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SUPPLEMENTARY TABLE 1: Characteristics and key findings of 32 studies on laboratory quality improvement conducted in low- and middle-income countries between 2012-2022

№	Study author, year	Objective	Study details					Key Findings	
			Country	Participants			Evidence of quality improvement provided	Success factors identified	Main barriers identified
				N	Type	SLMTA program partici-pation			
1	Abebe N., 2016	To share experience from Bethzatha Advanced Medical Laboratory's milestones in reaching ISO 15189 accreditation	Ethiopia	1	Private medical laboratory	No	ISO 15189 accreditation	Training for the top management about the benefit of accreditation Training for all the technical and non-technical staffs about the12 quality essentials Support of uninterrupted external quality assurance (EQA) scheme from Ethiopian Public Health Institute Laboratory managers and staff dedication	
2	Albert H. et al., 2017	To describe the development and early implementation of the Strengthening Tuberculosis Laboratory Management Toward Accreditation (TB SLMTA) program	Cameroon Ethiopia Lesotho Tanzania	18	Tuberculosis laboratories	Yes	SLIPTA*	Structured mentoring Institutionalisation of the quality management system (QMS) into country programs Senior-level engagement of the Ministry of Health (MOH)	The lack of experienced assessors Management had not been fully engaged in the TB SLMTA implementation (both at the facility level and the MOH) Staff shortage and high workload

3	Andiric L.R., Massambu C.G., 2015	To describe the implementation and improvement in the first groups of medical laboratories in Tanzania selected to participate in the training program on Strengthening Laboratory Management Toward Accreditation (SLMTA)	Tanzania	30	Regional and district laboratories	Yes	SLIPTA*	Laboratory management commitment An active and involved mentor (or focal person) Laboratory managers delegation improvement tasks to their staffs Available necessary supplies, reagents, and equipment in the country Continuing education for laboratory staff Appropriate practical training of laboratory students (only in accredited laboratories)	Not appropriate selection of laboratory management personnel Insufficient communication at all levels (facility-wide and to all laboratory staff) Poor remuneration for laboratory professionals Excessive offsite training for laboratory management personnel, inhibiting implementation of improvements Inadequate infrastructure (utilities, adequate water, etc.)
4	Audu R.A. et al., 2014	To describe the impact of SLMTA and discuss factors affecting the results, with an emphasis on mentorship	Nigeria	2	2 reference laboratories: Human Virology Laboratory National Tuberculosis Reference Laboratory	Yes	SLIPTA*	Mentorship	Challenges in interpreting ISO 15189 standard requirements and auditor recommendations The absence of National Laboratory Strategic Plans to provide roadmaps for the implementation of quality laboratory services Lack of National Laboratory Quality Standards to guide the provision of quality clinical laboratory services and accreditation in Nigeria

5	Beyanga M. et al., 2018	To share experience from Bugando Medical Centre laboratory's milestones in reaching ISO 15189 accreditation	Tanzania	1	Clinical Laboratory	No	ISO 15189 accreditation	Mentorship Financial resources Motivated staff Trained staff (both QMS training and training on technical procedures) Quality officer with strong leadership skills Human resources Formation of a laboratory management team Hospital management support	Difficulties in close follow-up of staff to ensure adherence to the established system
6	Cholakyans V. et al., 2019	To identify gaps, progress and evaluated the evolution in implementation QMS of the National tuberculosis reference laboratory (TB NRL) of Armenia, as well as estimate the specific quality indicators of TB NRL activity	Armenia	1	National tuberculosis reference laboratory	Yes	SLIPTA*	Staff training Introduction of standard operating procedures	Staffing gaps and high workload
7	Desalegn D.M. et al., 2019	To share the experiences, benefits, and challenges of the laboratory journey towards accreditation in a primary healthcare	Ethiopia	1	Primary healthcare laboratory	No	ISO 15189 accreditation	Continual training of staff Government and partners' support Laboratory manager leadership Multilevel laboratory management	Lack of internal quality control materials and other reagents Inconsistent electric power supply Limited number of trained laboratory personnel and qualified engineers

		laboratory in Addis Ababa, Ethiopia						Workload-based staffing structure Stepwise approach Partial-scope accreditation Well-coordinated commitment of the entire staff, organisation, mentors, and stakeholders Supplies and equipment service agreements with local vendors	High maintenance and calibration costs Lack of equipment and spare parts Lack of funds for renovation of existing structures Inadequate laboratory rooms Unsuitable laboratory design Additional workload as a reason why some staff and management members did not accept the standard at the beginning Staff shortages
8	Donovan G. et al., 2020	To describe and evaluates the methods, outputs, and outcomes of a quality improvement program implemented in 12 public hospital laboratories in Cambodia	Cambodia	12	Public hospital laboratories	No	CamLQMS**	Professional training and mentorship Remote mentoring through video conference	
9	Gachuki T. et al., 2014	To share the path the National HIV Reference Laboratory has taken in seeking accreditation, as well as challenges and lessons learned	Kenya	1	The National HIV Reference Laboratory	Yes	ISO 15189 accreditation	Staff dedication to a shared goal Leadership commitment Formation of accreditation team structure with a clear reporting mechanism Effective mentorship	Staff attrition Staff thought that the accreditation mandate belonged to the QA manager alone Lack of knowledge on ISO 15189 standard requirements

								Adequate funding and support ISO 15189 training for all laboratory personnel Good Laboratory Practice training for all laboratory personnel Mentorship training Internal audit training for QA manager Staff training through SLMTA SLIPTA scores and star levels An employee recognition scheme and incentives	Slow procurement process Various experts and mentors had contradicting styles and opinions Major safety deficiencies and shortage of space Lack of accredited public laboratories to use as back-up
10	Girma M. et al., 2018	To specify challenges Ethiopian laboratories encountered applying ISO 15189 standards	Ethiopia	12	Government hospital laboratories	Yes	SLIPTA* - 8 laboratories ISO 15189 accreditation - 1 laboratory No improvement - 3 laboratories		Nine major challenges: low hospital management support inadequate training insufficient infrastructure excessive documentation little mentorship increased accreditation-related workload poor equipment unavailable/poor-quality reagents high staff turnover Additional challenges: inadequate training materials low job satisfaction

									relative scarcity of motivated, stable, trained staff
11	Gopolang F. et al., 2021	To describe the effectiveness of this laboratory leadership programme in two Zambian cohorts, using the laboratories' compliance with the SLIPTA checklist as the main outcome measure	Zambia	16	Hospital laboratories	No	SLIPTA* - 9 laboratories No improvement - 2 laboratories ISO 15189 accreditation - 5 laboratories	Leadership and management training Mentorship Strong working relationship between the management team and the technical staff	Staff turnover
12	Guevara G. et al., 2014	To describe the impact of the SLMTA training programme and mentorship amongst five clinical laboratories in the Caribbean after 18 months	4 countries in the Caribbean Region	5	National reference laboratories	Yes	SLIPTA* - 4 laboratories ISO 15189 accreditation - 1 laboratory	Early engagement of key stakeholders (Permanent Secretaries, Chief Medical Officers, top management officials of the hospital, technical staff) Endorsement by top management for laboratory systems strengthening activities An implementation roadmap Structured improvement approach Staff training on the principles of continuous quality improvement Mentorship	Insufficient number of well-qualified laboratory workers High level of attrition as staff leave the public sector for more lucrative jobs (remaining staff are overworked) Shortage of qualified mentors Considerable funds needed to mentorship

13	Gumma V. et al., 2019	To describe the implementation of the TB SLMTA program in Vietnam and provide results from the six TB culture pilot laboratories, impact of the program, lessons learned from implementation, and recommendations for scaleup of the program	Vietnam	6	Tuberculosis laboratories	Yes	SLIPTA*	Intensive remote mentoring Policy environment that recognized the importance of QMS strengthening SLIPTA checklist as an effective tool for directing improvements Efficient management and administrative departments Highly motivated staff to resolve nonconformities	High workload
14	Hiwotu T.M. et al., 2014	To evaluate the implementation and impact of the SLMTA programme in Ethiopian laboratories, the findings from the evaluation process and key challenges	Ethiopia	44	National reference, regional reference and public hospital laboratories	Yes	SLIPTA* - 42 laboratories Level decrease - 2 laboratories	Mentorship (intensive supportive site visits) Continuous advocacy at all levels of the health system	Lack of laboratory quality manuals, guidelines, policies, and procedures that provide clear and concrete directions and instructions
15	Kibet E. et al., 2014	To describe ISO 15189:2007 accreditation process of the Aga Khan University Hospital Nairobi laboratory	Kenya	1	Diagnostic laboratory in private teaching and referral institution	No	ISO 15189 accreditation	Interaction between clinical pathologists and medical technologists Leadership Establishing a managerial infrastructure and delineation of management responsibilities Well-structured laboratory education	

								Adoption of a continual improvement culture in the laboratory Financial resources Mentorship programs	
16	Makokha E.P. et al., 2014	To examine results from the eight regional laboratories in the initial SLMTA group, with a focus on mentorship models	Kenya	8	7 provincial general hospital laboratories 1 high-volume district hospital laboratory	Yes	SLIPTA*	Institutional mentorship and twinning approach (to bring the research and public laboratories) Highly-skilled personnel with technical expertise Additional funding and staff	
17	Maruta T. et al., 2012	To measure the improvement in quality systems of laboratories receiving model of laboratory mentorship	Lesotho	4	3 districts hospital laboratories 1 central hospital laboratories	Yes	SLIPTA*	Mentorship conducting over a sustained period Embedding the mentor within the daily routines of the laboratory and coaching on how to perform internal quality controls, calibration, etc. The support from the MOH	
18	Maruti P.M. et al., 2014	To describe how the SLMTA programme and enhanced quality interventions changed the culture and management style at Bungoma District Hospital Laboratory and instilled a quality system designed to	Kenya	1	District Hospital Laboratory	Yes	SLIPTA*	Hospital management support Staff participation Use of progress-monitoring tools and feedback systems Incorporation of improvement processes into daily routine Engagement of all hospital management and clinicians in the process	Staff turnover

		sustain progress for years to come						Appointing a deputy for each key function, performing on-the-job mentorship of staff Encouragement of staff participation throughout the hospital (an annual award scheme, ‘Wall of Fame’ and a ‘Wall of Shame’) Quarterly meetings for one-on-one mentorship with each laboratory staff Quarterly meetings with clinicians Regular laboratory staff meetings and weekly hands-on continuous medical education sessions Training of new staff Involving of all staff members in budget and planning discussions Adopting written protocols and practices that prescribe clear policies, procedures, values and behaviours Teaching the principles and methods of quality improvement and related behaviours	

19	Masamha J. et al., 2014	To outline the steps followed to establish a national framework for quality improvement and embedding the SLMTA programme within existing MOH laboratory systems	Mozambique	6	Reference and central hospital laboratories	Yes	SLIPTA*	Country leadership, ownership, and institutionalisation of the SLMTA programme Laboratory personnel commitment	
20	Mbah H. et al., 2014	To report on efforts and progress in piloting SLMTA program	Nigeria	6	5 stand-alone antiretroviral treatment laboratories 1 hospital laboratory	Yes	SLIPTA*	Technical assistance by partners in terms of infrastructural upgrade, capacity building, follow up visits, mentoring and advocacy, etc. Staff commitment Ownership and support by facility management, State and Federal Ministry of Health Top-bottom advocacy Assessment Gap analysis Capacity building Training and mentorship	Resource constraint Unwillingness of staff to cooperate as they consider QMS implementation as an additional burden (especially paperwork burden)
21	Mokobela K.O. et al., 2014	To describe the process and lessons learned in implementing SLMTA and the role of supplemental training and mentoring to achieve Botswana's	Botswana	7	National, regional, district and primary-level laboratories	Yes	SLIPTA* - 5 laboratories No improvement - 2 laboratories	Strong staff commitment and involvement Support and buy-in from hospital management Supplemental mentorship and training	Staff turnover Weak medical equipment maintenance/calibration and EQA programmes throughout the country Lack of funding

		national laboratory quality improvement goal							
22	Mothabeng D. et al., 2012	To describe the experience of Lesotho in implementing the SLMTA programme and share this experience and the lessons learned from it with other countries that are implementing, or planning to implement, the SLMTA programme.	Lesotho	25	National reference, regional and district laboratories	Yes	SLIPTA* - 17 laboratories No improvement- 7 laboratories Negative improvement- 1 laboratory	Strong commitment, ownership, and leadership of The Ministry of Health Technical support by partners The high level of SLMTA participants dedication Enthusiasm within the laboratories	Staff turnover Ever-increasing workloads
23	Nkrumah B. et al., 2014	To demonstrate how Ghana, which received very limited PEPFAR funding, was able to achieve marked quality improvement using local human resources	Ghana	15	2 national level laboratories 12 regional-level laboratories 1 district level laboratories	Yes	SLIPTA*	Top-down programme implementation approach Hospital management engagement and commitment Training and hiring of local human resources Mentorship	Inadequate staffing Lack of motivation staff High workload Lack of internal audit skills Limited experience of mentors Institutional bottlenecks, such as administrative and procurement processes
24	Nkwawir S.C. et al., 2014	To evaluate the results of SLMTA implementation at the Bamenda Regional Hospital Laboratory and	Cameroon	1	Regional Hospital Laboratory	Yes	SLIPTA*	Training activities Intensive on-site mentorship Engagement of Bamenda Hospital management	Resistance to change in the beginning

		discuss lessons learned						Ensuring financial support and sufficient human resources Acceptance of the need for continuous improvement by laboratory staff	
25	Ntshambiwa K. et al., 2014	To describe the impact of implementing SLMTA in Sekgoma Memorial Hospital Laboratory in Serowe, Botswana	Botswana	1	District laboratory	Yes	SLIPTA*	Structured quality improvement programme Staff motivation Involving management in the early stages Productive and frequent discussions between clinicians and laboratory staff Staff training Focused mentorship	
26	Nzabahimana I. et al., 2014	To describe the achievements of Rwandan laboratories four years after the introduction of SLMTA in the country, using the SLIPTA scoring system to measure laboratory progress	Rwanda	15	National Reference Laboratory Central referral laboratories Military hospital laboratory District hospital laboratories	Yes	SLIPTA*	Stepwise approach and gradual improvement process High levels of commitment and teamwork Hospital management support Additional funding Extensive on-site expert mentorship Performance-based financing	Heavy and fluctuating workload for the staff Senior management's lack of focus on the accreditation preparation process
27	Nzombe P. et al., 2014	To examine the results achieved by the 19 laboratories after implementing four different	Zimbabwe	19	Reference, central hospital, private, provincial,	Yes	SLIPTA*	Mentorship (separate from SLMTA training) All laboratory staff mentoring on site (so they all understood the	

		mentorship models in order to determine their effectiveness, relative cost and lessons learnt			district and city council laboratories			process and were eager to play their part)	
28	Perrone L.A. et al., 2016	To present the achievements in implementation of mentored laboratory quality stepwise implementation (LQSI) programme to strengthen the quality and capacity of Cambodian hospital laboratories	Cambodia	12	4 national and 8 provincial tertiary level referral laboratories	No	Increase of baseline completeness scores (utility of the LQSI checklist)	Regular on-site mentoring on LQSI Regular presence of fully dedicated mentors Detailed action plan in the local language Mentor training Laboratory staff training Strong team coordination, rapid communication and collaborations including frequent in-country meetings Strong leadership from hospital and laboratory directors Financial resources	Global need to improve health laboratory leadership and management
29	Robinson C. et al., 2020	To identify critical success factors for medical laboratories implementing a QMS project and 'why' a laboratory's score may or may not improve over time	Vietnam	4	3 city level laboratories 1 district level laboratory	Yes	ISO 15189 accreditation - 1 laboratory In the process of ISO accreditation - 2 laboratories QMS has not been successfully implemented- 1 laboratory	Staff QMS knowledge Manager leadership Staff commitment Mentorship Hospital administration support	

30	Sisay A. et al., 2015	To assess the outcome of SLMTA on laboratory quality management system in Addis Ababa, Ethiopia	Ethiopia	29	4 hospital laboratories 25 district health centre laboratories	Yes	SLIPTA* - 20 laboratories No improvement- 9 laboratories	Getting adequate training how to implement SLMTA Coaching and mentoring Regular staff meeting Satisfaction with current salary Assessment of customer satisfaction Availability of enough equipment Regular equipment maintenance Staff motivation (like vaccination)	Shortage of resource Lack of regular equipment maintenance
31	Viegas S.O. et al., 2017	To describe the road map taken by the National Tuberculosis Reference Laboratory (NTRL) to achieve international accreditation	Mozambique	1	National Tuberculosis Reference Laboratory	Yes	ISO 15189 accreditation	Institutional commitment Commitment at all levels, especially from high-level leadership and stakeholders Staff motivation Well-trained staff Availability of financial resources Adequate infrastructure Comprehensive action plan Mentorship and supervision	Lack of local companies with proper expertise and certification to provide services for equipment maintenance and calibrations Difficulties in maintaining an EQA for culture, including customs clearance of imported EQA schemes In case of an emergency, difficulty in referring samples to an accredited laboratory located in Mozambique, since NTRL was the first to be accredited
32	Zohoun A. et al., 2021	To outline the strategy, implementation,	Benin	1	University Teaching	No	SLIPTA*	Laboratory staff engagement Staff commitment	High staff turnover

		outcomes and military-specific challenges of the Army Teaching Hospital–University Teaching Hospital laboratory quality improvement programme			Hospital Laboratory			Training personnel in both technical and quality management topics Mentorship Strong support of the hospital management Underpinning laboratory staff motivation to sustain quality improvements Implementing partner support	

* – the improvement of laboratories' quality audit scores using Stepwise Laboratory Quality Improvement Process Towards Accreditation (SLIPTA) Checklist;
** – the improvement of laboratories' quality audit scores using Cambodia Laboratory Quality Management System Checklist for Accreditation (CamLQMS).

EQA, external quality assurance; ISO, International Standardization Organization; MOH, Ministry of Health; QMS, quality management system; SLMTA, Strengthening Laboratory Management Toward Accreditation.