Preplanned Studies

Assessment of the Public Health Laboratory Capacity — Sierra Leone, 2021

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Summary

What is already known about this topic?

Public health laboratories (PHLs) are critical for effectively identifying, detecting, preventing, and responding to emerging and reemerging infectious diseases. Following the 2014 Ebola outbreak, Sierra Leone implemented a national laboratory strategic plan (2015–2020) aimed at creating, strengthening, and maintaining laboratory capacities for detecting, assessing, notifying, and reporting incidents, with a requirement to review PHL capabilities every five years.

What is added by this report?

This study assessed the comprehensive capacity and personnel status of PHLs in Sierra Leone using a standardized assessment tool following the implementation of the 2015 National Laboratory Strategic Plan. Among 11 indicators evaluated, laboratory infrastructure and equipment, data and information management, experimental technical training, and laboratory performance received low scores. The assessment revealed critical personnel gaps, including limited staff with extensive work experience and advanced education. Additionally, laboratory staff demonstrated limited capabilities in specialized areas such as gene library creation, primer design, sequencing, surveillance, and field epidemiology and laboratory-related training.

What are the implications for public health practice?

Continued investment and capacity building are essential for PHLs to deliver high-quality testing services and effectively support public health functions. The identified gaps across various indicators must be systematically addressed to strengthen PHL capacity in Sierra Leone.

Public health laboratories (PHLs) serve as cornerstones for patient diagnosis, disease management, surveillance, and epidemiological investigations (*1*). The 2014–2016 Ebola outbreak exposed critical weaknesses in Sierra Leone's laboratory system capacity (*2*). In response, the Ministry of Health and Sanitation (MoHS) of Sierra Leone committed to strengthening its laboratory infrastructure in alignment with international frameworks — including the Global Health Security Agenda, International Health Regulations, and Economic Community of West African States guidelines — to establish, enhance, and sustain laboratory capabilities for detecting, assessing, notifying, and reporting infectious disease incidents (*3*). The country's laboratory network comprises eight public health laboratories: one central public health reference laboratory, four national public health laboratories, and three regional public health laboratories (*4*). In 2015, Sierra Leone implemented a national laboratory strategic plan, scheduled for review every five years, focusing on improving diagnostic quality and disease surveillance across all tiers of the laboratory system (*5*). This study evaluated the comprehensive capacity and personnel status of PHLs in Sierra Leone to inform strategic improvements in their capabilities for diagnosing, preventing, and controlling infectious diseases, including tuberculosis (TB), malaria, Acquired Immune Deficiency Syndrome (AIDS), Ebola, Lassa fever, and coronavirus disease 2019 (COVID-19).

This study assessed all PHLs in Sierra Leone in 2021, including the Central Public Health Reference Laboratory (CPHRL), four national-level laboratories, and three regional laboratories. The national-level facilities comprised the Ola During Children's Hospital (ODCH), Connaught Hospital Lab (Connaught), Jui Public Health Laboratory (Jui Lab), and National TB Reference Laboratory Lakka (TB). The regional facilities included Kenema Laboratory, Bo Reference Lab (Bo), and Makeni Laboratory. Assessment was conducted using a standardized tool modified from the World Health Organization

(WHO) laboratory assessment framework and the 2016 Ministry of Health and Sanitation laboratory capacity survey. The tool evaluated both comprehensive laboratory capabilities and personnel status (Supplementary Material, available at https://weekly.chinacdc.cn/). Laboratory directors assessed their facilities' comprehensive capacity using the organizational structure component, while data on staff education and work experience were collected through face-to-face interviews. Of the 79 total staff across all PHLs, 51 (64.6%) were randomly selected based on each facility's human resource distribution and completed the personnel survey. All data were verified and documented using standardized forms and underwent double data entry into Excel spreadsheets. Performance scores were categorized as excellent (100%–85.0%), good (84.0%–70.0%), fairly good (69.0%–60.0%), poor (59.0%–30.0%), or very poor (29.0%–0%).

Statistical analysis employed descriptive methods, with indicator scores calculated as percentages. Inter-facility comparisons were conducted using Student's *t*-test, with statistical significance set at $P<0.05$. All analyses were performed using SPSS (version 20, United States, IBM).

The comprehensive assessment revealed that Sierra Leone's PHLs demonstrated good overall capacity, with a mean score of 71.0% across all indicators. Kenema and CHPRL achieved the highest average scores (83.0% and 81.0%, respectively), followed by Jui Lab (79.0%) and Connaught Lab (70.0%). The remaining facilities — TB, Makeni, ODCH, and Bo — scored 69.0%, 66.0%, 64.0%, and 57.0%, respectively (Table 1). Statistical analysis revealed significant differences in average scores between PHLs ($P<0.05$) (Figure 1).

Laboratory capacity exhibited considerable variation across indicators. Six of the eleven indicators were assessed as fairly good (60.0%–69.0%), with laboratory infrastructure and equipment, data and information management, and experimental technical training receiving notably low scores. Infrastructure limitations were evident, as only four PHLs maintained 24-hour electricity service. Additionally, half of the facilities lacked sequencing equipment, and while some PHLs had internet-connected personal computers, none possessed servers. Specimen management and biosafety and waste disposal demonstrated moderate performance (70.0% and 81.0%, respectively). Transport and specimen referral and organization and management achieved high scores (88.0% and 94.0%, respectively). Laboratory performance emerged as the sole indicator rated as poor, scoring 59.0% (Table 1). Capacity disparities were also observed among PHLs.

TABLE 1. Scores for 11 indicators and comprehensive capacity of public health laboratories in Sierra Leone, 2021.

Indicators	Public health laboratories' scores (%)								
	CPHRL*	Connaught†	TB†	ODCH†	Jui Lab†	Makeni§	Bo§	Kenema§	Average
Organization and Management	100	100	100	50	100	100	100	100	94
Transport & Specimen Referral	100	100	100	67	100	67	67	100	88
Biosafety & waste disposal	65	75	100	60	95	90	80	85	81
Specimen Management	67	100	56	89	33	44	94	78	70
Stock management for reagents & consumables	89	63	50	63	75	63	63	89	69
Public health functions	92	52	60	73	68	71	61	68	68
Human Resource	90	79	76	39	70	70	31	79	67
Laboratory infrastructure & equipment	80	60	50	50	100	51	30	80	63
Data and information Management	80	55	90	30	60	50	30	100	62
Experimental technical training received	78	33	56	78	89	67	22	56	60
Laboratory Performance	50	50	25	100	75	50	50	75	59
Comprehensive capacity score¶	81	70	69	64	79	66	57	83	71

Abbreviation: CPHRL=Central Public Health Reference Laboratory; Connaught=Connaught Hospital Lab; TB=National TB Reference Laboratory Lakka; ODCH=Ola During Children's Hospital; Jui Lab=Jui Public Health Laboratory; Bo=Bo Reference Lab; PHLs=Public Health Laboratories.

* National reference laboratory.

† National PHLs.

§ Regional PHLs.

¶ Comprehensive capacity score was calculated as the mean of 11 indicators for each PHL.

CPHRL	Makeni	Bo	Kenema	TB	ODCH	Jui Lab	PHLs
t=−2.042 P=0.066	t=0.112 P=0.913	t=2.453 P=0.032	t=−2.755 P=0.019	t=−0.192 P=0.815	t=0.192 P=0.852	t=−1.351 P=0.204	Connaught
	t=3.092 P=0.010	t=3.061 P=0.011	t=0.051 P=0.960	t=2.072 P=0.063	t=1.789 P=0.101	t=0.206 P=0.841	CPHRL
		t=1.550 P=0.149	t=−2.468 P=0.031	t=−0.436 P=0.671	t=−0.128 P=0.901	t=−2.758 P=0.019	Makeni
			t=−3.778 P=0.003	t=−1.644 P=0.128	t=−1.161 P=0.270	t=−2.421 P=0.034	Bo
				t=2.225 P =0.048	t=1.721 P=0.113	t=0.142 P=0.890	Kenema
					t=0.299 P=0.770	t=−1.460 P=0.172	TB
						t=−1.636 P=0.130	ODCH

FIGURE 1. Statistical differences in the scores of different public health laboratories in Sierra Leone, 2021.
Abbreviation: CPHRL=Central Public Health Reference Laboratory; Connaught=Connaught Hospital Lab; TB=National TB Reference Laboratory Lakka; ODCH=Ola During Children's Hospital; Jui Lab=Jui Public Health Laboratory; Bo=Bo Reference Lab; PHLs= Public Health Laboratories.
Note: Statistic values of comparisons between PHLs from Student's t test. Color in yellow presents P<0.05, grey presents P≥0.05.

For instance, the human resources indicator ranged from excellent at CPHRL (90.0%), followed by Connaught and Kenema (both 79.0%), and TB (76.0%), to poor at Bo and ODCH (31.0% and 39.0%, respectively). Laboratory performance scores varied substantially, with TB, Kenema, and Jui laboratories achieving excellent to good ratings, while the remaining facilities scored poor. Notably, each PHL exhibited at least one indicator assessed as poor, scoring below 60.0%.

Regarding educational qualifications and continuing professional development, the laboratory system faces significant limitations in advanced degree holders and specialized public health training. The majority of laboratory staff held bachelor's degrees (52.9%) or national diplomas (27.5%), with only 13.6% possessing master's degrees. Advanced qualifications including PhDs, doctoral degrees, or postgraduate diplomas represented just 6.0% of the workforce. Analysis of educational backgrounds revealed that 41.2% specialized in medical laboratory science, 31.3% in biological sciences, while public health laboratory specialization (2.0%) and public health (5.8%) were notably underrepresented (Table 2). Training assessment indicated high participation rates (74.5%–98.0%) in core competencies including data management, laboratory management, bio-risk and biosafety management, quality assurance systems, specimen handling, and diagnostic techniques. However, critical specialized skills showed concerning deficits, with only 27.5% to 41.2% of staff trained in bioinformatics, epidemiological surveillance, and field epidemiology and laboratory methods (Table 2).

The workforce analysis revealed significant experience gaps, with most staff having less than five years of professional experience and few personnel possessing more than a decade of laboratory practice. While staff demonstrated high competency rates in fundamental laboratory procedures, including diagnostic techniques (100%) and specimen management (92.2%), advanced capabilities were markedly limited. Specifically, proficiency in epidemiological surveillance (39.2%), field epidemiology and laboratory training (37.3%), and bioinformatics (39.2%) was notably deficient. Bioinformatics expertise was particularly constrained in command-line operations and high-throughput sequencing data analysis. Regarding technical competencies, while a substantial proportion of staff (68.6%–100%) demonstrated proficiency in standard procedures such as bacterial culture and identification, rapid diagnostic testing, blood film analysis, malaria parasite microscopy, PCR, and nucleic acid extraction, advanced molecular techniques showed significant gaps. Only a small fraction of personnel demonstrated competency in gene library preparation (15.7%), primer design (19.6%), sequencing (21.6%), and tissue anatomy (23.5%) (Table 3).

DISCUSSION

Our assessment identified critical gaps in Sierra Leone's public health laboratory system that necessitate nationwide commitment to capacity building and

TABLE 2. Educational attainment and continuous medical education in public health laboratories in Sierra Leone, 2021.

Indicators	No. of staff	Percentage
Education		
Bachelor of science degree	27	52.9
National diploma	14	27.5
Master of science	7	13.6
Doctor of Philosophy	1	2.0
Doctoral degree	1	2.0
Postgraduate diploma	1	2.0
Major		
Medical laboratory	21	41.2
Biological science	16	31.3
Chemistry	4	7.7
Public health	3	5.8
Environmental management & quality control	1	2.0
Epidemiology and medical statisitcs	1	2.0
General medicine	1	2.0
Graduate diploma/B.SC chemistry	1	2.0
Immuno-virology	1	2.0
Advance nursing & medical technology	1	2.0
Public health laboratory	1	2.0
Professional training ever received		
Laboratory diagnostic techniques	50	98.0
Specimen collection, packaging and transportation	47	92.2
Laboratory quality assurance	47	92.2
Bio-risk and biosafety management	46	90.2
Laboratory management	41	80.4
Data management	38	74.5
Epidemiological surveillance	21	41.2
Field Epidemiology and Laboratory Training Programme	21	41.2
Bioinformatics	14	27.5
Competency assessment		
Yes	43	84.3
No	8	15.7

enhancement across multiple indicators. The results revealed that laboratory infrastructure and equipment, data and information management, experimental technical training, and laboratory performance represent the most significant weaknesses compared to other indicators. Furthermore, substantial capacity disparities exist among different PHLs, with some facilities demonstrating relatively balanced development, such as the CPHRL, Kenema, and Jui laboratories, while others exhibited poor performance in at least three indicators requiring immediate improvement.

The National Health Sector Strategic Plan 2015–2020 in Sierra Leone established standards and priorities for PHLs, emphasizing laboratory administration (infrastructure, utilities, equipment), human resources (service levels, training), and health and safety (safety officials, biosafety and biosecurity) as top priorities for laboratory development (*1*). Our 2021 assessment revealed that inadequate infrastructure remains prevalent across PHLs. The most critical concern is insufficient electrical supply,

TABLE 3. Work experience of staff in public health laboratories in Sierra Leone, 2021.

Indicators	No. of staff	Percentage
Work in HCS		
≤5 years	25	49.0
>5 years and <10 years	13	25.5
≥10 years	13	25.5
Work in Lab		
≤5 years	33	64.7
>5 years and <10 years	12	23.5
≥10 years	6	11.8
Work experience in the following areas		
Laboratory diagnostic techniques	51	100.0
Specimen collection, packaging and transportation	47	92.2
Laboratory quality assurance	47	92.2
Bio-risk and biosafety management	43	84.3
Laboratory management	42	82.4
Data management	35	68.6
Epidemiological surveillance	20	39.2
Bioinformatics	20	39.2
Field Epidemiology and Laboratory Training Programme	19	37.3
Understanding of molecular genetics	49	96.1
Bioinformatics background		
Basic evolutionary	43	84.3
Heard about bioinformatics genomics	41	80.4
Heard about comparative genomics	23	45.1
Experience on command lines	10	19.6
High-throughput sequencing data	9	17.6
Biological experiments and tests		
Malaria rapid diagnostic tests	51	100.0
Polymerase chain reaction	45	88.2
Blood film and microscopic examination	43	84.3
Nucleic acid extraction	41	80.4
Bacterium culture and identification	35	68.6
Mosquito identification	24	47.1
Microbial strain isolation	22	43.1
Tissue anatomy	12	23.5
Sequencing	11	21.6
Primer design	10	19.6
Gene library creation	8	15.7

Abbreviation: HCS=healthcare system.

with half of PHLs lacking 24-hour electricity service, which compromises normal laboratory operations. Regarding human resources, our findings indicate that the number of skilled professionals is insufficient to meet diagnostic testing needs in several PHLs. This challenge was also highlighted in the Public Health Surveillance Strategy Plan 2019–2023 in Sierra Leone (*4*), which noted that one-third of skilled specialists are approaching retirement age. Despite the inclusion of training initiatives in the National Health Sector

Strategy Plan 2015–2020 (*4*), the high-quality training in specialized fields such as bioinformatics, epidemiological surveillance, and field epidemiology and laboratory programs requires further enhancement to meet minimum qualified personnel requirements for supporting testing services in disease surveillance and outbreak response.

Laboratory information management system development was designated as the second priority for PHLs capacity building in Sierra Leone, with the goal of establishing an integrated laboratory information and management system within the national health management information system by 2020 (*1*,*6*). While paper-based laboratory management information systems were established and electronic systems initiated in some facilities by 2019 (*6*). The shortage of competent staff and inadequate computer infrastructure (*6*) necessitates improvements in basic data management processes, such as standardization of data collection, storage, analysis, and utilization. In addition, laboratory performance remains a critical concern in several facilities, representing the only indicator rated as poor in the assessment. Public health laboratories serve as the cornerstone of emergency response capabilities and are responsible for testing key epidemic-prone diseases in Sierra Leone, including monkeypox, zika, cholera, meningitis, influenza, measles, and rubella (*4*). However, inconsistent funding streams, delays in equipment and reagent procurement. The shortages of qualified personnel have compromised the efficiency and availability of testing services for severe infectious diseases like COVID-19 and Ebola in certain regions (*4*).

This study has several limitations that warrant consideration. First, the high scores achieved by some PHLs may not accurately reflect their actual testing capabilities, potentially leading to an overestimation of their performance. Second, while our investigation focused on PHL capabilities, we did not explore the underlying factors contributing to low-scoring indicators, which should be addressed in future studies.

In conclusion, while PHLs have established foundational capabilities and demonstrate strengths in certain areas, significant capacity disparities and weaknesses persist across different facilities. Continued investment and systematic improvement of PHL capacity are essential to ensure the delivery of high-quality testing services and effective public health functions.

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SUPPLEMENTARY MATERIAL

INSTRUCTIONS

This assessment tool comprises the following components:

PART I: Organizational structure

1. Human resources
2. Laboratory infrastructure and equipment
3. Transport and specimen referral
4. Stock management for reagents and consumables
5. Laboratory performance
6. Specimen management
7. Biosafety and waste disposal
8. Public health functions
9. Organization and management
10. Data and information management
11. The need of experimental technical training

PART II: Personal status

1. Educational attainment and continuous medical education
2. Work experience
3. Biology and bioinformatics background
4. Biological experiments and tests experience