RESEARCH ARTICLE

UTILISING THE MEDICAL LABORATORY TECHNICAL STAFF'S EXPERIENCES AND PERCEPTIONS TO ASSESS PERFORMANCE OF BOTSWANA'S PUBLIC MEDICAL LABORATORIES-A CASE STUDY

Tapologo Tepa Nkoane
1. Graduate School of Business, University of Zambia, Lusaka, Zambia

………………………………………………………………………………………………....

Manuscript Info	*Abstract*
……………………..	………………………………………………………………
	Background Accurate and reliable clinical laboratory testing is a critical component of a public health approach to disease management in sub-Saharan Africa. Lack of documented causes of suboptimal public medical laboratories hinders the design of impactful interventions for a sustained high performing medical laboratory system. Medical laboratory personnel are instrumental in identifying causes of poor performance of medical laboratories for evidence-based interventions. **Objectives** The aim of the study was to utilise Botswana government employed medical laboratory personnel's experiences and perceptions to assess the status of Botswana's public medical laboratory system against the modified President's Emergency Plan for AIDS Relief Site Improvement Through Monitoring system version 4.2 assessment tool. **Methods**This exploratory convenient sampling study drew insights from 16 medical laboratory personnel from the Botswana's Greater Gaborone District Health Management Team public medical laboratories who responded to the self-administered questionnaire and semi-structured interview which targeted two key-informants from Ministry of Health. Data was collected from 11-28 September 2023. The questionnaire results were utilized to guide the interview design. The questionnaire data was analysed using Microsoft Excel, interview data was analysed using the reflective Thematic Analysis. **Results**The study highlighted the following eight priority areas as key to a strengthened laboratory service: national policy and strategy, equitable funding and support, capacity building, refined workflow, multiplexing, monitoring and evaluation strategy, contract management, equipment standardization. **Conclusion** Laboratory personnel possessed a wealth of knowledge and experience that provided gaps in medical laboratory service and contribute valuably to the direction of future interventions for laboratory strengthening and optimal service delivery.

………………………………………………………………………………………………......

Introduction:
The medical laboratory system is the foundation of any healthcare system, for disease surveillance, prevention, diagnosis, and monitoring prognosis of patient conditions (1-3). A global diagnosis gap of 47% where only 19% of the population in developing countries accessing healthcare (4, 5), the laboratory has been deemed the weakest link in the healthcare cascade (6). Low performance of public health laboratories has been document (7, 8) and the many contributing factors identified as; reagents stock-outs, equipment breakdowns, inadequate space, inadequate staff (8) poor quality management (9, 10); governance (4); shortage of personnel (11), and resource allocation (5). Strategic attempts to improve health care service delivery in Africa include implementation of the lean principles (12-14), and strategic and change management principles (15, 16).

Laboratory Situation in Developing Countries
Majority of the population in developing countries receive health services in public facilities (17). Public medical laboratories are struggling to meet the demands of healthcare despite some countries like Botswana having the quality of laboratory testing comparable to those found in developed countries (18). Thus, private laboratories are perceived to offer better service than public laboratories (19) and this may be attributed to their flexibility in decision making that offers shorter turnaround time in implementation of interventions (8). Efforts have been directed to improve public medical laboratory service delivery in developing countries (7, 20-22) with results disproportionate to the investment.

The goal of this study was to use the medical laboratory personnel's experiences and perceptions to explore the status of medical laboratory servicesin Botswana government-owned facilities against the modified President's Emergency Plan for AIDS Relief (PEPFAR)'s Site Improvement Through Monitoring system (SIMS) version 4.2 assessment tool (23)

Materials and Methods :
Ethical Consideration
The study ethical approval required multiple ethical approvals from different institutions. Ethical approval was sought from the University of Zambia Biomedical Research Ethics Committee (3998-2023) and Botswana ministry of health Human Research and Development (HPRD:6/14/1). Further approvals were sought and granted by the following ethics commities: Greater Gaborone District Health Management Team (GGDHMT6/17/1IV (64) granted study permission for Nkaikela and Julia Molefhe clinic laboratories; National Health Laboratory (6/16/1I) granted permission for National Health Laboratory (NHL), National TB Reference Laboratory (NTRL), Botswana HIV Reference Laboratory (BHHRL) and Botswana National Quality Laboratory (BNQAL); and Princess Marina Referral Hospital (PM2/11AII) granted permission for Princess Marina Hospital Laboratory (PMHL) and subsidiary clinic laboratories.

A consent was sought and obtained from each laboratory management through email, phone call and in-person meeting. Consent from each participant was obtained through a written informed consent. The participants' identifying information such as names and contact details were not collected to safeguard confidentiality. A password protected online Google Form was used to collect the survey responses. The key-informant interviews were conducted in a safe and conducive place chosen by the participant. The interview audio recordings were stored in a password protected folder. Additionally, the names and identifying information that could link the participant to the study was blotted out on the interview transcripts. The transcripts were stored in a lockable cabinet accessible only to the investigator.

Study Design
This was a case study design which used the Botswana's Greater Gaborone District Health Management Team (GGDHMT) medical laboratories, which is one of the 27 health districts in Botswana to gain understanding of the state of medical laboratories in Botswana. This wasacross-sectional, representative, non-randomised, non-probability, purposeful sampling study of public medical laboratories.

Data collection and study setting
A sequential mixed method approach utilizing self-administered questionnaire followed by key-informant semi-structured interview was used to explore the status of public medical laboratories in Botswana. Government

employed medical laboratory personnel from the Greater Gaborone District Health Management Team (GGDHMT) facilities participated in the questionnaire. These facilities were (a) Reference laboratories, namely, Princess Marina Referral Hospital Laboratory (PMHL), National Health Laboratory (NHL), National TB Reference Laboratory (NTRL), Botswana HIV Reference Laboratory (BHHRL) (b) The proficiency providing laboratory-Botswana National Quality Laboratory (BNQAL) and (c) clinic laboratories: Botshelo Diabetic Clinic, Nkaikela and Julia Molefhe Clinic laboratories. The printed questionnaire was handed to BNQAL participants, an electronic version of the questionnaire was emailed to the rest of the participants. The semi-structured interview targeted two-key ministry of health leadership positions.

The questionnaire design
The questionnaire design used a mix of question formats including drop down menu options, multiple choice, "YES" or "NO", and choosing options that apply to question, moreover, it allowed for participants to give their comments after most question. Additionally, respondents were asked to rate core laboratory services delivery activities through the utilization of the 5-part Likert Scale (24) and each respondent was asked to give their laboratory staff compliment, their level of education, and years of experience and length of time at current position. The questionnaire was adapted from the President's Emergency Plan For AIDS Relief (PEPFAR) Site Improvement Through Monitoring System (SIMS) version 4.2 assessment tool(23) and from 'Assessment report on reference laboratories in the SADC' (25) and captured the following elements: quality management system, test interruptions, specimen referral, laboratory capacity and professional development, quality control, commodities, laboratory policy, infection control and safety, physical infrastructure and operation, laboratory finance, laboratory information management.

Questionnaire Pilot
The questionnaire was piloted at two facilities to gauge the process flow and evaluate the design of questions (26). Feedback from the pilot was used to refine the tool before full implementation. The pilot study resulted in adoption of two approaches to administrating the questionnaire: electronic and paper based.

Administration of questionnaire.
The following questionnaire link was shared through participants' email address
https://docs.google.com/forms/d/1XNoPDXnoIo4rFvovMs4bewGSTFP2YGhheM8_qeStUog/edit?usp=drive_web.
Printed version was availed to participants who preferred paper-and-pen version of questionnaire. The study was only opened for a week, September 11-15, 2023. Halfway into the week an email reminder, accompanied by the questionnaire study permit and consent form was sent to the participants (27-29).

Semi-structured interviews
The interviews were conducted from 27-28 September 2023. With the participants' permission, the interview was recorded. The recording was transcribed verbatim.

Data Analysis
Data from questionnaire and data from key informant semi-structured interviews were analysed separately and then a combined report providing study findings was made.

Questionnaire
The Microsoft Excel was used to analyse questionnaire to provide quantitative data which provided descriptive and inferential statistics. The descriptive statistics provided summary of large chuck of data for easier utilisation while inferential statistics allowed for generalisation of data (30). The questionnaire was analysed for data response rate and data quality which were the study's dependent variables. Response rate was defined as the percentage of the actual questionnaire that were returned (numerator) out of the total that was sent (denominator),the denominator excluded emails that were "undelivered", while data completeness was calculated as percentage ratio of completed questionsout of the total questions(29, 31).Data completeness was used as a proxy for data quality, any question skipped contributed to this variable (29).

Semi-structured interviews:
Thematic analysis was utilized to analyse interview data, following the six-step methodology (32). Thematic analysis has been described as "a method for identifying, analysing and reporting patterns (themes) within data" (32). This method has been used widely in qualitative research (32-34) with increasing use in healthcare over the

recent years (34). This research followed reflexive approach, where codes are organized around a cohesive concept to produce a theme (35).

Results :

Questionnaire data

A total of 65 emails were sent to participants of approved study laboratories with the following breakdowns: 26 to PMHL, eight to NHL, 13 to BHHRL, four to BNQAL, nine to NTRL and two to Nkaikela and two to Julia Molefhe. A total of seven emails were undelivered, four from PMHL and three from BHHRL, which means then that BHHRL and PMHL had 10 and 22 participants respectively, and the final study target of 58. Response rate varied from zero % (Nkaikela and Julia Molefhe) to 100 % (BNQAL) with an average 27.6 % (16/58). The study achived an overall 98% data completeness.

Characteristics of survey study population

Table 1 provides summary of the characteristics of the participants. A total of 16 participants of which 68.75 % represented either reference or referral hospital testing laboratories, while BNQAL contributed 25 %. 62.5 % of participants had a degree or higher qualification, while 68.75% of the interviewed had worked for five years or more.

Table 1: Characteristics of the Study Participants and Botswana's Public Medical Laboratories in
The Greater Gaborone District Health Management Team District, 11-15 September 2023

Characteristics	N (%)
Participants	16
Type of Laboratory	
Clinic Laboratory	1(6.25)
National Reference Laboratory	7(43.75) †
Referral Hospital Laboratory	4(25) †
National Quality Laboratory	4 (25) †
Cadre	
Lab Manager	2(12.5) ‡
Other	2(12.5)
Section Head/Technical Manager	5(31.25) ‡
Technical person	7(43.75)
Highest Qualification	
Degree	7(43.75)
Diploma	6(37.5)
Masters	3(18.75)
No of years working in the current position	
>10years	7(43.75)
0-2 years	4(25)
2-5 years	1(6.25)
5-10 years	4(25)

Source:Adapted from 'Assessing performance of Botswana's public health medical laboratories: utilization of the 2008 Maputo declaration framework for laboratory strengthening'(36)
†94% (15) participants were from either referral or reference laboratories
‡44 % (7) of the participants held supervisory position

As depicted in Table 2, the study achieved an average of 98% data completeness with online questionnaire achieving 100% and manual questionnaire achieving 91% data completeness.

Table 2: Data completeness of study questionnaire conducted in The Greater Gaborone District Health Management Team District laboratory facilities from 11-15 September 2023

Data completeness	N
Total (online and paper-based questions expected to be completed)	668
Online questionnaires (516 expected)	516 (100%)
Paper-based (172 expected)	157 (91%) §
Total data completeness	653 (98%)

§The paper-based questionnaire gave less completed questionnaire compared to online questionnaire

Testing interruptions

Participants were asked if they experienced test interruption for two consecutive days in the last three months. Table 3 gives a summary of causes of test interruptions. 8/16 (50 %) participants reported test interruptions,6/16 (37.5%) did not experience test interruptions and 2/16 (12.5%) did not respond to the question. From those who reported test interruptions, 4 participants gave multiple answers leading to 15 outcomes from the 8/16 participants who experienced test interuptions. The breakdown of the 15 outcomes were as follows: reagents stockouts 47% (7/15), equipment failure 20%(3/15) , expired reagnets 20%(3/15), staff shortage 13% (2/15).

Table 3:Factors affecting test interruption in Botswana's public medical laboratories in the Greater Gaborone District Health Management Team during the period of 11-15 September 2023
Source: Author, unpublished

| Respondent's affiliated lab	Test interruptions in last 3 months for 2 consecutive days			Attribution to Test Interruption				
	YES	NA	NO	Equipment failure	Reagents or supplies stock-outs	Expired reagents/ supplies	Shortage of staff	Power supply, water or temperature conditions
NHL			X					
BHHRL	X				X			
PMH			X					
NTRL			X					
BHHRL			X					
NHL	X				X			
NTRL			X					
NTRL	X			X	X	X	¶	
PMH			X					
PMH	X				X			
PMH	X			X	X	X	¶	
Block 6 Clinic	X			X	X		¶	
BNQAL	X						X	
BNQAL		X						
BNQAL		X						
BNQAL	X				X	X	X¶	
Total	8	2	6	3	7	3	2	

Abbreviation:
NA, No Answer
¶Participants giving more than one reason for testing interruptions

Staff's Opinion On Laboratory Service Delivery
Figure I depict the results of participants' opinion on the performance of their laboratory service delivery. 86% of the respondents indicated satisfactory (agree and strongly agree) laboratory service delivery, 100% (agree and strongly agree) with satisfactory results turnaround time. 69% (agreed and strongly agree) with "management support", 93% (disagreed and strongly disagree) indicated shortage of staff. On availability of learning opportunities 56% agreed (agree and strongly agree) while 44% disagreed (disagree and strongly disagree) with the statement.
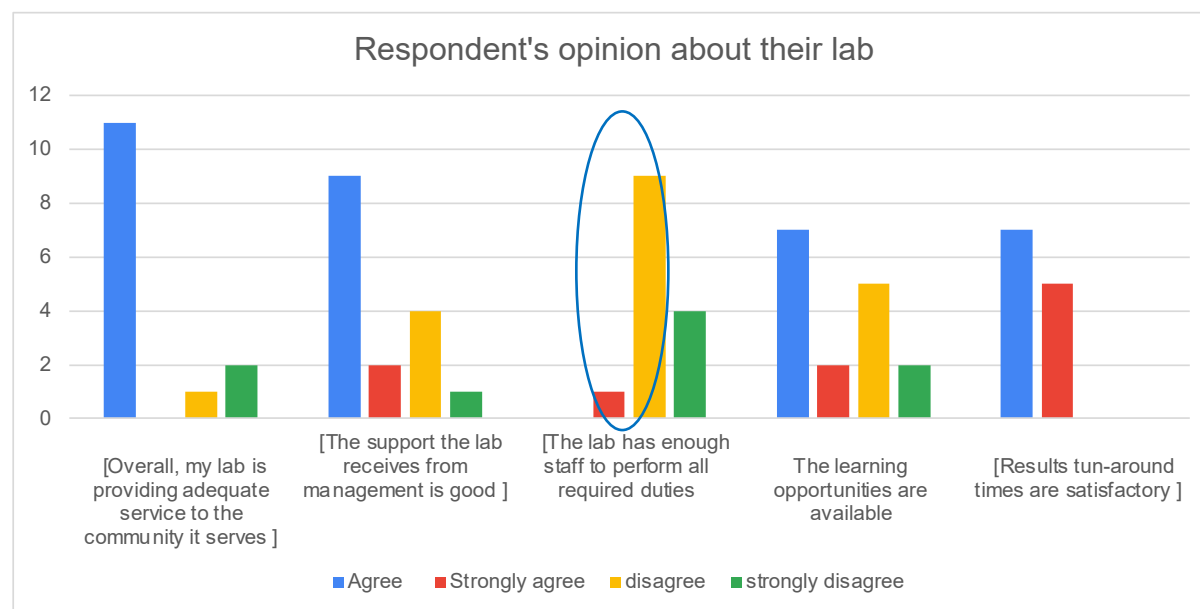
Source: Adapted from 'Assessing performance of Botswana's public health medical laboratories: utilisation of the 2008 Maputo declaration framework for laboratory strengthening'(36)
> 90% of staff indicating that their laboratories experienced shortage of staff
Figure I: The Greater Gaborone District Health Management Team District Laboratories Personnel's Opinion About the Service Offered by their Laboratories from 11-15 September 2023

Interview data analysis and results
A six step approach was used to analyse data (32). The first step,*Familiarization with data*, started with engaging with the participants during the interview. The interviews were recorded to preserve data. Then audio recording was listened to several times to gain understanding before being transcribed verbatim using Microsoft Word 2021. In Step two, Generating initial codes,the transcribed data was read and interesting portion that was thought to contribute to answering research questions was highlighted through the utilization of "comments" function of the Microsoft Word 2021. Additionally, as illustrated in Figure II, the 'comment' function allowed the codes to be written on the margins of the text and for established codes to be numbered for easy tracking of the coding process.
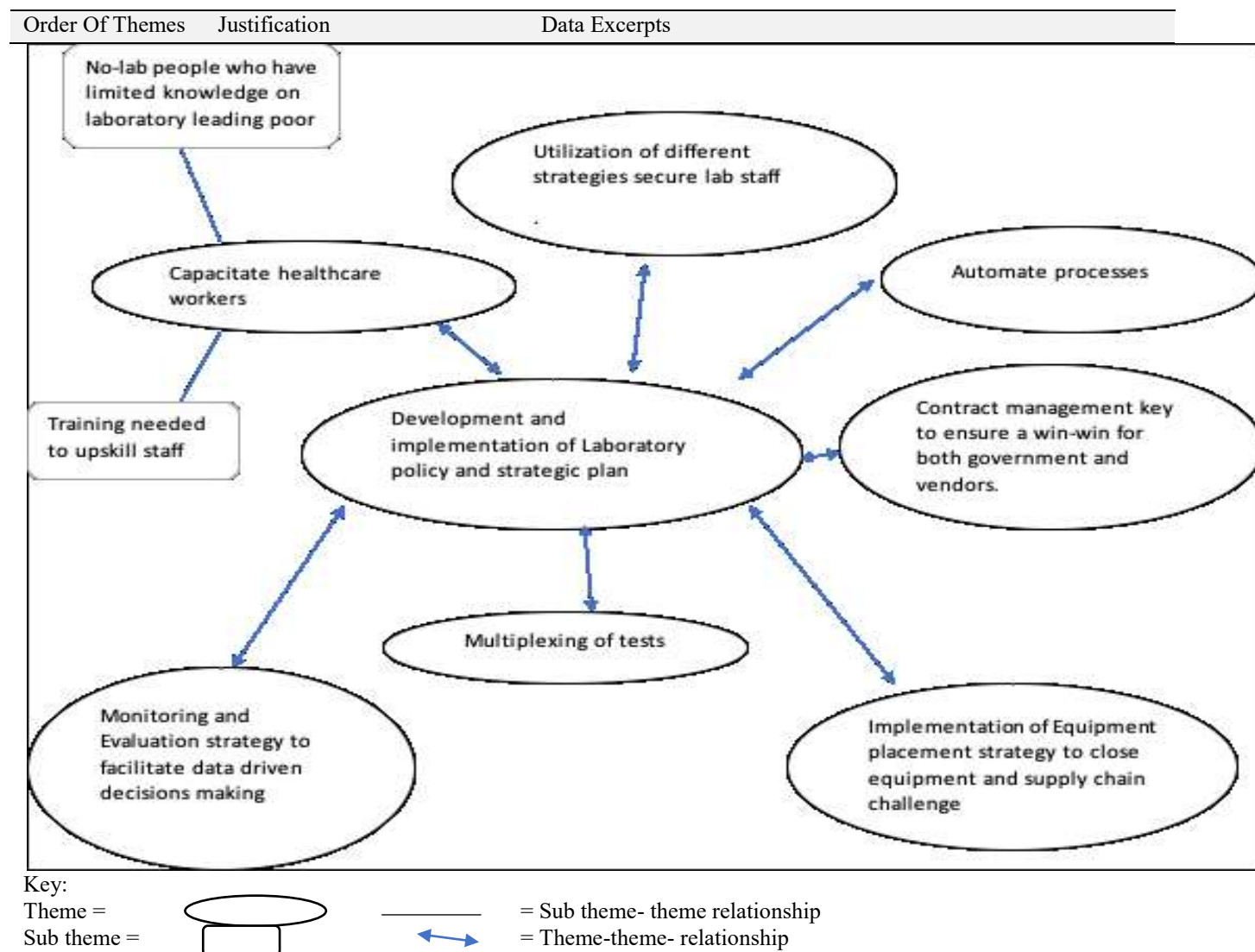
Source: Adapted from 'Assessing performance of Botswana's public health medical laboratories: utilisation of the 2008 Maputo declaration framework for laboratory strengthening' (36)

Microsoft Word 'comment' function was vital for formulation and tracking codes.

Figure II: Excerpt of Initial Coding Highlighting the Use of the 'Comment' Function of Microsoft Word for Better Tracking and Numbering of Codes During Thematic Analysis of Interview Data.

Step three, *Searching and generating initial themes*: Codes with similar message were grouped together, and themes were developed for each cluster to capture the essence of the meanings which resulted in 13 themes and two sub-themes. In Step four, *Reviewing themes,* appropriateness of developed codes and themes was re-examined to ensure cohesiveness of codes and themes in storytelling of the data set (32).A process map as depicted in Figure III, was utilised for visualisation of the process.

Order Of Themes	Justification	Data Excerpts

Key:
Theme = ⬭ ———— = Sub theme- theme relationship
Sub theme = ▱ ⟷ = Theme-theme- relationship

Source: Adapted from 'Assessing performance of Botswana's public health medical laboratories: utilisation of the 2008 Maputo declaration framework for laboratory strengthening'(36)

A process map as a visualization tool showcasing the anchoring theme 'Developmentand implementation of laboratory policy and strategy'and its interrelation to other themes.

Figure III: Process Map Showing Final Themes, Sub-Themes and their Relationship to Each Other During Thematic Analysis.

Step five, Defining and naming themes; The themes were re-examined against associated codes and data excerpts to ensure relatedness and connection to ensure general flow of storytelling of data as related to the research question. The final step, Step six focused on Producing a report, and this, as indicated in Table 4, focused on establishing the order of themes to guarantee a meaningful and logical connection to communicate the study data.

Table 4: Themes Developed from Informant Semi-Structured Interview Conducted in Gaborone, Botswana 27-28 September 2023

Development And Implementation of National Laboratory Policy and Strategy	This theme, when established, will be a blueprint of the very essence of the laboratory, its governance and operations and properly guides all the functions of the laboratory.	"First of all, I think that we are to address policy, policy in the sense that, if you only have policy is not a law, but the policy helps you to be able to say, this is the direction that we want to go. And the beauty about the policy is that when you have, when it's done properly, you will have feedback from different ministries" ……. "Here is the policy that is approved, now we have a strategy, lets implement this policy with a strategy, so it, it works very well cause now if you have a strategy, you can start filling a few of the gaps in addressing them" (CS, Key-informant, 27 September 2023)
		Supporting literature: Strategic plan will incorporate the needs of public health laboratories (17).
Equitable Funding and Support	Availability of resources to carry out the laboratory mandate. Basically, costing the strategic plan and budgeting appropriately. Harnessing all available avenues for resources	"So essentially, when you are talking equity, and uhm, and you have 95% of your population being reliant on a public health system". (CS, Key-informant, 27 September 2023)
		Supporting literature low visibility and lack of prioritization of labs (5). Lack of awareness of significance of lab (4). medical laboratory in resource limited countries have no dedicated budget (8, 17, 37)
Capacity Building Through Training and Continuous Learning	Educating and upskilling personnel to execute the laboratory vision	"Continuous education, CPD…. programs, where people who are in the lab, they continuously have to learn, particularly where they can do as technology is evolving, fields are evolving". (NL, Key-informant, 28 September 2023)
		Supporting literature Unskilled and inappropriately distribution staffing (38)
Contract Management to Ensure a Win-Win for Both Government and Vendors	Contract management will ensure all parties adhere to their promise to ensure fairness and uninterrupted service delivery.	"Quite often government gets fleeced or cheated out because people don't read, we don't read the contracts, we don't manage the contracts such that, when you don't manage the contracts, when the supplier or the vendor does not deliver, you are not able to take them to really being able to work amicably through thing is a relationship that you do, so contract management means key, even in whatever jobs that you do" (CS, Key-informant, 27 September 2023) Supporting literature: (39, 40)
Equipment Standardization Through Implementation of Equipment Placement Strategy to Close Equipment and Supply Chain Challenges"	Equipment standardization ensures menu standardization across all tiers, manageable of contracts and reagents/consumables.	"First is the machine- the equipment. You see when you have equipment that is being able to respond on time, when equipment breaks down, and you rely on service provision from South Africa, where they come and fix the equipment, it takes time. And then the second one after equipment breakdown, the service and maintenance of the equipment, using old equipment, and also, buying equipment. One of the key things in terms of equipment which now has moved is that, at the beginning of the program we used to buy equipment, so when equipment upgrades, you can't upgrade because it's your own equipment and its yours. Then, looking at the challenges that were associated with that, we moved to lease- placement, based on the reagents. Because when it's not performing, the supplier is in charge of making sure that the machine runs and serviced on time and does not affect your accreditation system" (NL, Key-informant, 28 September 2023). Supporting Literature: "Strong country leadership and commitment are needed to assure development and sustained implementation of policies and strategies for standardization of equipment, and regulation of its procurement, donation, disposal, and replacement" (39) (NL, Key-informant, 28 September 2023)

Workflow Optimization and Processes Automation	Utilization of automation, and workflow optimization will cut down required hands-on time and free the scientist to do more work. This	"And also refine it, work processes. If you do everything in work processes and everyone has a buy-in in work processes..." (NL, Key-informant, 28 September 2023)
		Supporting Literature: Benefits of automation takes time as lab has to deal with inherent problems of automation (41)
Optimization Of Multiplexing of Tests in High Throughput Analysers	Multiplexing testing saves resources including time to build competency, need to buy multiple equipment, and laboratory space. Optimizing multiplexing hence will ensure effective and efficient service delivery	"Test that are coming up are multiplexing, in other words they can do, they can do your HIV hepatitis, and you could do Syphilis, 3 tests in one. Those are the kind of tests you look into in order for you to address a number of issues, a broader issue, is like you could look at your HIV, your hepatitis B, and then syphilis". (CS, Key-informant, 27 September 2023)
		Supporting Literature: Multiplex will improve the ultimate goal of labs by increasing its capacity for disease monitoring and bio-surveillance (42)
Monitoring And Evaluation Strategy to Facilitate Data - Driven Decision Making	Evidence based decision making saves time and resources, hence monitoring and evaluation of all processes is imperative in moving the laboratory in its ability to prevent, diagnose, monitor diseases	"But as long as we don't have data, as long as we don't have distilled data, then it doesn't help. ..... we need to have a strong data management strategy". (CS, Key-informant, 27 September 2023)
		Supporting Literature monitoring and evaluation system one of the required coordinated elements of lab system strengthening (39, 40).

Source: Adapted from 'Assessing performance of Botswana's public health medical laboratories: utilisation of the 2008 Maputo declaration framework for laboratory strengthening' (36)
Abbreviations:
CPD, continuing profession development
Lab, Laboratory

Discussion:

Through the self-administered questionnaire, the results highlighted shortage of staff, reagents shortage or expiries and equipment breakdowns as the main impediments to optimal service delivery. The one-on-one semi-structured interviews expounded on these issues, giving more details surrounding each issue and identified challenges in the following thematic areas: laboratory governance, equitable funding, capacity building, refined workflow, multiplexing, monitoring and evaluation strategy, contract management and equipment standardisation.The questionnaire gave net response rate of 27.6% comparable to similar study(31) which gave a 20.4% yield. The response rate from emailed electronic questionnaire, yielded low response rate compared to the pen-and -paper-based method, consistent with literature(28, 29). Several reasons may have attributed to the received response rate including timing, as some people may have been on leave or dealing with other laboratory priorities or having survey fatigue due to multiple requests to participate in studies (29). Other contributing factors may include length of questionnaire though this claim was disputed by (29, 31, 43) who found that shorter questionnaire increased response rate slightly though at a risk of losing important information omitted in the questionnaire. Fear of being victimized? Security of confidentially may be perceived better in paper-based survey (29) as was noted in this study where a laboratory which opted for paper-based questionnaire gave a 100% response rate. Lack of incentives? Some studies (29, 31) indicate that offering incentives increases the response rate. It is possible that the email with the study link may have been sent to the email spam instead of inbox of the participants.

Consistent with findings by (44) on performance of Botswana public health hospitals, poor governance and inadequate resources were amongst those highlighted in this study fundings. Not surprising that National Laboratory governing documents was an anchoring theme in the thematic analysis highlining the importance of having a roadmap to guide priorities of medical laboratory. National governing documents advocates for strategic and operations of laboratory including themes in this study such as a having a dedicated medical laboratory budget-line to allow for autonomous decision making and improved medical laboratory service delivery (37). The current system of promoting staff based mainly on length of service rather than skill hampers the capability of laboratories hence there is need to upskill staff prior to promotion (8) and utilize skill matrix to facilitate the staff transfer

process to achieve equitable staff distribution (38), better welfare and staff retention (11). Contract Management could promote accountability and presents a mutual benefit between government and vendors while guaranteeing a sustained supply-chain of laboratory commodities, currently, the Botswana ministry of health is working on Equipment Placement Strategy to safeguard against testing interruptions (39, 40). Workflow optimization (13) and multiplexing may increase laboratory capacity (42) and efficiency. A Monitoring and Evaluation Strategy is imperative to guide mining and utilisation of data to facilitate data-driven decision making (39, 40).

Recommendations:
Lack of documented causes of suboptimal public medical laboratories hinders the design of impactful interventions for a sustained high performing medical laboratory system (45). This study results echo the need to have a laboratory system evaluation prior to implementing interventions for effective results. It is recommended that this study be repeated in future to allow for comparison of similarities and differences (37) between now and after implementation of interventions, to appreciate how time has affected the medical laboratory service delivery (38).

Limitations:
The study has several limitations. It should be noted that Botswana has 27 districts, but the study was limited to laboratories in only one district due to the long process of acquiring study permits from different ethical review boards as, depending on their size and specialty, the laboratories are governed by different institutions.

Conclusion:
The study identified eight (8) thematic areas that if implemented could optimize medical laboratory service delivery in public health facilities. This study used the laboratory personnel's experiences and opinions to explore the issues of the medical laboratory sub-optimal service delivery to guide the research findings and conclusions (46) thus promoting buy-in of the interventions that would be made. The study highlights the often-underrated medical laboratory scientists as instrumental in identifying solving their own problems.

References:
1. Dzinamarira T, Dzobo M, Chitungo I. COVID-19: A perspective on Africa's capacity and response. Journal of medical virology. 2020.
2. Lippi G, & Plebani. The critical role of laboratory medicine during coronavirus
disease 2019 (COVID-19) and other viral outbreaks. Clinical Chemistry and Laboratory Medicine
2020;58(7):58(7), 1063-9.
3. Keet R, & Rip, D. . Listeria monocytogenes isolates from Western Cape, South
Africa exhibit resistance to multiple antibiotics and contradicts certain global resistance patterns. AIMS microbiology. 2021;7(1):40.
4. Sayed S, Cherniak, W., Lawler, M., Tan, S. Y., El Sadr, W., Wolf, N., ... & Fleming, K. A. , (2018). . Improving pathology and laboratory medicine in low-income and middle income countries: roadmap to solutions. The Lancet. 2018;391(10133): 1939-52.
5. Fleming KA, Horton S, Wilson ML, Atun R, DeStigter K, Flanigan J, et al. The Lancet Commission on diagnostics: transforming access to diagnostics. The Lancet. 2021;398(10315):1997-2050.
6. Boehme C, & Pai, Madhukar. Diagnostic Gaps in Global Health: Lack
of diagnostic capacity in primary care impacts patient outcomes, damages health systems, and lowers health security. . Think Global health. 2020.
7. Williams J, Umaru F, Edgil D, Kuritsky J. Progress in harmonizing tiered HIV laboratory systems: challenges and opportunities in 8 African countries. Global Health: Science and Practice. 2016;4(3):467-80.
8. Koster W, Ndione, A. G., Adama, M., Guindo, I., Sow, I., Diallo, S., ... & Ondoa, P. . An oral history of medical laboratory development in francophone West African
countries. An oral history of medical laboratory development in francophone West African
countries. 2021;10(1): 1-10.
9. Kibet E, Moloo, Z., Ojwang, P. J., Sayed, S., Mbuthia, A., & Adam, R. D. . Measurement of improvement achieved by participation in international laboratory accreditation in sub-Saharan Africa: the Aga Khan University Hospital Nairobi experience. American journal of clinical pathology. 2014;141(2): 188-95.
10. Peter TF, Rotz, P. D., Blair, D. H., Khine, A. A., Freeman, R. R., & Murtagh, M. M. . Impact of laboratory accreditation on patient care and the health system. American journal of clinical pathology. 2010;134(4): 550-5.

11. Naicker S, Plange-Rhule, J., Tutt, R. C., & Eastwood, J. B. Shortage of healthcare workers in developing countries—Africa. Ethnicity & disease. 2009;19: 60-4.

12. Mannon M. Lean healthcare and quality management: The experience of ThedaCare. Quality Management Journal. 2014;21(1):7-10.

13. Yüksel H. An application of lean thinking principles in a laboratory of a hospital. Iioab journal. 2018;9(6): 21-7.

14. Van Rossum L AK, Simons FE, van der Eng N, Ten Have WD. Lean healthcare from a change management perspective: the role of leadership and workforce flexibility in an operating theatre. Journal of health organization and management. 2016; 16;30(3):475-93.(3):475-93.

15. Lawrence GA, & Frater, T. G. Change management in healthcare: managing paradigmatic change in the Australian National Cervical Screening Programme. . New Zealand Journal of Medical Laboratory Science. 2017;7(2):31.

16. Mosadeghrad AM. Implementing strategic collaborative quality management in healthcare sector. International Journal of Strategic Change Management 2012;4(3-4):203-28.

17. Alemnji G, Zeh C, Yao K, Fonjungo P. Strengthening national health laboratories in sub-S aharan A frica: a decade of remarkable progress. Tropical Medicine & International Health. 2014;19(4):450-8.

18. Schroeder LF, Amukele T. Medical laboratories in sub-Saharan Africa that meet international quality standards. American journal of clinical pathology. 2014;141(6):791-5.

19. Alemnji GA, Branch S, Best A, Kalou M, Parekh B, Waruiru W, et al. Strengthening national laboratory health systems in the Caribbean region. Global public health. 2012;7(6):648-60.

20. WHO X. Consultation on technical and operational recommendations for clinical laboratory testing harmonization and standardization. 2008.

21. Luboga SA, Stover B, Lim TW, Makumbi F, Kiwanuka N, Lubega F, et al. Did PEPFAR investments result in health system strengthening? A retrospective longitudinal study measuring non-HIV health service utilization at the district level. Health policy and planning. 2016;31(7):897-909.

22. Nkengasong JN, Mbopi-Keou F-X, Peeling RW, Yao K, Zeh CE, Schneidman M, et al. Laboratory medicine in Africa since 2008: then, now, and the future. The Lancet infectious diseases. 2018;18(11):e362-e7.

23. PEPFAR. Site Improvement Through Monitoring Systems (SIMS): Implementation guide. 2022.

24. Makadzange PF. A descriptive narrative on the current situation against the gold standards regarding institutionalisation of national monitoring and evaluation system for Botswana and Zimbabwe. African Evaluation Journal. 2022;10(1):578.

25. SADC. Assessment report on reference laboratories in the SADC region. . . Gaborone, Botswana. : Directorate of Social & Human Development & Special Programs SADC Secretariat; 2009.

26. Kontio J, Lehtola L, Bragge J, editors. Using the focus group method in software engineering: obtaining practitioner and user experiences. Proceedings 2004 International Symposium on Empirical Software Engineering, 2004 ISESE'04; 2004: IEEE.

27. Cagetti MG, Cairoli JL, Senna A, Campus G. COVID-19 outbreak in North Italy: an overview on dentistry. A questionnaire survey. International journal of environmental research and public health. 2020;17(11):3835.

28. Ebert JF, Huibers L, Christensen B, Christensen MB. or web-based questionnaire invitations as a method for data collection: cross-sectional comparative study of differences in response rate, completeness of data, and financial cost. Journal of medical Internet research. 2018;20(1):e24.

29. Ellis LA, Pomare C, Churruca K, Carrigan A, Meulenbroeks I, Saba M, et al. Predictors of response rates of safety culture questionnaires in healthcare: a systematic review and analysis. BMJ open. 2022;12(9):e065320.

30. Fisher MJ, Marshall AP. Understanding descriptive statistics. Australian critical care. 2009;22(2):93-7.

31. Deutskens E, De Ruyter K, Wetzels M, Oosterveld P. Response rate and response quality of internet-based surveys: An experimental study. Marketing letters. 2004;15:21-36.

32. Braun V, Clarke V. Using thematic analysis in psychology. Qualitative research in psychology. 2006;3(2):77-101.

33. Kiger ME, Varpio L. Thematic analysis of qualitative data: AMEE Guide No. 131. Medical teacher. 2020;42(8):846-54.

34. Bowman R, Nadal C, Morrissey K, Thieme A, Doherty G, editors. Using thematic analysis in healthcare HCI at CHI: A scoping review. Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems; 2023.

35. Byrne D. A worked example of Braun and Clarke's approach to reflexive thematic analysis. Quality & quantity. 2022;56(3):1391-412.

36. Nkoane TT. ASSESSING PERFORMANCE OF BOTSWANA'S PUBLIC HEALTH MEDICAL LABORATORIES: UTILIZATION OF THE 2008 MAPUTO DECLARATION FRAMEWORK FOR LABORATORY STRENGTHENING [Doctoral dissertation]. Unpublished: University of Zambia; 2024.

37. Martin R, Barnhart S. Global laboratory systems development: needs and approaches. Infectious Disease Clinics. 2011;25(3):677-91.

38. Getahun MS, Yemanebrhane N, Desalegn DM, Kitila KT, Dinku TT, Wondimagegnehu DD, et al. Medical laboratory accreditation in a resource-limited district health centre laboratory, Addis Ababa, Ethiopia. African journal of laboratory medicine. 2019;8(1):1-5.

39. Fonjungo PN, Kebede Y, Messele T, Ayana G, Tibesso G, Abebe A, et al. Laboratory equipment maintenance: a critical bottleneck for strengthening health systems in sub-Saharan Africa? Journal of public health policy. 2012;33:34-45.

40. Nkengasong JN, Mesele T, Orloff S, Kebede Y, Fonjungo PN, Timperi R, et al. Critical role of developing national strategic plans as a guide to strengthen laboratory health systems in resource-poor settings. American Journal of Clinical Pathology. 2009;131(6):852-7.

41. Lam CW, Jacob E. Implementing a laboratory automation system: experience of a large clinical laboratory. Journal of laboratory automation. 2012;17(1):16-23.

42. Deshpande A, McMahon B, Daughton AR, Abeyta EL, Hodge D, Anderson K, et al. Surveillance for emerging diseases with multiplexed point-of-care diagnostics. Health security. 2016;14(3):111-21.

43. Bolt EE, van der Heide A, Onwuteaka-Philipsen BD. Reducing questionnaire length did not improve physician response rate: a randomized trial. Journal of clinical epidemiology. 2014;67(4):477-81.

44. Seitio-Kgokgwe O, Gauld RD, Hill PC, Barnett P. Assessing performance of Botswana's public hospital system: the use of the World Health Organization Health System Performance Assessment Framework. International journal of health policy and management. 2014;3(4):179.

45. Davies J, Abimiku Al, Alobo M, Mullan Z, Nugent R, Schneidman M, et al. Sustainable clinical laboratory capacity for health in Africa. The Lancet Global Health. 2017;5(3):e248-e9.

46. VanWynsberghe R, Khan S. Redefining case study. International journal of qualitative methods. 2007;6(2):80-94.