-makers and members of the top management at different structural levels of the health sector to guide the development of all health facilities toward a better future with reliability, accreditation, and high quality. Evaluating the quality of laboratory outputs and the effectiveness of management practices can provide valuable insights for continuous improvement. Thus, the desired outcomes and targeted goals can be achieved as planned. By embracing this dual focus, Somaliland's medical laboratories can significantly enhance their operational effectiveness and the quality of patient care. Furthermore, the healthcare system can ensure its departments' long-term sustainability and well-strengthened collaboration. Rwanda's National Reference Laboratory improved diagnostic services and achieved accreditation through phased upgrades and international partnerships, showcasing the importance of external collaboration and representation of laboratory professionals at the Ministry of Health [113–115]. Accredited laboratories in Rwanda indicate that the quality of management must ensure continuous quality improvement for laboratory practices, which can be achieved by keeping laboratories up with regular follow-ups, as opposed to those that phased out these follow-ups prematurely. Studies on accredited laboratories in

Rwanda have also affirmed the necessity of maintaining mentorship and conducting regular quality assessments until requisite quality routines are established to sustain laboratory quality services [113].

3.5 Recommendations

Due to the complexities within the landscape of medical laboratories in Somaliland, we suggest an actionable recommendation to enhance medical laboratory practices. For example, the implication of a dual focus policy is recommended as a way forward for accreditation and ensuring compliance with international standards. This will help take medical laboratories to the next level and ensure sustainable development for the health-care system. The Pathology Division of the 37 Military Hospital in Ghana attained accreditation for its hematology and chemical pathology departments by ensuring a dual culture for quality, which is critical in supporting quality patient care, demonstrating that quality management and management quality are significant aspects to consider within the national healthcare delivery system. Evidence from national laboratories and their departments in Ghana demonstrates an efficient approach to Somaliland's laboratory accreditation process and indicates the need to make medical laboratory accreditation an integral part of the national healthcare delivery system. It also emphasizes the need to strengthen laboratories and ensure laboratory management is adopted towards accreditation [116]. Otherwise, consultation and guidance from external authorities may be needed for gap analysis, providing quality assurance, and international accreditation.

Furthermore, implementing a dual-focus policy will promote effective management of available limited resources. Uganda's HIV, TB Laboratory Network, including accredited and non-accredited laboratories, demonstrated that the centralized diagnostic services improved reliability and access, highlighting the benefits of strategic planning in resource-constrained settings [51]. The efficient approach from Ghana National Laboratories, including the Pathology Division of the 37 Military Hospital, demonstrates that accreditation for its hematology and chemical pathology departments has succeeded by the involvement of senior management in all accreditation activities and the use of specific teams to focus on key improvement projects coordinated by an efficient mentorship program [116]. Additionally, establishing robust quality assurance protocols and quality management systems is essential. This will assist in operating efficiently with the capability to respond effectively to health crises and promote a collaborative healthcare system. Moreover, we recommend prioritizing the medical laboratory for investment in modern technologies and allocating more resources to enhance its infrastructure and services. This will further provide specialized services with high quality and reliability and prevent those travelling overseas from seeking medical diagnosis and treatment. Also, we recommend developing comprehensive training programs aimed at improving staff capability and increasing the number of specialists in the most required fields. This will promote the role of specialized service delivery and ensure the satisfaction of patients. The participation of medical laboratory staff in policy change and decision-making enables the development of policy and decision-making effectively. Finally, we recommend conducting further research and studies to assess how far the current practices match the national policy and plan since data is vital in decision-making and policy implementation.

It is important to note that developing a national health research policy and increasing funding is critically needed for further research and publication. The need for additional financing, local research capacity building, and strengthening the governance of the health research system and its infrastructure is paramount in Somaliland [38]. Accordingly, we recommend further collaboration with international organizations for knowledge sharing, resources, and guidance on establishing national health centres and policies necessary to manage data and information of the current standards effectively.

4 Conclusion

The landscape of medical laboratories in Somaliland confronts multifaceted challenges, including a lack of laboratory consumables, a shortage of outdated equipment, a limited number of skilled personnel, a deficiency in the number of educators and training programs, inadequate logistical support, and a de-emphasis of laboratory testing, insufficient monitoring of test quality, decentralization of laboratory facilities, and a lack of standardized protocols for laboratory testing. While the government achieved key milestones within the healthcare system, serious consideration, promotion, and implementation of some reforms are needed to navigate the challenges and raise the efficiency, quality, and advancement of diagnostic technology and medical laboratory practices. Compliance with international standards represents the key solution in addressing the challenges of the medical laboratory landscape and providing effective healthcare services in Somaliland. There is a need to strengthening local accreditation bodies that support TQM, simultaneously with promoting local prudent financial options. Strategic implementation represented by establishing national accreditation body, developing and adopting clear accreditation standards, regular training & capacity building, promoting quality management systems, facilitating inter-laboratory comparison are an effective approach recommended to strengthen local accreditation, which requires considerations to local culture context, socioeconomic status, resources availability and stakeholders engagement as addressing the existing challenges that hamper TQM. As a way forward, it is recommended to strengthening regulatory frameworks and local governance, conducting awareness campaigns, monitoring, evaluation and approval on a potential and feasible standards frameworks for Somaliland; alongside the government's support and collaboration with international bodies for maximum implications. For instance, the establishment of robust quality assurance protocols and quality management systems is an essential assistant that ensuring medical laboratories operating efficiently with the capability to respond effectively to health crises and promote a collaborative healthcare system. Accordingly, further collaboration with international organizations is recommended for guidance to be received on establishing national health centres and policies necessary to manage data and information of the current standards effectively. Meanwhile, it is important to promote local prudent financial options with effective strategies and initiatives to increase internal fundings and gradually reduce over-reliance on international aid. As we showcased the priority of medical laboratory for investment in modern technologies and allocating more resources to enhance its infrastructure and services, we recommend a significant approach in increasing local funding and ensuring financial independence. Public–private partnerships, community-based health financing and insurance schemes, health taxes and levies, local philanthropy and donations, capacity building and training, technological and innovations utilities and strengthening

local governance can effectively increase local funding and promote financial independence for successful implementation without interruption or delay. The local financial options not only promote sustainability but also empower the community to take an active role in improving their healthcare services. Thus, such strategies demands collaborative efforts for implementation.

However, ensuring effective compliance toward the future of medical laboratories requires a dual focus to maintain total quality management. The implication of a dual focus policy is recommended as a way forward for accreditation and ensuring compliance with international standards. To take medical laboratories to the next level and ensure sustainable development for the healthcare system in Somaliland, the implication of a dual focus policy that has been developed and designed to be provided within our work here is recommended as a way forward for accreditation and ensuring compliance with international standards; as the dual-focus policy will promote effective management in a limited-resources settings. Medical laboratory practices can be improved at each level of the national laboratory structure by simultaneously addressing the quality and quality of management. This comes with compliance with international standards and the recognized benchmarks globally to make a resilient healthcare system. In contrast, consultation for effective compliance is highly recommended to navigate the challenges of simultaneously considering and implementing the proposed dual focus. Guidance from external authorities is crucially needed in terms of gap analysis, providing quality assurance, and international accreditation. Accordingly, engagement among national accreditation body with international authorities can ensure a successful establishment and implementation. Then, accreditation can be obtained as the consultations promote continuous evaluation of complaints via gap analysis and achieving the targeted improvements.

Abbreviations

AI	Artificial intelligence
BMS	Business management standards
ESSs	World Bank Environment and Social Standards
ISO	International Organization for Standardization
LED	Light-emitting diode fluorescence microscopy
NCDs	Non-communicable diseases
NHPC	National Health Profession Commission
SSA	Sub-Saharan Africa
SQCC	Strategic Quality Control Commission
TB	Tuberculosis
TQM	Total quality management
WHO	World Health Organization

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1007/s42452-025-07350-1>.

Supplementary Material 1.

Author contribution

OASA: Conceptualization, Formal analysis, Methodology, Project administration, Data curation, Visualization, Literature review, Communication, Writing—original draft, Writing—review & editing. ZKO: Collaboration, Conceptualization, Data curation, Investigation, Validation, Writing—review & editing. EIU: Collaboration, Writing—review & editing. TS: Collaboration, Conceptualization, Data curation, Investigation, Validation, Writing—review & editing. OJO: Collaboration, Investigation, Validation, Writing—review & editing. JBO: Collaboration, Investigation, Validation, Writing—review & editing. DELP: Supervision, Writing—review & editing.

Funding

The authors received no funding for this study.

Availability of data and materials

No datasets were generated or analysed during the current study.

Declarations**Ethics approval and consent to participate**

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that there are no competing interests related to this manuscript. Omar Abdulkarim Saeed Alhammadi; as an associate agent of Q-Share International Ltd, received no funding for this research and has no other financial interests that could be perceived as influencing the submitted work. All other authors have no competing interests to disclose. They critically reviewed, judged, validated, conceptualized, curated, and analyzed the manuscript entirely, ensuring accuracy and integrity in the research process to avoid any potential bias. This statement is made in accordance with the journal's requirements for transparency and disclosure, aimed at fostering trust and clarity in the research community.

Received: 10 February 2025 / Accepted: 17 June 2025

Published online: 01 July 2025

References

1. ID Watson P Wilkie A Hannan GH Beastall 2018 Role of laboratory medicine in collaborative healthcare Clin Chem Lab Med (CCLM) 57 1 134 142
2. MJ Hallworth 2011 The '70% claim': what is the evidence base? Ann Clin Biochem 48 6 487 488 <https://doi.org/10.1258/acb.2011.011177>
3. U Waheed M Ahmad A Wazeer M Saeed N Saba F Rasheed 2023 Medical laboratory science education: shaping competent and skilled healthcare professionals Mirpur J Med Sci. 1 1 58 63
4. UP Rohr C Binder T Dieterle F Giusti CG Messina E Toerien H Moch HH Schäfer 2016 The value of in vitro diagnostic testing in medical practice: a status report PLoS ONE 11 3 e0149856
5. RK Ephraim GP Kotam E Duah FN Gharthey EM Mathebula TP Mashamba-Thompson 2024 Application of medical artificial intelligence technology in Sub-Saharan Africa: prospects for medical laboratories Smart Health. 2 100505
6. LF Schroeder T Amukele 2014 Medical laboratories in sub-Saharan Africa that meet international quality standards Am J Clin Pathol 141 6 791 795
7. P Ondoa A Broek van der C Jansen H Bruijn de C Schultsz 2017 National laboratory policies and plans in sub-Saharan African countries: gaps and opportunities Afr J Lab Med. 6 1 1 20 <https://doi.org/10.4102/ajlm.v6i1.578>
8. CA Petti CR Polage TC Quinn AR Ronald MA Sande 2006 Laboratory medicine in Africa: a barrier to effective health care Clin Infect Dis 42 3 377 382
9. P Ondoa G Kapoor Y Alimi E Shumba G Oseno M Maina D Batra A Sow M Matu M Moreira Y Kebede 2025 Bacteriology testing and antimicrobial resistance detection capacity of national tiered laboratory networks in sub-Saharan Africa: an analysis from 14 countries The Lancet Microbe. <https://doi.org/10.1016/j.lanmic.2024.100976>
10. McKinesy Company, Tania Holt, Ying Sunny Sun, Marilyn Kimeu, Parusha Raidoo. Overcoming sub-Saharan Africa's health workforce paradox, 2024 [Online article; Website]. <https://www.mckinsey.com/industries/social-sector/our-insights/overcoming-sub-saharan-africas-health-workforce-paradox>
11. HP Pierre Donfouet, Tania Dmytraczenko, Gaston Sorgho, 2023. Three strategies to unlock the potential of primary health care in Sub-Saharan Africa, World Bank Blogs [Website]. <https://blogs.worldbank.org/en/health/three-strategies-unlock-potential-primary-health-care-sub-saharan-africa>
12. SC Ifeagwu JC Yang R Parkes-Ratanshi 2021 Health financing for universal health coverage in Sub-Saharan Africa: a systematic review Glob Health Res Policy <https://doi.org/10.1186/s41256-021-00190-7>
13. GT Aboye GL Simegn JM Aerts 2024 Assessment of the barriers and enablers of the use of mHealth systems in sub-Saharan Africa according to the perceptions of patients, physicians, and health care executives in Ethiopia: qualitative study J Med Internet Res 27 26 e50337
14. P Ondoa A Broek van der C Jansen H Bruijn de C Schultsz 2017 National laboratory policies and plans in sub-Saharan African countries: gaps and opportunities Afr J Lab Med 6 1 1 20 <https://doi.org/10.4102/ajlm.v6i1.578>
15. S Devi 2015 Slowly and steadily, Somaliland builds its health system The Lancet 385 9983 2139 2140
16. Q-Share International Ltd. Business management system of the quality management [Website]. Business management standards: 75000, BMS75000; 2020. [cited 1 Nov 2024] Available from: <https://www.bms75k.co/copy-of-management-systems>
17. Improving Healthcare Services in Somaliland (2023), Environmental and social management framework (ESMF) [Internet]. Somaliland: the ministry of health development. [cited 1 Nov 2024] Available from: https://somalilandmohd.com/wp-content/uploads/2023/10/ESMF_Damal-Caafimaad-Somaliland-Project_5-Oct.23_clean.pdf
18. Medical Services and Health Facilities [Internet]. Somaliland ministry of health development. [cited 1 Nov 2024] Available from: <https://somalilandmohd.com/medical-services-and-health-facilities/>
19. AS Said DI Kicha 2024 Implementing health system and the new federalism in Somalia: challenges and opportunities Front Public Health 12 1205327 <https://doi.org/10.3389/fpubh.2024.1205327/full>
20. National Health Policy III, 2022 [Internet]. Somaliland ministry of health development. [cited 1 Nov 2024] Available from: https://somalilandmohd.com/wp-content/uploads/2023/03/Somaliland_New_HP_Final-1.pdf

21. Ojo OO, Hersi OO, Falobi AA, Ali N, Tan L, Ali Y. Assessment of the capacity of health facilities in preventing and managing non-communicable diseases in selected regions of Somaliland. <https://www.researchsquare.com/article/rs-3421090/latest>
22. Strategic Plan (2020–2024) [Internet]. THE Somaliland quality control commission-SQCC. Somaliland government [cited 10 Nov 2024] Available from: <https://sqcc.govsomaliland.org/site/downloadfile/file/MjAyNC8wNS8yMDI0LTA1LTASLTxLT4LT AxLTczNTQzMTCxNTI2MTI4MS5wZGY%3D>
23. Regulation Standards, Tools, and Procedures for Inspection, Registration, and Licensing of Healthcare Facilities (Under the Health Regulation Act 19/2001) [Internet]. Somaliland law: national health professions commission (NHPC). [cited 1 Oct 2024] Available from: http://www.somalilandlaw.com/REGULATION_TOOLS_FOR_HCF.pdf
24. Regulation Standards, Tools, and Procedures for Inspection, Registration, and Licensing of Health Training Institutions. (Under the Health Regulatory Act 19/2001) [Internet]. The Republic of Somaliland: National Health Professions Commission (NHPC). [cited 1 Oct 2024] Available from: <https://www.nhpcsomaliland.org/documents/HTI%20REGULATION%20TO OLS%20.pdf>
25. Mustapha AA. Review on Somaliland accreditation authority [Internet]. Accreditation and quality assurance, Oman academic accreditation authority; 2022. [cited 1 Oct 2024] Available from: https://www.academia.edu/89104922/Somaliland_Accreditation_Authority
26. Ahmed HY, Mussa AA, Yousuf AM, Mohamed HH, Ali NA, Ahmed ZM, Abdi YM. Factors that lead to patient mistrust of the healthcare system in Hargeisa, Somaliland: a qualitative exploration. medRxiv. 2023; 2023–11. <https://doi.org/10.1101/2023.11.23.23298819.abstract>
27. J Sane P Ruutu S Soleman M Elmi 2020 Implementation of the international health regulations in Somaliland supports multisectoral response to COVID-19 J Glob Health 10 2 20364
28. MM Hassan AN Ali I Ali ZO Mohamed HM Abdullahi MM Ahmed AK Mohamud YA Adebisi OJ Okesanya DE Lucero-Prisno III 2024 Regulation of health professions education and the growth of schools in Somalia BMC Med Edu 24 1 1178 <https://doi.org/10.1186/s12909-024-06179-3>
29. D Zizzola 2013 Local practices of development in Somaliland J Int Displace. 3 2 6 21
30. Mohamoud IM. Contributions of Somali diaspora in the health institutions building: a case of migration for development in Africa, in health programs for ministry health in Somaliland (Doctoral dissertation, University of Nairobi). <http://ereposit uonbi.ac.ke/handle/11295/154180>
31. Grothuesmann D. Private health care services in a fragile country context Somaliland physicians' perspective. <https://dg-m aternalhealth.de/wp-content/uploads/2017/10/Dirk-Master-Thesis-FGS-Word-2013-II.pdf>
32. Elmi MA. Validation of modified Alvarado score in Hargeisa group hospital (Hgh) Somaliland: diagnostic accuracy in acute appendicitis (doctoral dissertation, University of Nairobi). <http://erepository.uonbi.ac.ke/handle/11295/101835>
33. G Hagos N Hammad S Stanway A Yusuf T Hailemariam 2023 Cancer care in needle hospital, Hargeisa Somaliland e cancer-medicalscience 30 17 1642
34. AE Finlayson A Baraco N Cronin O Johnson S Little A Nuur D Tanasie A Leather 2010 An international, case-based, distance-learning collaboration between the UK and Somaliland using a real-time clinical education website J Telemed Telecare 16 4 181 184 <https://doi.org/10.1258/jtt.2010.004004>
35. MA Omer 2024 Assessing the safety of chemical management practices in academic laboratories in Hargeisa, Somaliland Cogent Educ. 11 1 2372188 <https://doi.org/10.1080/2331186X.2024.2372188>
36. Mohamed H. The Feasibility and acceptability of a new fluorescence microscopy technology for TB diagnosis in Fragile States: a Somaliland case study (doctoral dissertation, London School of Hygiene & Tropical Medicine). <https://researchonline.lsh t m.ac.uk/id/eprint/4661822>
37. JA Egal A Essa F Osman M Klingberg-Allvin K Erlandsson 2023 Facility-based maternal deaths: their prevalence, causes and underlying circumstances. A mixed method study from the national referral hospital of Somaliland Sex Reprod Healthc. 37 100862
38. SH Ahmed J Kiruja A Solieman CK Wangamati 2023 Health research systems in Somaliland: a qualitative study on perspectives of government and non-governmental staff Front Health Serv 3 1225141 <https://doi.org/10.3389/frhs.2023.1225141/full>
39. Buckley J, O'Neil L, Aden M. Assessment of the private health sector in Somaliland, Puntland and south central. <https://ww w.academia.edu/download/96962586/Assessment-of-the-Private-Health-Sector-in-Somaliland-Puntland-and-South-Centr al.pdf>
40. Heen EK, Størdal K, Abdi A, Walmann F, Lundebj KM. Facility-based care of small and sick newborns: experiences with establishing a neonatal special care unit in Somaliland. J Glob Health Rep (JoGHR). 2022; 6:e2022015. <https://doi.org/10.29 392/001c.33619>
41. Dahir HM, Osiri JO, Hassan MS, Korse AH, Ibrahim KA. Factors affecting vaccine cold chain management practices in public health facilities in Hargeisa, Somaliland. Preprint; Posted on 4 Jan 2025, by Amoud University Researchers. Document link: <https://www.authorea.com/doi/pdf/10.22541/au.173599406.68080590> <https://doi.org/10.22541/au.173599406.68080590>
42. A Aggarwal H Aeran M Rathee 2019 Quality management in healthcare: the pivotal desideratum J Oral Biol Craniofac Res 9 2 180 182
43. Wikipedia contributors. Avedis Donabedian. Wikipedia, The free encyclopedia. Available from: https://en.wikipedia.org/wiki/Avedis_Donabedian [cited 30 Dec 2024].
44. A Donabedian 1966 Evaluating the quality of medical care Milbank Memor Fund Q 44 3 166 206
45. MRA Mohammad 2006 The impact of organizational culture on the successful implementation of total quality management TQM Magaz 18 6 606 625 <https://doi.org/10.1108/09544780610707101/full/html>
46. EA Al-Shdaifat 2015 Implementation of total quality management in hospitals J Taibah Univ Med Sci 10 4 461 466
47. Mahmed SM, Elfaki TE, Abdalla AM. The impact of accreditation on laboratories performance regarding ISO/IEC 17025: 2017 (a case study: nano for measurement and calibration center, Khartoum State-Sudan). https://www.researchgate.net/profile/Ammar-Abdalla/publication/351267081_The_Impact_of_Accreditation_on_Laboratories_Performance_Regardin g_ISOIEC_170252017_A_Case_Study_Nano_for_Measurement_and_Calibration_Center_Khartoum_State-Sudan/links/60 8e5fe2299bf1ad8d70013a/The-Impact-of-Accreditation-on-Laboratories-Performance-Regarding-ISO-IEC-170252017-A-C ase-Study-Nano-for-Measurement-and-Calibration-Center-Khartoum-State-Sudan.pdf

48. Africa CDC. Somalia's lab plan prioritizes better diagnostics and supplies [Interent]. Laboratory systems and networks theme, central Africa, Eastern Africa, Northern Africa, Southern Africa, Western Africa; 2024 [cited 1 Dec 2024]. Available from: [https://africacdc.org/news-item/somalias-lab-plan-prioritizes-better-diagnostics-and-supplies/#:~:text=Somalia's%20plan%2C%20tailored%20to%20the,Health%20Regulations%20\(IHR%202005\).](https://africacdc.org/news-item/somalias-lab-plan-prioritizes-better-diagnostics-and-supplies/#:~:text=Somalia's%20plan%2C%20tailored%20to%20the,Health%20Regulations%20(IHR%202005).)
49. K Diaconu J Falconer A Verbel A Fretheim S Witter 2021 Paying for performance to improve the delivery of health interventions in low-and middle-income countries *Cochrane Database Syst Rev* <https://doi.org/10.1002/14651858.CD007899.pub3/abstract>
50. Ngubo MA. The effect of human factors on the implementation of accreditation in the medical laboratories in KwaZulu-Natal (Doctoral dissertation). https://openscholar.dut.ac.za/jspui/bitstream/10321/4059/3/Ngubo_MA_2021.pdf
51. M Matovu E Musiime P Olak M Mulindwa E Namisango K Songwe 2022 Impact of accreditation on health care services performance in Kiryandongo district, Uganda: a longitudinal study *BMC Health Serv Res* 22 1 174 <https://doi.org/10.1186/s12913-022-07603-4>
52. MA Okezie MC Adeyeye SJ Byrn VO Abiola KL Clase 2020 Impact of ISO/IEC 17025 laboratory accreditation in sub-Saharan Africa: a case study *BMC Health Serv Res* 20 1 9 <https://doi.org/10.1186/s12913-020-05934-8>
53. Mohamed Abdiweli, 2025. Wake-up call: the impact of USAID cuts on Somali humanitarian professionals and the shift toward entrepreneurship [Online article]. <https://www.linkedin.com/pulse/wake-up-call-impact-usaid-cuts-somali-humanitarian-shift-abdiweli-0r15f/>
54. USAID Org. Congressional Budget Justification, 2020. Foreign operation; appendix 2. [Online document]. <https://2021-2025.state.gov/wp-content/uploads/2019/05/State-and-USAID-Appendix-2.pdf>. [cited 2 May 2025].
55. USAID. Providing \$40,000,000 in total funding: welcomes applications from NPOs and civic groups, 2024. [website] <https://www2.fundsfornpos.org/latest-funds-for-ngos/usaid-providing-40000000-in-total-funding-welcomes-applications-from-npos-and-civic-groups/>. [cited 2 May 2025].
56. Donor Tracker, an initiative by SEEK Development [Website]. Policy updates, USAID provides US\$29 million in additional support to Somalia. The Donor tracker team who regularly brings the most important policy and funding news across issue areas in the form of Policy Updates [cited 2 May 2025]. https://donortracker.org/policy_updates?policy=usaid-provides-us-29-million-in-additional-support-to-somalia-2024%E2%80%AC
57. DTGlobal. Somalia: Building sustainable private sector healthcare financing and service networks, 2025 [Website]. Private sector partnerships for health (PSPH) [cited 2 May 2025]. <https://dt-global.com/projects/psph/>
58. World Bank Group. Improving healthcare services in Somalia (DAMAL CAAFIMAAD) project, 2023. Consulting service: public private partnership specialist [Website]. Federal government of Somalia, ministry of health and human services [cited 2 May 2025]. Link: <https://projects.worldbank.org/en/projects-operations/procurement-detail/OP00231423#:~:text=Closely%20working%20with%20and%20coordinating,time%20by%20the%20Director%20General>
59. BEAM Exchange. PSPH: private sector partnerships in health, 2023 [Website]. <https://beamexchange.org/practice/programme-index/305/>. [cited 2 May 2025].
60. United Republic of Tanzania, Ministry of Health. Community health fund (chf), operations guidelines [Online document]. <https://hssrc.tamsemi.go.tz/hssrc/storage/app/uploads/public/5ac0ad6091e68820565238.pdf#:~:text=From%20the%20Community%20Health%20Fund%20management%20perspective%2C,hospital%20costs%20of%20major%20illness%20or%20injury>
61. GONAHASA DN. Evaluation of the effectiveness of CBHIS in improving health care access in Uganda a case study of schemes in Bushenyi region. <https://asbatlibrary.s3.eu-central-1.amazonaws.com/af96fbd6-eec3-4e53-a575-d41d5c178b57-Doreen%20Nsiiire%20Gonahsa.pdf#:~:text=Community%20health%20insurance%20schemes%20are%20voluntary%20arrangements,financial%20access%20to%20health%20care%20through%20prepayment>
62. AS Said DI Kicha 2024 Implementing health system and the new federalism in Somalia: challenges and opportunities *Front Public Health* 12 1205327
63. World Health Organization. Tobacco taxation and innovative health-care financing. In: Tobacco taxation and innovative health-care financing 2012. <https://apps.who.int/iris/bitstream/handle/10665/206014/B4844.pdf?sequence=1%26isAllowed=y>
64. TF Peter PD Rotz DH Blair AA Khine RR Freeman MM Murtagh 2010 Impact of laboratory accreditation on patient care and the health system *Am J Clin Pathol* 134 4 550 555 <https://doi.org/10.1309/ajcph1skq1hnwghf>
65. Chris Lane, Evan Blecher, Janos Nagy, Ceren Ozer, Danielle Bloom and Daniel Prinz. KN1. Why health taxes matter: a mechanism to improve health and revenue outcomes, 2022 [Online document]. World Bank Group [cited 2 May 2025]. <https://documents1.worldbank.org/curated/en/099446002132366565/pdf/IDU036b3c4370c15f047e2087a3029ed3a36321f.pdf>
66. L Deigh J Farquhar M Palazzo A Siano 2016 Corporate social responsibility: engaging the community *J Cetacean Res Manag* 19 2 225 240 <https://doi.org/10.1108/QMR-02-2016-0010>
67. FundForNGOs. The role of local philanthropy in replacing international aid, 2025 [Website]. <https://www2.fundsfornpos.org/articles/the-role-of-local-philanthropy-in-replacing-international-aid/>. [cited 2 May 2025].
68. Robin Waite. Giving back: the role of philanthropy and social responsibility in entrepreneurship, 2025 [Website]. <https://www.robinwaite.com/blog/giving-back-the-role-of-philanthropy-and-social-responsibility-in-entrepreneurship>. [cited 2 May 2025].
69. Brenda Salles. Corporate philanthropy: best practices & how to start, 2025 [Online article]. Otimy website, Blogs, CSR. <https://www.optimy.com/blog-optimy/corporate-philanthropy>. [cited 2 May 2025].
70. Hongoro C, Normand C. Health workers: building and motivating the workforce. <https://www.ncbi.nlm.nih.gov/books/NBK11730/>. [cited 2 May 2025].
71. S Noor MH Shaheen M Shaheen 2016 Economic empowerment through human capital, social development and poverty control strategies-a case study of Bagh district (AJ&K) *Kashmir Econ Rev*. 25 2 17 29
72. World Health Organization. Working for health and growth: investing in the health workforce. In: Working for health and growth: investing in the health workforce 2016. <https://iris.who.int/bitstream/handle/10665/250047/9789241511308-eng.pdf>
73. World Bank Group. Investing in health is key to job creation and economic growth [Website]. <https://www.worldbank.org/en/news/immersive-story/2025/04/07/investing-in-health-is-key-to-job-creation-and-economic-growth>. [cited 2 May 2025].

74. McPake B, Dayal P, Zimmermann J, Williams GA. What steps can improve and promote investment in the health and care workforce. Enhancing efficiency of spending and rethinking domestic and international financing. Policy Brief. 2023; 54. Print ISSN 1997-8065. Web ISSN 1997-8073. The European Observatory has an independent programme of policy briefs and summaries which are available here: <https://eurohealthobservatory.who.int/publications/policy-briefs>. Document link: https://futohealth.org/wp-content/uploads/2023/04/EObs_WHO_2023_GlobalForum_Investment-Brief.pdf
75. A Hussain M, Umair S, Khan WB, Alonazi SS, Almutairi A, Malik 2024 Exploring sustainable healthcare: innovations in health economics, social policy, and management Heliyon. <https://doi.org/10.1016/j.heliyon.2024.e33186>
76. A Haleem M, Javaid RP, Singh R, Suman 2021 Telemedicine for healthcare: capabilities, features, barriers, and applications Sensors Int 1 2 100117 <https://doi.org/10.1016/j.sintl.2021.100117>
77. PA Anawade D, Sharma S, Gahane PA, Anawade Sr DS, Sharma 2024 A comprehensive review on exploring the impact of telemedicine on healthcare accessibility Cureus. <https://doi.org/10.7759/cureus.55996>
78. DC Gonçalves-Bradley AR, Maria I, Ricci-Cabello G, Villanueva MS, Fønhus C, Glenton S, Lewin N, Henschke BS, Buckley GL, Mehl T, Tamrat 2020 Mobile technologies to support healthcare provider to healthcare provider communication and management of care Cochrane Database Systemat Rev. <https://doi.org/10.1002/14651858.CD012927.pub2>
79. El Nwankwo EV, Emeihe MD, Ajegbile JA, Olaboye CC, Maha 2024 Integrating telemedicine and AI to improve healthcare access in rural settings Int J Life Sci Res Arch. 7 1 59 77 <https://doi.org/10.53771/ijlsra.2024.7.1.0061>
80. Tarun Nagar. How much does healthcare software development cost in 2023 [Online article]. <https://devtechnosys.ae/blog/healthcare-software-development-cost/#:~:text=3.%20Telemedicine%20and%20Consultation%20Fees%20Integrate%20Telemedicine,charged%20for%2C%20generating%20revenue%20and%20providing%20convenience>
81. MM Ahmed NI, Dirie AK, Mohamud AH, Elmi SS, Musa OA, Alhammadi MA, Lemma J, Uwachahoro R, Bananeza Y, Abdullahi ZK, Othman 2024 Advancing digital healthcare in Somalia: a review of modern technologies and their implications BMC Digital Health 2 1 1 6 <https://doi.org/10.1186/s44247-024-00111-x>
82. ZK Othman SS, Musa MM, Ahmed OJ, Okesanya OA, Alhammadi DL, Eliseo 2025 Digital health technologies in Kurdistan region of Iraq: a narrative review of enhancing healthcare accessibility and quality Discov Public Health 22 1 1 3 <https://doi.org/10.1186/s12982-025-00648-w>
83. OA Alhammadi HI, Mohamed SS, Musa MM, Ahmed MA, Lemma U, Joselyne B, Roméo Y, Abdullahi ZK, Othman MR, Hamid O, Kasimieh 2024 Advancing digital health in Yemen: challenges, opportunities, and way forward Expl Digital Health Technol. 2 6 369 386
84. Productivity Commission 2024, Leveraging digital technology in healthcare, Research paper, Canberra. ISBN 978-1-74037-790-4 (online) ISBN 978-1-74037-789-8 (print). <https://www.pc.gov.au/research/completed/digital-healthcare/digital-healthcare.pdf#:~:text=If%20implemented%20well%2C%20digital%20technologies%20such%20as,and%20make%20care%20more%20convenient%20for%20patients>
85. Case study on the digitalisation of health (eHealth). https://commission.europa.eu/document/download/652a3175-d410-4608-8f0e-642049433c35_en?filename=case-study-on-the-digitalisation-of-health-ehealth.pdf
86. FundForNGOs. What role does transparency and accountability play in securing CSR funding, 2025 [Website]. <https://www.fundforngos.org/all-questions-answered/what-role-does-transparency-and-accountability-play-in-securing-csr-funding/>. [cited 2 May 2025].
87. R Krah G, Mertens 2023 Financial transparency, trust and willingness to pay in local governments of sub-Saharan Africa J Public Budg Account Manag 35 6 100 120 <https://doi.org/10.1108/JPAFM-06-2022-0110>
88. P Anjani 2023 Enhancing transparency and trust through effective financial statement audits Adv Manag Audit Res. 1 3 103 113 <https://doi.org/10.60079/amar.v1i3.228>
89. MO Ezech AD, Ogbu AH, Ikevuje EP, George 2024 Stakeholder engagement and influence: strategies for successful energy projects Int J Manag Entrepreneurship Res. 6 7 2375 2395 <https://doi.org/10.51594/ijmer.v6i7.1330>
90. United Nations Development Programme. Best practices for promoting transparency
91. At the Local Level, 2011 [Book]. Link: <https://www.local2030.org/library/108/Best-Practices-for-Promoting-Transparency-at-the-Local-Level.pdf>
92. FundForNGOs. Why Transparency and accountability are key to securing assured grants, 2025 [Website]. <https://www2.fundforngos.org/articles-searching-grants-and-donors/why-transparency-and-accountability-are-key-to-securing-assured-grants/>. [cited 2 May 2025].
93. N Balci M, Aksaraylı P, Tuncel GT, Bakırcı 2021 Accreditation impact on service quality in medical laboratories: university hospital staff viewpoints Hacettepe Sağlık İdaresi Dergisi. 24 4 729 746
94. B Mesganaw A, Fenta Z, Hibstu H, Belew K, Misganaw M, Belayneh 2023 Medical laboratories quality management and challenges in Ethiopia: a systematic review Pathol Lab Med Int 31 13 26 <https://doi.org/10.2147/PLMI.S395895>
95. Eshetu G. Quality assurance initiative and organizational performance: the case of Ethiopian standard agency, Addis Ababa Ethiopia. Addis Ababa Ethiopia (10 Nov 2023). 2023. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4629408
96. Godfrey Partridge, inventor, American National Standards Institute-ANSI, USA administrative authority for ISO. Business management quality standards (BMS) standard appendix a correlation and cross reference with ISO9001:2015). United Kingdom, Kidderminster in Worcestershire. Issued Aug 31, 2015. Updated to business management standards; BMS: 75000, 2020; Cross reference with ISO9001: 2015. Available from: https://www.bms75k.co/_files/ugd/586bec_656bf4451a444e9d863e4f5e3623f443.pdf?index=true
97. Q-Share International Ltd. Standard and specification for business management systems; executive summary of BMS75000:2020 Issue 1 Revision B [Internet]. United Kingdom, Kidderminster in Worcestershire, Q-Share International Ltd; 2020 [cited 25 Dec 2024]. Available from: <https://www.bms75k.co/>
98. E Ahmet E, Adem 2023 The impact of laboratory accreditation in patient safety and quality care J Bras Patol Med Lab. 59 16 23
99. SYTECH. Promoting quality standards: the importance of ISO17025 accreditation [Website]. <https://sytech-consultants.co.uk/promoting-quality-standards-the-importance-of-iso17025-accreditation/>. [cited 2 May 2025].
100. ISO/IEC 17025. Testing and calibration laboratories [Website]. <https://www.iso.org/ISO-IEC-17025-testing-and-calibration-laboratories.html#:~:text=ISO/IEC%2017025%20enables%20laboratories,nationally%20and%20around%20the%20world.> [cited 2 May 2025].

101. Lab People, Inc. Importance of ISO 17025 accreditation for laboratories, 2025 [Website]. <https://www.labpeople.com/the-importance-of-iso-17025-accreditation-for-laboratories/#:~:text=Laboratories%20accredited%20to%20the%20standard,enhancing%20the%20credibility%20of%20results>. [cited 2 May 2025].
102. SimplerQMS, Bruna DLC. Healthcare quality management system (QMS), 2025 [Online article]. <https://simplerqms.com/healthcare-quality-management-system/#:~:text=Compliance%20with%20ISO/IEC%2017025:2017%20ensures%20that%20testing,in%20diagnosis%2C%20treatment%20decisions%2C%20and%20patient%20care>. [cited 2 May 2025].
103. Austin A. Health IT test 2, 2025 [Website]. <https://quizlet.com/194290208/health-it-test-2-flash-cards/>. [cited 2 May 2025].
104. G Guevara K Parris R Albalak G Alemnji F Gordon Y Irving I Whymys S Beckles T Maruta N Ndlovu 2016 The impact of SLMTA in improving laboratory quality systems in the Caribbean region *Afr J Lab Med* 5 2 1 9 <https://doi.org/10.4102/ajlm.v5i2.199>
105. TS Manickam S Ankanagari 2015 Evaluation of quality management systems implementation in medical diagnostic laboratories benchmarked for accreditation *J Med Lab Diagnosis* 6 5 27 35 <https://doi.org/10.5897/JMLD2015.0104>
106. -Ramly EF, Ramly ES, Yusof SR. Effectiveness of quality management system audit to improve quality performance—A conceptual framework. In: Fifth international conference on quality and reliability (ICQR 2007), Chiang Mai, Thailand 2007. https://www.researchgate.net/publication/267400023_Effectiveness_of_Quality_Management_System_audit_to_improve_quality_performance_-_A_conceptual_framework
107. AS Chaudhry Y Inata E Nakagami-Yamaguchi 2023 Quality analysis of the clinical laboratory literature and its effectiveness on clinical quality improvement: a systematic review *J Clin Biochem Nutr.* 73 2 108 115 <https://doi.org/10.3164/jcbn.23-22>
108. M Beyanga L Gerwing-Adima K Jackson B Majaliwa H Shimba S Ezekiel C Massambu D Majige M Mwasegaka W Mtetela P Mateta 2018 Implementation of the laboratory quality management system (ISO 15189): experience from Bugando medical centre clinical laboratory-Mwanza Tanzania *Afr J Lab Med* 7 1 1 6 <https://doi.org/10.4102/ajlm.v7i1.657>
109. Godavari D. Implementing QMS in medical laboratory: a comprehensive guide, 2024 [Website]. <https://blog.creliehealth.com/a-comprehensive-guide-to-implementing-qms-in-medical-laboratories/>. [cited 4 May 2025].
110. NC Ifudu Z Ekeocha S Byrn K Clase 2023 Continual improvement in laboratory quality management system of a regulatory laboratory in West Africa *Proc BIRS Commun.* 1 1 9
111. The College of American Pathologists. Laboratory accreditation program, 2025 [Website]. <https://www.cap.org/laboratory-improvement/accreditation/laboratory-accreditation-program#:~:text=CAP%20Laboratory%20Accreditation%20helps%20laboratories,from%20CLIA%2C%20FDA%20and%20OSHA>. [cited 4 May 2025].
112. T Zima 2017 Accreditation of medical laboratories—system, process, benefits for labs *J Med Biochem* 36 3 231 <https://doi.org/10.1515/jomb-2017-0025>
113. National Accreditation Board for Testing and Calibration Laboratories. NABL accreditation in India. Explore meaning, process and benefits, 2024 [Website]. <https://www.bajajfinserv.in/all-about-nabl#:~:text=Importance%20of%20NABL%20accreditation%26text=Demonstrates%20compliance%20with%20international%20standards,in%20testing%20and%20calibration%20services>. [cited 5 May 2025].
114. V Rusanganwa I Nzabahimana M Evander 2024 Quality and resilience of clinical laboratories in Rwanda: a need for sustainable strategies *Glob Health Action* 17 1 2358633 <https://doi.org/10.1080/16549716.2024.2358633>
115. Operational Plan Report FY 2010. FACTS Info v3.8.3.30. <https://www.state.gov/wp-content/uploads/2019/08/Rwanda-7.pdf>
116. Kayobotsi C. Laboratory quality management systems towards accreditation in Rwanda: a case study of selected laboratories in Rwanda (Doctoral dissertation, University of Rwanda). <https://dr.ur.ac.rw/bitstream/handle/123456789/194/Claver%20Kayobotsi.pdf?sequence=1%26isAllowed=y>
117. S Attoh IT Kodjoe C Boateng AM Yakubu LX Adusu-Donkor J Bofo PN Matey S Kwao J Ani-Amponsah E Sarkodie K Boaheng 2020 Lessons Learnt of the first public sector ISO 15189 accredited laboratory in Ghana *Postgr Med J Ghana.* 9 1 25 30

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