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REVIEW

Global health development aid initiatives and the quality of medical laboratory services in sub-Saharan Africa: a narrative review

Hazel Musuka[a], Oscar Mano[b,*], Patrick Gad Iradukunda[c], Gashema Pierre[d], Ferris Tatenda Munyonho[b], Enos Moyo[e], Tafadzwa Dzinamarira[f]

[a] School of Medicine, Medical Science and Nutrition, University of Aberdeen, Aberdeen, UK
[b] Department of Medical Laboratory Sciences, University of Zimbabwe, Harare, Zimbabwe
[c] Rwanda Food and Drug Authority, Kigali, Rwanda
[d] College of Medicine and Health Sciences, University of Rwanda, Kigali, Rwanda
[e] School of Nursing and Public Health, Faculty of Medicine and Health Sciences, University of KwaZulu Natal, Durban, South Africa
[f] School of Health Systems & Public Health, University of Pretoria, Pretoria, South Africa

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ABSTRACT

Background: Medical laboratory diagnostic services play a critical role in the diagnosis, treatment, and management of diseases, forming the cornerstone of effective healthcare systems. Despite the crucial role of laboratory services, the quality and accessibility of medical laboratory services in sub-Saharan Africa (SSA) face significant challenges. Global health development aid has been pivotal in supporting SSA laboratory services. This study aimed to examine global health development aid initiatives that have successfully enhanced the quality of medical laboratory services and the challenges and barriers to effectively improving medical laboratory services through global health development aid in SSA.

Methods: We used a narrative review study design. We searched PubMed, Web of Science and Scopus for articles published in the last 15 years. These three databases are generally considered premier databases for peer-reviewed articles in global health, public health, health systems, and biomedical sciences. The inclusion criteria for this review included research studies, reports, and grey literature. Only articles published in English from 2010 onward were considered. The analysis followed a qualitative approach, emphasizing thematic synthesis and critical interpretation.

Results: Forty articles were included in this study. Of these, 18 were primary research studies, 11 were reports, 7 were commentaries, and 4 were reviews. Five sub-themes from the successful global health development aid initiative themes were capacity building and training programs, infrastructure development, partnership models, policy advocacy and regulatory support, quality control and standardization of laboratory services. The sub-themes from the challenges and barrier theme were insufficient funding and resource allocation, human resource constraints, inadequate infrastructure and equipment, and political and institutional barriers. This review revealed that several factors, including financial sustainability, human resource capacity, institutional support, resilience, and effective monitoring systems, shape the sustainability of improvements in medical laboratory services in SSA.

Conclusion: Achieving long-term sustainability requires strategies that ensure financial self-sufficiency, foster a skilled and stable workforce, and integrate laboratory services into national health frameworks.

1. Introduction

Medical laboratory diagnostic services play a critical role in the diagnosis, treatment, and management of diseases, forming the cornerstone of effective healthcare systems.[1] Accurate and timely laboratory diagnostics are essential for guiding clinical decision-making, improving patient outcomes, and preventing the spread of infectious diseases.[2–4] They are particularly crucial in the context of sub-Saharan Africa (SSA), where the burden of infectious diseases is high and where access to healthcare resources is often limited.[5]

Despite the critical role of laboratory services, the quality and accessibility of medical laboratory services in SSA face significant chal-

* Corresponding author.
E-mail address: oscarmano98@gmail.com (O. Mano).

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lenges. Many countries in the region struggle with inadequate infrastructure, lack of trained personnel, insufficient quality control, and limited access to essential diagnostic equipment and reagents.[4,6–8] These limitations often result in delayed diagnoses, misdiagnoses, and poor treatment outcomes. Despite these challenges, the region has reported some successes over the years, such as the growing efforts to improve laboratory training, the emergence of regional laboratory networks, and the increasing adoption of innovative technologies aimed at enhancing diagnostic capacity.[9–12]

In SSA, global health development aid has been pivotal in supporting health systems, including laboratory services. Over the years, international donors, development agencies, and non-governmental organizations have invested in strengthening health systems across SSA,[13] with a significant focus on improving medical laboratory services. These initiatives include investments in infrastructure, capacity building, and the provision of essential diagnostic equipment and reagents. While such interventions have yielded positive outcomes, concerns remain about their long-term sustainability and the overall impact on healthcare systems.[14,15]

Sustainability is a critical concern in the context of development aid. Short-term projects and interventions may lead to improvements, but the benefits can be fleeting without long-term strategies for capacity building, financial support, and local ownership. Ensuring that improvements in medical laboratory services are sustained beyond the duration of aid projects is vital for fostering self-reliant healthcare systems in SSA. To ensure the long-term sustainability of laboratory services in SSA, it is essential to adopt a comprehensive approach that addresses the underlying challenges. This includes building robust health systems, investing in human resources, and establishing sustainable financing mechanisms.[15,16]

This narrative review examines the impact of global health development aid initiatives on the quality of medical laboratory services in SSA. Specifically, the review will address two research questions: (1) What specific global health development aid initiatives have successfully enhanced the quality of medical laboratory services in SSA? (2) What are the challenges and barriers to effectively improving medical laboratory services through global health development aid in SSA?

2. Methods

This narrative review was conducted to explore the impact of global health development aid initiatives on the quality of medical laboratory services in SSA. The review aimed to synthesize existing literature, critically interpret findings, and identify successful interventions and challenges in improving laboratory services through aid initiatives. The methods followed the standard approach for narrative reviews as recommended by Ferrari,[17] which is flexible and allows for an in-depth, subjective analysis of diverse studies.

2.1. Study design

This study employed a narrative review design, chosen for its flexibility and ability to synthesize a wide range of research across diverse disciplines. A narrative review was particularly suited for this topic as we aimed to capture multiple perspectives and interdisciplinary approaches necessary to understand the complexity of global health development aid toward strengthening the quality of medical laboratory services in SSA. Unlike systematic reviews, which rely on strict inclusion criteria and predefined search protocols, the narrative approach allows for a broader exploration of available literature, including both empirical and theoretical studies.[18]

2.2. Clarity of boundaries, scope, and definitions

The scope of this narrative review was clearly defined by focusing on global health development aid initiatives and their role in enhancing medical laboratory services in SSA. The literature included studies, reports, and articles on aid interventions to improve the region's laboratory infrastructure, training, diagnostic capabilities, and overall service quality. Global health development aid was defined as any form of international assistance provided to improve health outcomes, including financial, technical, and humanitarian aid directed toward strengthening health systems and services.[19] Medical laboratory services were defined as a broad category encompassing diagnostic laboratory functions, infrastructure, equipment, human resources, and processes that support healthcare delivery.[20] The geographical context was defined as SSA. The review focused on initiatives from global health organizations, bilateral and multilateral agencies, governments, and non-governmental organizations working within SSA.

2.3. Inclusion and exclusion criteria

The inclusion criteria for this review included research studies, reports, and grey literature (e.g., program evaluations and policy documents) addressing global health development aid initiatives aimed at improving medical laboratory services in SSA. Publications discussing successes and barriers to strengthening laboratory services through aid programs were considered. Only articles published in English from 2010 onward were considered, reflecting the most current understanding and interventions in the field.

Exclusion criteria included studies not directly related to medical laboratory services or those focused on other aspects of health infrastructure. Articles not relevant to SSA or those focused on global health aid in other regions were also excluded. Unless they provided new theoretical insights or frameworks relevant to the review questions, opinion pieces were excluded. Non-peer-reviewed materials, unless they were major reports from reputable organizations, were also excluded.

2.4. Search strategy

Table 1 presents the search strategy used for each major database searched and the number of articles retrieved.

2.5. Reflexivity and criteria for saturation/sufficiency

A key characteristic of narrative reviews is reflexivity, which acknowledges the influence of the researchers' perspectives and experiences in shaping the selection, analysis, and interpretation of literature.[21] In conducting this review, the authors' prior knowledge of global health initiatives, experience in medical laboratory services, and perspectives on aid effectiveness shaped the interpretation of the findings. The authors were mindful of these biases throughout the review process, ensuring a broad and balanced range of literature was included.

Regarding saturation, the review aimed for thematic sufficiency rather than exhaustive inclusion of all available studies.[22] As the literature search progressed, the team identified recurrent themes and patterns related to successful aid interventions and challenges in improving laboratory services. Once these themes were sufficiently represented in the literature, further additions to the review were deemed unnecessary. While the review does not claim to capture every piece of literature on the topic, the selected studies were deemed adequate to address the research questions and provide a meaningful synthesis of the evidence.

2.6. Analysis and interpretation of findings

The analysis followed a qualitative approach, emphasizing thematic synthesis and critical interpretation. The literature was reviewed iteratively, with findings categorized into broad themes based on the research questions. For each theme, various authors and organizations examined various studies to identify key insights, challenges, and solutions. First, key findings from selected studies were extracted, including details on the scope, objectives, methods, and outcomes of global health

Table 1
The literature search strategy per database.

Database	Search strategy	Number of articles retrieved
PubMed	("Medical Laboratory Services"[Mesh] OR "clinical laboratory services" OR "medical laboratories" OR "diagnostic services" OR "laboratory diagnostics") AND ("Health Aid"[Mesh] OR "International Cooperation"[Mesh] OR "Foreign Aid"[Mesh] OR "Global Health"[Mesh] OR "Development Assistance" OR "donor funding" OR "international development aid" OR "health development aid" OR "donor-supported programs" OR "bilateral aid" OR "multilateral aid") AND ("Africa South of the Sahara"[Mesh] OR "sub-Saharan Africa" OR "Africa, Eastern" OR "Africa, Western" OR "Africa, Southern" OR "SSA" OR "Angola" OR "Botswana" OR "Burkina Faso" OR "Burundi" OR "Cameroon" OR "Chad" OR "Congo" OR "Democratic Republic of the Congo" OR "Ethiopia" OR "Gabon" OR "Ghana" OR "Ivory Coast" OR "Kenya" OR "Lesotho" OR "Liberia" OR "Madagascar" OR "Malawi" OR "Mali" OR "Mozambique" OR "Namibia" OR "Niger" OR "Nigeria" OR "Rwanda" OR "Senegal" OR "Sierra Leone" OR "Somalia" OR "South Africa" OR "South Sudan" OR "Tanzania" OR "Togo" OR "Uganda" OR "Zambia" OR "Zimbabwe")	276
Web of Science	TS=("medical laboratory services" OR "clinical laboratory services" OR "laboratory diagnostics" OR "diagnostic laboratory" OR "medical laboratories") AND TS=("development aid" OR "development assistance" OR "health development aid" OR "foreign aid" OR "donor funding" OR "international cooperation" OR "global health funding" OR "international development programs" OR "external funding") AND TS=("sub-Saharan Africa" OR "SSA" OR "Africa South of the Sahara" OR "East Africa" OR "West Africa" OR "Southern Africa" OR "Central Africa"	83

aid initiatives related to medical laboratory services. Second, the findings were grouped into thematic categories aligned with the research questions. These included successes, challenges and barriers, and implications for sustainability. The successful intervention's theme examined aid programs that contributed to enhancing medical laboratory services. Challenges and barriers theme identified the factors limiting aid effectiveness in improving quality laboratory services. Third, the authors provided an interpretive analysis at the interpretation stage, drawing on both the literature and their perspectives to synthesize the findings. This involved critically evaluating the effectiveness of different initiatives, recognizing limitations, and suggesting areas for future research or improvement. Finally, a narrative synthesis was constructed, summarizing the key insights, challenges, and successes identified across studies. The interpretation also included recommendations for future global health initiatives and locally led solutions focused on improving laboratory services in SSA.

3. Results

3.1. Study screening

Initial search yielded a total of 406 articles. Of these, 359 were from electronic databases and 47 were from organizational websites and citation searching. More details on the screening steps are presented in Fig. 1. A total of 40 articles were included in this review. Of these, 18 were primary research studies,[23–40] 11 reports,[41–51] 7 commentaries[52–58] and four reviews.[3,59–61] More details on the characteristics of the studies included are presented in Table 2.

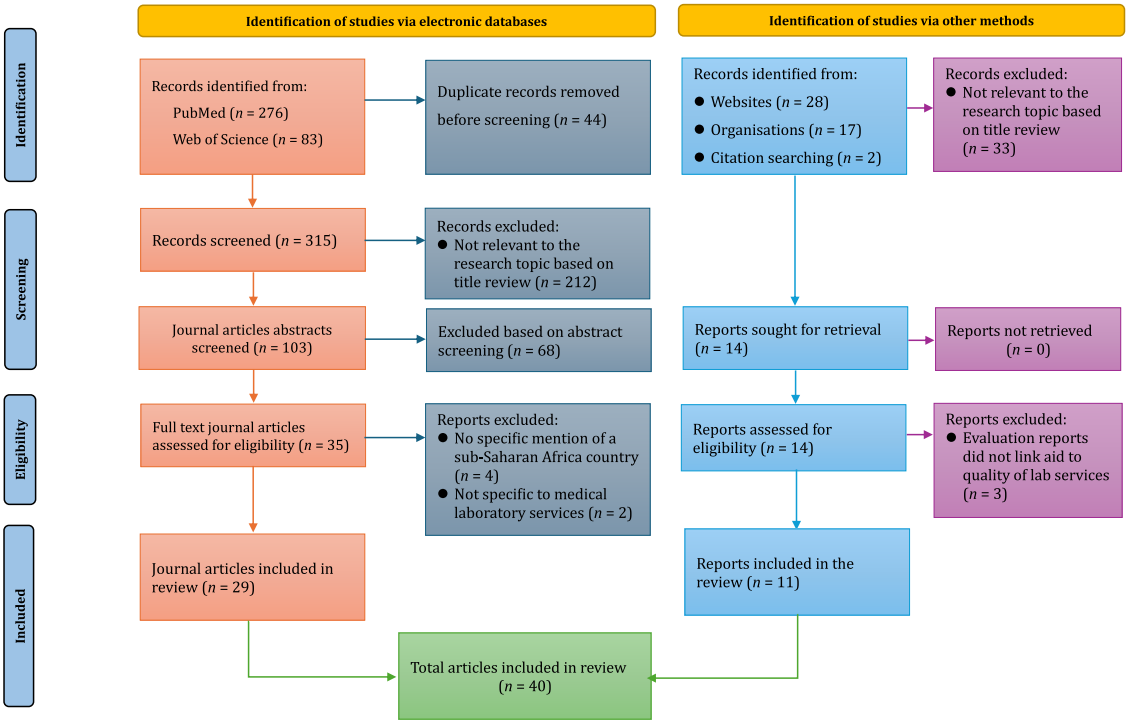

Fig. 1. PRISMA flow diagram.

Table 2
Characteristics of included studies.

Reference	First author, year	Country/Region	Article type
[3]	Obeagu EI, 2024	Uganda	Review
[23]	Hamel DJ, 2015	Nigeria	Primary research
[24]	Shrivastava R, 2023	Africa	Primary research
[25]	Abimiku AG, 2009	Nigeria	Primary research
[26]	Shrivastava R, 2021	SSA	Primary research
[27]	Ndlovu N, 2024	Africa	Primary research
[28]	Kebede Y, 2016	Ethiopia	Primary research
[29]	Yao K, 2016	Africa	Primary research
[30]	Yao K, 2010	Africa	Primary research
[31]	Garcia A, 2014	LMIC	Primary research
[32]	Dama E, 2020	Burkina Faso	Primary research
[33]	Cobbina E, 2012	Ghana	Primary research
[34]	Odhiambo CO, 2023	SSA	Primary research
[35]	Chiliza J, 2021	South Africa	Primary research
[36]	Banigbe B, 2019	Nigeria	Primary research
[37]	Duah E, 2022	Ghana	Primary research
[38]	Umutesi G, 2021	Rwanda	Primary research
[39]	Ondoa P, 2020	Africa	Primary research
[40]	Oyando R, 2023	Kenya	Primary research
[41]	Centers for Disease Control and Prevention, 2024	Africa	Report
[42]	Sexton C, 2020	Eswatini	Report
[43]	Dacombe R, 2016	LMIC	Report
[44]	Mwaikambo, 2011	Nigeria	Report
[45]	Kumar ML, 2016	East Africa	Report
[46]	Chelsea S, 2024	Global	Report
[47]	Schneidman M, 2023	Africa	Report
[48]	Ndihokubwayo JB, 2016	Africa	Report
[49]	The Global Fund, 2024		Report
[50]	MOH Ghana, 2020	Ghana	Report
[51]	World Health Organization, 2021	Africa	Report
[52]	Sturchio JL, 2012	Africa	Commentary
[53]	Nkengasong J, 2018	Africa	Commentary
[54]	Moon TD, 2010	Mozambique	Commentary
[55]	Acheampong G, 2021	Ghana	Commentary
[56]	Tawad FK, 2020	South Sudan	Commentary
[57]	Nkengasong J, 2018	LMIC	Commentary
[58]	Glynn EH, 2021	Africa	Commentary
[59]	Alemnji G, 2014	SSA	Review
[60]	Swiswa S, 2022	Zimbabwe	Review
[61]	Amukele T, 2017	Africa	Review

3.2. Theme 1: successful global health development aid initiatives

Five sub-themes emerged from this theme—capacity building and training programs, infrastructure development, partnership models, policy advocacy and regulatory support, and quality control and standardization of laboratory services.

3.2.1. Capacity building and training programs

Training and capacity building have been cornerstones of many successful global health development aid initiatives to improve medical laboratory services in SSA. Effective laboratory services require skilled personnel, including medical laboratory technicians, laboratory managers, and other healthcare professionals. However, a significant challenge in SSA has been the lack of trained personnel and the inability to retain skilled staff.

Programs like those supported by the United States President's Emergency Plan for Acquired Immune Deficiency Syndrome Relief (PEPFAR) have made substantial investments in building the capacity of laboratory personnel in SSA.[24,26,53] For instance, with PEPFAR funding, US Centers for Disease Control and Prevention (CDC) has worked with governments and implementing partners to train medical laboratory staff in more than 8000 laboratories in over 20 SSA countries.[43] These training initiatives aim to improve diagnostic testing and laboratory management in the context of HIV, TB, and other infectious diseases. The PEPFAR-funded laboratory training programs provide on-the-job training for laboratory technicians, focusing on areas such as HIV diagnostics, quality assurance, and biosafety. These trainings have been linked to improved quality of laboratory services in multiple countries, including Nigeria,[23] Eswatini[42] and many other countries.[24] The Fleming Fund, a UK aid program supporting countries across Africa and Asia to strengthen surveillance for antimicrobial resistance, builds skilled public workforce capacity through its Fellowship Scheme in 20 low-to-middle-income-countries.[46]

Global health aid has also invested in the continuous professional development of laboratory staff through the establishment of multiple Quality Assurance Programs in the region.[27] These programs help laboratory professionals stay updated on the latest technologies and best practices. In Nigeria, United States Agency for International Development (USAID) has supported continuous professional development initiatives that involve online training modules and in-person workshops to improve laboratory staff knowledge in areas such as molecular diagnostics, quality control, and laboratory safety.[44]

Global health development aid has also facilitated the organization of regional training workshops. The World Bank funded the East Africa Public Health Laboratory Networking Project support for training laboratory staff in Kenya, Uganda, Tanzania, Rwanda, and Burundi, helping establish national certification programs that meet international standards.[45] These programs often included workshops on disease surveillance, laboratory data management, and proficiency testing, providing recognized certifications.[45] Another notable output of global health development aid was the establishment of the African Society for Laboratory Medicine with PEPFAR support to represent the interests of laboratory workers and advance the standards of the laboratory profession.[47]

3.2.2. Infrastructure development

Infrastructure development is crucial for enhancing laboratory services, particularly in SSA, where outdated facilities and a lack of equipment have hindered service delivery.

3.2.2.1. Laboratory equipment and facility upgrades. The Gates Foundation has played a significant role in providing diagnostic equipment and technologies to improve laboratory capacity. For example, the Global Fund, PEPFAR, and the Gates Foundation have supported the installation of automated diagnostic machines capable of conducting a wide range of tests, including for HIV, malaria, and tuberculosis throughout the region.[49] This has significantly reduced diagnostic turnaround times and increased testing capacity in remote and underserved regions.[25] The Global Fund has provided funding for infrastructure upgrades, including establishing new laboratory centers to strengthen the laboratory network. These upgrades included installing high-quality laboratory equipment and improving the physical environment, ensuring better working conditions for laboratory staff.

3.2.2.2. Improvement of laboratory storage and specimen transport systems. Proper storage and transportation of samples are essential for maintaining the integrity of laboratory results. Multiple global health development aid donors have partnered with various partnerships with local governments and non-governmental organizations to support the improvement of specimen storage and transport systems.[32] In Ethiopia, the USCDC supported the Ethiopian Public Health Institute (EPHI) to streamline Ethiopia's specimen referral system.[28] This collaboration leveraged the Ethiopian Postal Service to improve specimen logistics, leading to a significant reduction in turnaround time for specimen testing in both Addis Ababa and Amhara regions.[28] Notably, the average turnaround time decreased from 7 to 2 days in Addis Ababa and from 10 days to 5 days in Amhara. This achievement was facilitated by enhanced training programs for laboratory personnel and postal workers, ultimately improving access to laboratory services for a broader segment of the population.[28]

3.2.3. Partnership models

Collaboration between international donors, local governments, and aid agencies has proven essential in strengthening laboratory services. These partnerships foster the exchange of knowledge, best practices, and technical expertise.[52] The EPHI exemplifies these partnerships and integrated laboratory governance. Operating within the national health system and accountable to the Ministry of Health, EPHI focuses on health research, public health emergencies, and laboratory services. EPHI's laboratory unit strengthens the national public health laboratory network by (1) conducting research and validating diagnostics; (2) improving quality assurance; (3) supporting accreditation efforts; (4) enhancing clinical, public health, and biosecurity services; and (5) providing in-service training. EPHI collaborates with regional health bureaus and international partners, including the World Health Organization (WHO), Food and Agriculture Organization, USAID, USCDC, PEPFAR, and the World Bank.[46]

3.2.3.1. Policy advocacy and regulatory support. Policy advocacy and regulatory support are essential for ensuring that laboratory improvements are sustainable and aligned with international standards. Many global health development aid initiatives have focused on strengthening national policies and regulatory frameworks. PEPFAR has strengthened the laboratory quality control systems in several countries, including Mozambique and Uganda. These initiatives aim to develop national laboratory policies that align with the best international practices. Through its funding, PEPFAR has supported the creation of national quality assurance standards for laboratories, improving the consistency and reliability of diagnostic services in multiple SSA countries.

3.2.3.2. Regulatory frameworks and improvements in laboratory accreditation systems. The World Bank has worked with several African countries, including Ghana, to establish regulatory frameworks that enforce safety and standards for medical laboratories. This support includes the establishment of the Ghana Standards Authority, which ensures that laboratories comply with national regulations concerning laboratory safety, equipment maintenance, and the disposal of hazardous materials.[33,50] The Global Fund and PEPFAR have supported countries like South Africa in strengthening their laboratory accreditation systems. Through the South African National Accreditation System, which has received technical support from the Global Fund, laboratories can meet international accreditation standards, ensuring high-quality services and enhancing credibility with both local and international partners.[34]

3.2.4. Quality control and standardization of laboratory services

Quality control and standardization ensure that laboratory results are accurate, reliable, and comparable across different settings. Global health aid has played a key role in establishing quality assurance and standardization systems in SSA. Initiatives such as Strengthening Laboratory Management Towards Accreditation (SLMTA), backed by PEPFAR through the US CDC, and the Stepwise Laboratory Quality Improvement Process Towards Accreditation, developed by WHO regional office for Africa, assist nations in enhancing their laboratory services to achieve accreditation from a recognized accrediting body.[46,48,59] These programs are mutually supportive, with SLMTA delivering training and the Stepwise Laboratory Quality Improvement Process Towards Accreditation conducting progress assessments. This integrated approach aims to cultivate expertise across all fundamental areas, encompassing record management, personnel management, equipment maintenance, inventory control, process optimization, and facility management.[46,48,59] SLMTA has transformed the laboratory landscape in SSA and has the potential to substantially and sustainably impact the quality of laboratory testing and patient care.[29,30]

Other global health donors have funded several initiatives to improve quality assurance in SSA. The Fleming Fund has supported the introduction of standard operating procedures for antimicrobial resistance surveillance in multiple countries.[43] With this support, the Fleming Fund has helped ensure consistent testing practices, reducing errors and improving the reliability of diagnostic results. In multiple SSA countries, United States National Institute of Health and Global Fund-supported programs have introduced proficiency testing for HIV and tuberculosis diagnostics, enabling laboratories to assess their performance regularly.[31] These programs have enhanced the accuracy and consistency of laboratory results, contributing to better patient care.[31]

3.3. Theme 2: challenges and barriers to effectively improving medical laboratory services through global health development aid in SSA

Despite the success of many global health development aid initiatives in improving medical laboratory services in SSA, significant challenges and barriers still impede their effectiveness and sustainability. These challenges range from inadequate funding to human resource constraints and infrastructural limitations.

3.3.1. Insufficient funding and resource allocation

Many global health development aid projects provide funding for short-term cycles (usually 3–5 years), and once these periods end, sustaining the momentum can be difficult. For example, PEPFAR's support for HIV testing and diagnostics in Nigeria and South Africa initially helped improve laboratory systems, but as the funding cycles ended, both countries faced difficulties maintaining laboratory infrastructures and training programs without continued support.[35,36] In Eswatini, the Ministry of Health has faced challenges maintaining external quality assurance programs due to funding issues.[42] Although The Global Fund

and other partners have invested in laboratory improvements in Mozambique, limited resources have hindered the full implementation of programs. The Mozambique Ministry of Health has often faced difficulties in securing sufficient local funds to maintain laboratory equipment and meet the growing demands of testing for malaria, tuberculosis, and HIV.[54] The lack of funding has led to delays in the provision of consumables and reagents, reducing the effectiveness of even well-funded programs.

3.3.2. Human resource constraints

One of the major barriers to improving laboratory services in SSA is the shortage of skilled laboratory personnel. Human resource constraints impact health systems' ability to provide quality diagnostic services and sustain improvements made through aid initiatives.

Many SSA countries face a severe shortage of qualified medical laboratory technicians. Despite significant support from organizations like the WHO and PEPFAR, the demand for skilled laboratory staff outstrips the supply.[51] High turnover rate among trained laboratory staff is another significant challenge. In Ghana, due to relatively low salaries, poor working conditions, and limited career development opportunities, many trained laboratory technicians leave government facilities for better-paying jobs in the private sector or abroad.[37] This turnover hampers the continuity of services, particularly in remote and underserved areas, where trained professionals are already in short supply. Recruiting and retaining qualified laboratory staff in rural and remote areas is a significant challenge across SSA. In Rwanda, while the global health aid donors have provided substantial support to improve laboratory services, particularly in rural regions, recruitment and retention of qualified personnel remain challenging due to limited access to amenities, training opportunities, and financial incentives.[38] Global health aid has supported incentives like housing allowances and continuing education programs, but attracting staff to remote areas continues to be a barrier.

3.3.3. Inadequate infrastructure and equipment

Inadequate infrastructure and outdated equipment present significant barriers to improving laboratory services in SSA, even where global health development aid has been allocated. In Zimbabwe, despite Fleming Fund funding to upgrade diagnostic services, laboratories in remote areas still struggle with limited access to modern diagnostic equipment.[60] The inability to provide state-of-the-art tools for testing, such as polymerase chain reaction machines, limits the quality of diagnostic services. While larger cities may have access to advanced equipment, remote areas are often left behind, contributing to inequalities in healthcare access. Additionally, inadequate maintenance systems frequently hinder the sustainability of laboratory improvements. In Ghana, although the Global Fund has helped fund the expansion of laboratory services, equipment maintenance remains a challenge.[55] Hospitals and clinics in remote areas face difficulties repairing broken-down equipment, such as microscopes and diagnostic machines, which often sit idle due to lack of skilled technicians or spare parts. This issue leads to interruptions in services, ultimately affecting patient care. In South Sudan, the lack of reliable transportation networks and refrigeration systems for sample transport had been a significant obstacle to improving laboratory services.[56] Despite support from USAID and PEPFAR in improving laboratory infrastructure, the transport of blood samples from remote clinics to central laboratories for testing is often delayed due to poor roads and a lack of proper refrigeration. This results in compromised test accuracy and delays in diagnosing and treating patients.

3.3.4. Political and institutional barriers

This review revealed that political and institutional factors, including governance issues and lack of political will, impede the effectiveness of laboratory improvements supported by global health development aid. In some countries, despite substantial support from international partners such as the Global Fund and Fleming Fund, the lack of political commitment to sustaining laboratory services has hindered progress.[39] In some cases, there has been a reluctance to allocate sufficient budgetary support for laboratories, undermining the sustainability of donor-funded improvements. Bureaucratic inefficiencies and corruption are persistent issues in several SSA countries, negatively impacting the effective implementation of laboratory improvements. In some countries, despite World Bank and WHO funding to improve laboratory systems, corruption and inefficiencies in the allocation of funds have led to delays in equipment procurement and the mismanagement of resources.[58,62] Finally, while PEPFAR and The Global Fund have provided significant support to strengthen laboratory services, there has been a lack of coordination between international aid organizations and some governments. This fragmentation of health policies has led to duplicative efforts and inefficiencies, with different donors working on separate projects without a unified national strategy for laboratory development. These coordination issues have led to gaps in service delivery and uneven distribution of resources.

3.4. Theme 3: sustainability of the gains realized due to global health development aid for SSA laboratories

This review revealed that several factors, including financial sustainability, human resource capacity, institutional support, resilience, and effective monitoring systems, shape the sustainability of improvements in medical laboratory services in SSA. The challenges and barriers faced during aid implementation inform the strategies required to maintain and enhance the gains achieved through global health development aid.

3.4.1. Ensuring long term financial sustainability

Ensuring the financial sustainability of laboratory services is crucial for maintaining and scaling improvements after global health development aid projects end. This review revealed several strategies that can help transition from donor-funded models to self-sustaining funding mechanisms. In Kenya, the PEPFAR program has helped improve laboratory services, particularly HIV diagnostics. However, there have been efforts to transition from reliance on PEPFAR funding to more sustainable local financing. One promising model has been the establishment of a National Health Insurance Fund that integrates laboratory services into the national health insurance scheme.[40] This shift has allowed Kenyan health facilities to fund laboratory services through locally raised funds, reducing dependence on external aid. Another strategy is strengthening local governments' capacity to allocate and manage resources for laboratories.[53,57] Most countries have incorporated laboratory services into their National Health Strategic Plan. This integration helps ensure that laboratory service funding is part of the broader healthcare system's budget, facilitating more sustainable financing mechanisms. Over time, governments should take steps to increase their contribution to the laboratory services sector, ensuring continuity even as donor funding is reduced.

3.4.2. Strengthening human resource capacity for long-term impact

The long-term impact of laboratory service improvements depends significantly on the capacity of the local workforce. Sustainable improvements require a well-trained and stable workforce. Firstly, this desk review revealed the importance of local training and retention strategies for laboratory professionals. In collaboration with international partners, Ethiopia's Ministry of Health has established a National Laboratory Training Program focusing on training laboratory technicians in diagnostics for diseases like tuberculosis, malaria, and HIV. This program has enhanced the quality of laboratory services and helps address the shortage of skilled professionals, as graduates are encouraged to stay and work in underserved areas. Finally, the review revealed that to ensure the sustainability of the gains realised from donor aid to the laboratory services in SSA, labor migration and brain drain issues need to be addressed. The challenge of labour migration and brain drain, particularly in Uganda and Zimbabwe, remains a significant barrier to sus-

tainability. To combat this, initiatives like the African Centre for Disease Control (Africa CDC), supported by PEPFAR and Gates Foundation, have focused on creating regional training hubs and scholarships for laboratory professionals, particularly for countries in the African Union. This initiative aims to reduce brain drain by offering better career prospects and professional development opportunities within Africa.

3.4.3. Institutionalizing improvements in laboratory services

This review reviewed that institutionalizing laboratory service improvements is key to ensuring their integration into broader health systems and long-term sustainability. One such example is embedding quality control systems within national health frameworks. The Global Fund has supported integrating quality control systems into the national healthcare framework in Ghana. Ghana Health Service established a national Quality Assurance Framework for Laboratory Services, standardizing laboratory procedures, ensuring regular proficiency testing, and aligning practices with international standards. This integration of quality control into the national health strategy has helped institutionalize improvements, ensuring that quality lab services are maintained beyond the life of donor-funded programs. Incorporating laboratory services into broader National Health Policy and Planning is also key. In Rwanda, development partners have worked with the Ministry of Health to embed laboratory services into broader health planning. This includes ensuring laboratory services are part of the Rwanda National Health Policy, which guides resource allocation and strategic planning for the country's healthcare system. Integrating laboratory services into national health policy ensures that these services receive attention and resources even after global health funding decreases. Finally, sustainability requires building local leadership to manage and drive laboratory service improvements.

3.4.4. Building resilience through flexible and adaptive programs

The long-term sustainability of laboratory improvements relies on the ability to adapt and respond to changing local conditions. Mozambique has benefited from flexible aid programs funded by PEPFAR and the Global Fund, which have shifted focus from HIV/AIDS to tuberculosis and malaria diagnostics in response to the evolving epidemiological landscape. This adaptability has allowed Mozambique to improve its laboratory systems continuously. Similarly, in Uganda, the MoH has incorporated community-based feedback mechanisms to adjust laboratory services in real-time, ensuring that diagnostic services meet local needs and improving sustainability.[3] In Kenya, local health authorities, in partnership with international donors like USAID, have taken on more responsibility for laboratory improvements. Kenya's National Laboratory Strategic Plan now includes guidelines for local governments to manage and sustain these services in the long term.[45]

4. Discussion

This review critically examined the successes, challenges, and sustainability of global health development aid in strengthening medical laboratory services across SSA. Its significance lies in offering a comprehensive synthesis of how external aid has shaped laboratory systems in low-resource settings, an area often underexplored despite its critical role in disease surveillance, outbreak response, and health system resilience.

One of the central findings is the substantial contribution of global health development aid to capacity building and infrastructure development. Training programs, especially those led by PEPFAR and supported by CDC, have expanded the diagnostic workforce across SSA.[24,26,41] These efforts address a long-standing gap highlighted in the literature: the chronic shortage of skilled medical laboratory professionals as a bottleneck to quality healthcare delivery.[63] Moreover, infrastructure investments from donors like the Global Fund and the Gates Foundation have modernized laboratory systems through the provision of automated diagnostic equipment and upgrades to testing facilities.[25,49,59] These interventions have directly enhanced the capacity for timely and accurate diagnosis of diseases such as HIV, tuberculosis, and malaria, aligning with global health priorities and strengthening pandemic preparedness.

The review also underscores the value of effective partnership models. Ethiopia's experience with the Ethiopian Public Health Institute exemplifies how donor-government collaboration can result in robust, integrated laboratory governance.[46] This aligns with previous research emphasizing that cross-sector partnerships foster shared accountability, technical expertise exchange, and policy coherence are all critical for long-term success.[64] However, the review also identifies that such partnerships must be well-coordinated and embedded within national systems to avoid fragmentation.

Despite these achievements, the review reveals serious structural challenges that limit the long-term sustainability of donor-funded initiatives. Chief among these is insufficient long-term funding. Many interventions remain donor-dependent, and once external funding cycles end, countries struggle to maintain laboratory infrastructure, procure consumables, or continue staff training.[35,36,42,54] This finding is consistent with prior critiques of donor aid, which highlight how short-term funding undermines sustainability unless there is a clear transition plan to domestic financing mechanisms.[16,65]

Another persistent barrier is human resource capacity. While training initiatives have been successful, high turnover continues to destabilize workforce continuity.[37,38,66] The review adds to this discourse by showing that even well-designed programs falter when retention strategies are weak. Current efforts, such as housing allowances or continuing education, remain insufficient unless complemented by broader systemic changes like wage reforms and career advancement opportunities.[67] Furthermore, infrastructure disparities further illustrate the uneven impact of donor aid.[28,56,60] These inequities reinforce broader health access gaps, calling for more targeted resource allocation strategies and maintenance systems that function beyond donor project cycles.[55,68]

To ensure lasting impact, several future directions emerge from this review. First, financial sustainability must be prioritized through domestic resource mobilization and innovative models such as national health insurance schemes (e.g., Kenya's NHIF) or co-financing partnerships.[40,53,69] Second, workforce development should shift from short-term training to long-term professionalization strategies, including regulatory recognition, competitive compensation, and retention incentives.[46,47] Third, institutionalization of laboratory systems within national health strategies is essential. Embedding quality assurance frameworks, regulatory standards, and strategic plans into health policies, as seen in Ghana and Rwanda, ensures these services are safeguarded against shifting donor priorities.[48,70]

While this review revealed interesting findings that are of relevance to policy makers and governments in the region, interpretation of its findings should acknowledge the limitations of the review process. A major limitation of the review process include a potential selective reporting bias, as it relies heavily on the authors' interpretations. Nonetheless, the findings provide insights critical to planning development aid in the medical laboratory sector in the region.

5. Conclusion

Global health development aid has significantly improved medical laboratory services in SSA, particularly in capacity building, infrastructure development, and collaborative partnerships. However, challenges related to funding sustainability, workforce shortages, infrastructure gaps, and political barriers remain substantial. Achieving long-term sustainability requires addressing these challenges through strategies that ensure financial self-sufficiency, foster a skilled and stable workforce, and integrate laboratory services into national health frameworks.

Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Hazel Musuka: Writing – original draft, Conceptualization. **Oscar Mano:** Writing – original draft. **Patrick Gad Iradukunda:** Writing – original draft. **Gashema Pierre:** Writing – review & editing. **Ferris Tatenda Munyonho:** Writing – review & editing. **Enos Moyo:** Writing – review & editing, Supervision. **Tafadzwa Dzinamarira:** Writing – review & editing, Supervision.

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