

Status Report of National Reference Laboratories for Epidemiological Surveillance of Communicable Diseases and Diseases with Epidemic Potential in Côte d'Ivoire after More Than a Decade of Existence

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Abstract Introduction: Many hospital, public health and university medical laboratories, whether public or private, contribute through their diagnostic activities to health care and the improvement of public health **Objective:** To evaluate the state of knowledge of the National Reference Centres (NRC) in order to identify measures for their improvement after more than a decade of practice. **Method:** A cross-sectional study was carried out with managers of national reference laboratories. **Result:** The NRCs are active in the surveillance of priority communicable diseases. Their activities are national and international in scope. The NRCs are headed by medical doctors or scientific biologists, all of whom are researchers with an experience of 18.4 ± 9.2 years, with 8 (72.7%) men and 3 (27.3%) women. These managers were appointed by a decision of the management. The NRCs estimated the funds allocated to their activities to be (91.7%) insufficient. The NRCs did not have a laboratory information management system (66.7%). Concerning the problem of infrastructure and operational equipment, the result shows that the NRCs are confronted with an interruption of electricity in 16.6% of cases. Half of the NRCs (58.4%) do not have sufficient laboratory space to carry out their work without compromising the quality of work and the safety of staff. 9 (75%) of the NRCs have successfully participated in proficiency testing programmes and 4 (33.3%) have organised proficiency tests. **Conclusion:** No national reference laboratory is accredited ISO 15189. The results of the assessment can be used to develop a work plan to improve laboratory surveillance and detection of communicable and potentially epidemic diseases in Côte d'Ivoire.

Keywords: national reference center, epidemiological surveillance, communicable diseases, evaluation, Côte d'Ivoire

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1. Introduction

The burden of infectious diseases is even greater in sub-Saharan Africa. Their diagnosis requires quality laboratory tests. This is essential to conduct infectious disease surveillance and guide public health policy [1]. The laboratory therefore plays an essential role in integrated disease surveillance and response by assisting

in the confirmation of cases of communicable diseases and diseases with epidemic potential.

For this reason, the International Health Regulations (IHR), adopted by the World Health Assembly in 2005, gave Member States of the World Health Organization (WHO) specific responsibilities for building and strengthening national capacities for surveillance, detection, assessment, early notification and response to disease outbreaks and other emergencies of potential public health concern.[2,3]

Existing laboratory management capacity building efforts have primarily targeted senior laboratory managers. The focus has been on laboratory policy, systems and network development as opposed to the day-to-day operations of individual laboratories.[4,5,6] Training programs are needed to enable laboratory managers to effectively use available resources (personnel, budgets, supplies, equipment, buildings, and information) for planning, implementing, and evaluating service delivery to meet patient and clinician expectations and public health needs.[7]

Many hospital, public health and university medical laboratories, both public and private, contribute through their diagnostic activities to health care and the improvement of public health.[8,9,10,11] In addition, animal health, food safety and environmental health laboratory services contribute to public health safety. As a result, many public health programs conduct laboratory assessments for different purposes and objectives.[8,11]

Some assessments focus on the technical capacity of a limited number of laboratories, such as the reference laboratories for polio or measles in WHO eradication programs. Other initiatives aim to assess laboratory services at the country level for specific diseases, such as HIV or tuberculosis programs, or cross-cutting laboratory assessments as part of measuring the availability and readiness of surveillance services.[11,12,13]

In Côte d'Ivoire, the Institut Pasteur de Côte d'Ivoire (IPCI) provides considerable support to various health programs. Of the 23 diseases under surveillance, [14] nineteen are capable of being diagnosed at the IPCI. As a result, in 2006, an interministerial order designated several laboratories as national reference centers or laboratories (NRC or NRL). The missions assigned to these CNR are the following: expertise, surveillance and microbiological monitoring, alert, advice to public authorities, conservation and contingency of infectious agents. [15]

NRCs have a critical role in managing the 2017 dengue epidemic [16], SARS Cov-2 in 2019, [17,18,19] in the fight against antimicrobial resistance, the Côte d'Ivoire polio eradication initiative process [20] etc.

However, the NRCs have not been subject to continuous evaluation of their technical capabilities and performance since their designation.

Despite the regulatory requirement of the interministerial decree N°393 of June 26, 2006 designating the list of NRCs of the IPCI in the field of communicable diseases, very few if any evaluations of these laboratories have been conducted to our knowledge.

The objective of this work is to evaluate the state of knowledge of NRCs in order to identify measures for their improvement after more than a decade of practice.

Table 1. lists of priority communicable diseases under surveillance in Côte d'Ivoire and typology of areas of intervention and activities of NRC (Interministerial Order designating the list of National Reference Centers (NRC) of the Institute Pasteur of Côte d'Ivoire in the field of communicable diseases, 2006)

No.	Designation	localization site	Evaluated	Areas of intervention and activities
1	Malaria Chemoresistance	Cocody	Yes	Resistance monitoring
2	Poliomyelitis	Adiopodoume	Yes	Eradication of poliomyelitis cases Virus monitoring in wastewater
3	Influenza and respiratory viruses	Adiopodoume	Yes	Influenza monitoring COVID-19 pandemic Contributes to the flu vaccine
4	Measles	Adiopodoume	Yes	Measles surveillance Strain genotyping (West and Central Africa)
5	Arboviruses: Yellow Fever...	Adiopodoume	Yes	Yellow fever epidemics, Dengue (including dengue 3)
6	Viral hemorrhagic fevers	Adiopodoume	Yes	Ebola case, Lassa, Crimea Congo
7	Rabies	Adiopodoume	Yes	Human case analyzes
8	Agents of Sexually Transmitted Infections	Cocody	Yes	Gonococcal Resistance Monitoring
9	Molecular typing of infectious agents	Adiopodoume	Not evaluated	Contribution to diagnostics by PCR, RT PCR and Sanger sequencing
10	viral hepatitis	Cocody	Not evaluated	Hepatitis B and C
11	Cholera and shigellosis	Cocody	Not evaluated	National surveillance, Very few cases currently
12	Bacterial Meningitis	Cocody	Yes	Molecular surveillance of epidemics (Ex: Pneumococcus)
13	Salmonella	Cocody	Yes	Serotype monitoring
14	Tuberculosis	Cocody	Yes	Resistance monitoring
15	Buruli Ulcer	Cocody	Yes	National Molecular Surveillance
16	Diarrhea viruses		Not evaluated	National Rotavirus Surveillance
17	Evaluation of microbiological diagnostic tests	IPCI and CHUY	Not evaluated	Assessment of COVID 19 tests (2020 to 2022)
18	The Observatory of Resistance of Microorganisms to Anti-infectives Côte d'Ivoire (ORMICI)	Cocody	Yes	National and Global Monitoring (GLASS)
19	The Ivorian Network for the Investigation and Surveillance of Nosocomial Infections (RIISIN)	Cocody	Not evaluated	Hospital surveillance of healthcare-associated infections
20	Biological control of antimicrobial tests and vaccines	Cocody	Not evaluated	Not yet operational

Table 2. Scope of activities of IPCI national reference centers or laboratories

	National scope	Regional scope	International activities
Malaria Chemoresistance	Yes	Yes	No
Poliomyelitis	Yes	Yes	Yes
Influenza and respiratory viruses	Yes	Yes	Yes (flu vaccine)
Measles	Yes	Yes	Genotype of West and Central African strains
Arboviruses: Yellow Fever...	Yes	Yes	No
Viral hemorrhagic fevers	Yes	No	No
Rabies	Yes	No	No
Agents of Sexually Transmitted Infections	Yes	No	Yes global gonorrhea surveillance WHO
Molecular typing of infectious agents	Yes: transversal activity for all cnr	Yes molecular monitoring for Buruli Ulcer	Yes service of yaws and leprosy
viral hepatitis	Yes	No	No
Cholera and shigellosis	Yes	No	No
Bacterial Meningitis	Yes	Yes pasteur network	No
Salmonella	Yes	No	Yes salm-survey network
Tuberculosis	Yes	Yes	Yes monitoring of the multiresistant tube
Buruli Ulcer	Yes	Yes African Buruli Network	No
The Observatory of Resistance of Microorganisms to Anti-infectives Côte d'Ivoire (ORMICI)	Yes	Yes	Yes GLASS

2. Material and Methods

2.1. Study DEsign and SETting

The setting for the study of this work was the Institut Pasteur of Côte d'Ivoire. It is a public establishment with industrial and commercial character directly placed under the supervision of the Ministry of Higher Education and Scientific Research of Côte d'Ivoire. The organization of the IPCI is made of a central direction and several technical departments. These departments are made up of units with specialized laboratories. The missions are research, training, public health, services and diagnostic activities.

This cross-sectional study was carried out over a period of 15 days from July 4 to 22, 2022. The study population of this evaluation was the managers of biology laboratories, particularly the NRCs of Côte d'Ivoire, in accordance with the interministerial decree [15] N°393 of June 26, 2006 designating the list of NRC of the Institut Pasteur of Côte d'Ivoire in the field of communicable diseases (Table 1).

All heads of laboratories or their representatives of the NRC of the IPCI were included in our evaluation, and specifically those who agreed in principle to participate in this study.

Considering the number of laboratories, the sampling was exhaustive. On the basis of the administrative documents consulted, fifteen (15) NRCs were identified and an interview was conducted with the heads.

2.2. Data Collection

The evaluation was conducted by interview using the information sheets developed from Microsoft Word. Data collection was done using the Kobo toolbox v2022.1.2 software. The NRC capacity assessment form was designed and adapted, i.e., modified using the WHO International tool as a model [21] and CDC [22,23] for laboratory assessment. The tool is organized into 13

sections. Each section consists of a series of questions that guide the laboratory capacity assessment process to help identify the laboratory's strengths and challenges, including priority areas for strengthening: 1) respondent information, 2) laboratory identification, 3) organization and management, 4) operational infrastructure and equipment, 5) human resources, 6) quality management system (QMS), 7) sample collection, 8) reporting, 9) data and information management, 10) consumables and reagents, 11) biorisk management policy, 12) public health functions of the NRC, 13) external quality assessment (EQA).

These questions were designed to determine the audited laboratory's ability to respond frequently to public health events, such as an outbreak, by accurately testing samples and reporting data in a timely manner; to identify the implementation of safety and biosafety measures in place; and to ensure the professional development of laboratory staff. These questions also gathered information on the role of the laboratory in public health surveillance; and the conditions of the facility, including the building, availability of electricity, water, and air conditioning.[2]

The tool was used to capture areas of strength and weakness to enable the country to prioritize areas that need strengthening first based on their public health goals and available resources.

Visits were made to the departments housing the NRCs to interview the NRC manager or designated laboratory staff, assess the facilities, and review key documents. IPCI management sent an information letter to all NRC managers informing them of the activity and requesting their support for the project.

2.3. Data Analysis

For the analysis, the data were transferred to an Excel file.

The analysis of the NRC components focused on the main pillars of the national health system : governance; financing; health information; human resources; infrastructure; strategic inputs, drugs and technologies; and services. This analysis was carried out from several

corners : i) institutional performance ; ii) health system resources; iii) health service delivery. Progress and then difficulties or shortcomings in each area were identified. An NRC is considered active when it produces activity reports and provides systematic information to the authorities

2.4. Ethical Considerations

The direction of the IPCI, which hosts the NCRs, and the institutional ethics committee gave their approval before the study was carried out.

3. Results

The evaluation showed that the NRCs are active in the surveillance of priority communicable diseases. The NRCs are distributed over the 2 sites of the Institut Pasteur of Côte d'Ivoire. Seven (7) are at the Adiopodoumé site (58.3%) and five (5) at the Cocody site (41.7%) (Table 1). The activities of the NRCs are national in scope for some NRCs and international for others, but it is mainly epidemiological surveillance (Table 2 and Figure 1). The list of notifiable national diseases is not available in some laboratories (41.7%) (Figure 1).

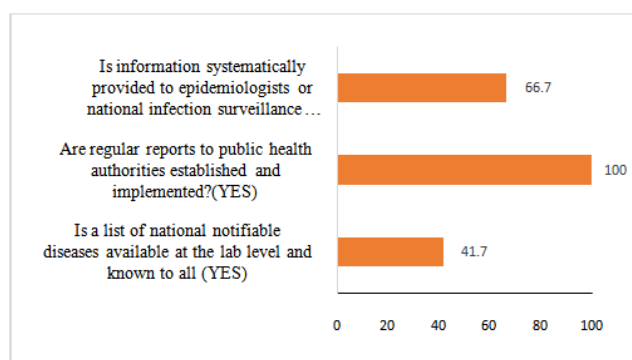


Figure 1. Responses from the 12 participants relating to reports of activities of the IPCI national reference centers

3.1. Institutional Performance

Governance

All NRCs are led by managers designated by a decision of IPCI management. Two out of 12 (16.7%) NRCs have a Stepwise Laboratory Improvement Process Towards Accreditation (SLIPTA) document, with technical support from PEPFAR Implementing Partners (IPs). Most of the 11 NRCs (81.7%) plan to acquire certification or accreditation (Table 3).

Funding

All the NRCs receive funding mainly from the state (budget of the ministry in charge 100%), and secondarily from certain research projects (66.7%). The NRCs have estimated that these funds are insufficient (91.7%) (Table 3)

Health information

Regarding the dissemination of information, all the NRCs have provided regular activity reports to the public health authorities for the implementation of the response. With regard to health information management tools,

the NRCs have developed paper tools (75.0%) and electronic tools (91.7%) for regular data reporting (Table 4). This includes the electronic tools EPIINFO version 3.5.4, for epidemiological surveillance data of certain viral diseases.

Paper tools are used for routine data management. All laboratories performed immediate notification of critical results to the Ministry and provided regular statistical data (100%). However, the NRCs did not have a laboratory information management system (LIMS) in 66.7% of cases due to the lack of basic equipment for the network.

Table 3. Answers from the 12 participants relating to the organization and financing of IPCI national reference centers

	Frequency	Percentage
Sources of funding for your CNR laboratory		
Projects	8	66.7
Line ministry budget	12	100
Development partners	6	50.0
WHO	4	33.3
Do you consider that the funds are sufficient? (NO)	11	91.7
Does the laboratory hold a valid certification and/or accreditation document (ISO 9001, ISO 17025, ISO 15189, national accreditation bodies)? WHO / SLIPTA system (YES)	2	16.7
Is the laboratory currently planned to acquire any certification / or accreditation(YES)	11	91.7

Table 4. Answers from the 12 participants relating to the Data and information management IPCI national reference centers

	Frequency	Percentage
Is there immediate notification of critical findings to the relevant ministry/surveillance network? (YES)	12	100
Does the laboratory provide basic statistical data (e.g. number of tests ordered, aggregated qualitative/quantitative data, etc.)(YES)	12	100
Is the data stored in a paper or electronic system		
Electronic	11	91.7
Paper	9	75
Is an effective backup in place to prevent loss of patient test result data in the event of theft or other incidents to the paper system(YES)	7	58.3
Is Laboratory and Information Management System (LIMS) used in the laboratory YES	4	33.3
Is the laboratory equipped with the following items		
Computer	11	91.7
Internet	7	58.3
Phone	5	41.7
Network Cabling	2	16.7

3.2. Resources

Human resources

The NRCs are directed by physicians or biologists, all of whom are researchers with an experience of 18.4±9.2 years with 8(72.7%) men and 3(27.3%) women.

Table 5 shows that all the NRCs have a training service (100%) but only 66.7% of the NRCs organize continuous training on their protocols etc. and 41.7 % of the NRCs train on site.

Regarding the training of human resources and the quality management system (QMS), most NRCs reported having in place standard operating procedures (SOPs) (100%) and offer a continuous training program (66.7%) for updating procedures and technical support to epidemiological surveillance sites (66.6%) (Figure 2).

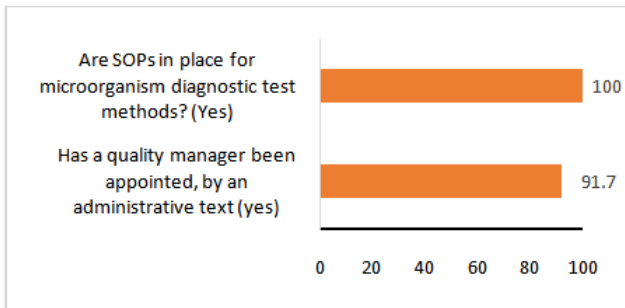


Figure 2. Answers from the 12 participants relating to the quality management system (QMS) to the Management Human resources of the IPCI national reference centers

Table 5. Answers from the 12 participants relating to the Management Human resources of the IPCI national reference centers

	Frequency	Percentage
Is there a service in charge of training in your establishment (yes)	12	100
Is there ongoing training for staff? i.e. regular updates on protocols, procedures, access to journals, etc (yes)	8	66.7
Does your laboratory provide training (regular, planned or random depending on the availability of funds) or technical support to epidemiological surveillance sites? (YES)	8	66.7
does the lab do onsite and/or training at regional labs		
On the site	5	41.7
Training in regional labs	4	33.3
Do you have a budget for training programs at the facility level? (YES)	3	25

Infrastructure

With regard to infrastructure and operational equipment, Table 6 shows that the NRCs are faced with an interruption of electricity in 16.6% of cases. However, all the NRCs have a backup power generator (100%), only 8 (66.6%) of the NRCs have protection for their key or sensitive equipment and 4 (33.3%) have a back-up machine in case of failure.

Concerning the allocated work space, more than half of the NRCs (58.4%) do not have laboratories that meet the standards, i.e., not large enough to carry out the work without compromising the quality of the work and the safety of the personnel.

Inputs and Technologies

For the biosafety profile, Table 7 (biorisk management) shows that a policy concerning biorisk management in the

laboratory (biosafety and biosecurity) is in place in accordance with international regulations, reflected in a Ministerial Order on pathogens at risk. The security level of the laboratories differs from one laboratory to another. Respectively 3 (25.0%), 7 (58.3%) and 1 (8.3%) laboratories are at level P1, P2 and P3. Most of the laboratories only have certified level 2 biosafety cabinets or microbiological safety station (MSS type II).

Table 6. Answers of the 12 participants relating to the infrastructures and operational equipment of national reference centers

	Frequency	Percentage
Is the lab facing a power outage		
Sometimes	10	83.3
Regularly	2	16.7
Do you have a backup power generator or other backup power source? (YES)	12	100
Are key/sensitive equipment protected by an uninterruptible power supply or uninterruptible power supplies (UPS or other) (YES)	8	66.7
If there is a machine shutdown/failure, do you have a backup plan for that?(YES)	4	33.3
Does the lab face water shortages?		
Sometimes	9	75
Never	3	25
Is the allocated space sufficient (large) to carry out the work without compromising the quality of the work and the safety of the personnel ? (No)	5	41.7

Table 7. Answers from the 12 participants relating to the biological risk management policy for IPCI national reference centers

	Frequency	Percentage
Is there a policy concerning the management of biological risks in the laboratory (biosafety and biosafety) YES	12	100
If yes, does the policy clearly state the risk assessment for pathogenic microorganisms? YES	12	100
If so, do they comply with local regulations and/or international standards?	12	100
What are the administrative texts at your disposal (yes a ministerial order on pathogens at risk)	12	100
What is the containment level of the laboratory?		
P1	3	25
P2	7	58.3
P3	1	8.3
Does the laboratory have a certified biosafety cabinet (PSM)? YES	12	100

With regard to samples, the samples and packaging of all the NRCs are processed according to international standards (Table 8).

In terms of technical laboratory practices, Table 9 shows that the NRCs reported performing serological tests (25%), culture/isolation (75%) and RT PCR (91.7%) and

sequencing (25%). Three quarters of the NRCs (75%) have their supply of reagents and consumables centralized at the management level, as opposed to 1% of acquisition by the laboratory. All the NRCs store their inputs within the laboratory.

Table 8. Responses from the 12 participants relating to the Sample Collections of the IPCI national reference centers

	Frequency	Percentage
Are sample collection procedures documented and available to relevant personnel (YES)	10	83.3
Is there a storage place for primary samples once analyzed		
NRL Lab	9	75
Biobank	3	25
Is there a separate area for sample collection/receipt before analysis, sample storage after analysis (yes)	12	100
Does the laboratory have an appropriate packaging system in accordance with IATA and UN regulations (triple packaging if transported by air, or any packaging in accordance with local regulations or recommendations)?(YES)	12	100
Are there enough trained personnel on the network to ensure safe shipping (YES)	12	100
Are shipping managers trained in international regulations and transport of infectious materials (YES)	12	100
Does the laboratory receive samples or isolates from the field when clinical services for the purpose of diagnosis and/or investigation of health events	12	100

3.3. Service Provision

Table 10 shows that most of the NRCs (91.7%) were in the public health and research fields. They all have activities with a national scope. On the other hand, only a quarter of the NRCs carry out activities of sub-regional scope. All these public health laboratories offer diagnostic services while 83.3% of them offer technical support.

Table 9. Responses from the 12 participants relating to Consumables and reagents of the IPCI national reference centers

	Frequency	Percentage
Is procurement centralized or decentralized?		
centralized	9	75
Decentralized	1	8.3
In the laboratory	1	8.3
Is the laboratory having problems with the delivery of reagents		
Out of stock	11	91.7
Late delivery	7	58.3
Cold chain break	2	16.7
What type of analysis do you perform?		
PCR	11	91.7
Cultivation/isolation	9	75
Sequencing	3	25
Serology	3	25
Are there evaluation protocols (for acceptance/rejection and quality assurance of consumables and reagents)? (YES)	4	33.33
Are consumables and reagents properly stored at the laboratory level (temperature, humidity, etc.)? (YES)	12	100

Table 10. Answers of the 12 participants relating to the characterization of the laboratories Management Human resources of the IPCI national reference centers

	Frequency	Percentage
Laboratory domain		
Public health (human)	11	91.7
Research	11	91.7
Environment	6	50
Veterinary	3	25
Academic/University	2	16.7
food control	1	8.3
Is your laboratory a reference laboratory		
National	12	100
Sub regional	3	25
What services does your NRL provide to other public health laboratories		
Diagnostic	12	100
Training	10	83.3
Technical Support	10	83.3
Audit	1	8.3
Is your laboratory a member of international networks (Yes)	12	100
Does your laboratory participate in epidemiological surveillance (Yes)	12	100
Location of public health laboratories covered by your National Reference Lab		
Côte d'Ivoire	12	100
West Africa	3	25
Central Africa	1	8.3

Table 11. Responses from the 12 participants relating to Public health functions of IPCI national reference centers

	Frequency	Percentage
Is the laboratory part of the surveillance network(s)		
National	11	91.7
Regional	4	33.3
International	2	16.7
Does the laboratory have defined responsibilities in national preparedness and response to public health emergencies such as epidemics YES	12	100
If yes, specify the responsibilities: diagnosis and confirmation of cases,	12	100

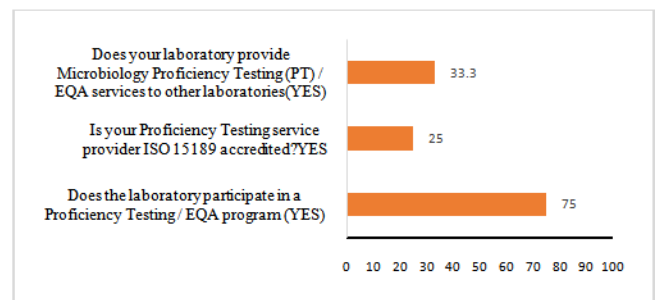


Figure 3. Answers from the 12 participants relating to the External Quality Assessment (EQA) of IPCI national reference centers

Table 11 showed that the NRCs are members of the national laboratory surveillance networks (91.7%). All NRCs reported having responsibilities in the diagnosis and confirmation of cases in the preparation of responses to communicable diseases and diseases with epidemic potential.

Regarding external quality assessments, 9 (75%) of the NRCs have successfully participated in proficiency testing

programs and 4 (33.3%) have organized proficiency testing or external quality assessment (EQA) for other laboratories in their national network (Figure 3).

4. Discussion

This evaluation described the situation of the NRCs after more than a decade of functioning. It will allow us to assess improvements or make comparisons. At the end of our evaluation, the institutional performance, resources and services of the NRCs have not reached the required levels. These public health laboratories require support in the various pillars of the health system and the implementation of quality improvement towards international standards.

At the legal level, the organization of the NCR has had only one interministerial order designating the list of national reference centers of the IPCI in the field of communicable diseases since 2006.[15]

Despite these efforts, much remains to be done to improve the legal and institutional framework. Indeed, a review of the texts governing the health laboratory sector reveals a legal vacuum concerning certain provisions. Thus, there are no decrees specifying the attributions, organization and minimum activities to be carried out at the level of the NRCs. Even if there is no decree appointing the heads of the NRCs, these heads of the NRCs have the institutional decisions of the heads of the units to which the laboratories belong.

Regarding the process of improving the quality of laboratory services, the level of implementation of laboratory standards in the African region, as verified by the accreditation process, has always been very low.[24] An initiative to implement a quality management system (QMS) in Medical Biology Laboratories in Africa has been designed by WHO-AFRO. Indeed, in line with WHO's core functions of standard setting and institutional capacity building, WHO-AFRO, in collaboration with the African Society of Laboratory Medicine (ASLM), the US Centers for Disease Control and Prevention (CDC) and host countries, has established the Stepwise Laboratory Improvement Process Towards Accreditation (SLIPTA) to strengthen the laboratory systems of the Member States of the Region with a view to their accreditation.[7,10]. In Côte d'Ivoire, Law no. 866 of December 23, 2013 on standardization and the promotion of quality obliges all health services to commit to a quality approach. [25] Similarly, the National Strategic Plan for laboratories calls for all public and private laboratories to adopt a quality approach by 2020. However, in France, in 2020, according to Law no. 2013-442 of May 30, 2013 and Decree no. 2016-1430 of October 24, 2016 on the accreditation procedures for medical biology laboratories, any laboratory that is not accredited will have to stop its activities. [26,27]

The main challenges are the sustainability and increase of financial resources for laboratory activities and equipment maintenance (no maintenance contract), as well as the insufficient or lack of political commitment (e.g., policies, budget) to support the laboratory. This seems to be specific to developing countries where sustainable funding for monitoring and networking activities remains difficult.[28] The vast majority of funding agencies' financial

resources have been focused on disease prevention and care delivery, while relatively little funding has been allocated to laboratory capacity building. [29,30,31]

For the NRCs, the lack of financial resources has directly affected the possibility of regular calibration and maintenance of equipment and the availability of facilities.

Fortunately, in recent years, several partners (Global Fund (GF), World Bank (WB), Tony Blair Foundation, Bill Clinton, Presidential Emergency Plan for the Fight against AIDS (PEPFAR), WHO) and the Ivorian government are aware of the importance of the laboratories. The AIDS epidemic, avian influenza, dengue fever, and COVID-19 have brought home the urgency of building capacity for biological screening.

In terms of health information, the requirements of information technology (IT) in pathology now extend far beyond the provision of purely analytical data.[32]

Despite the availability of tools (paper and electronic), we note: i) an insufficient supply of management tools to the NRCs due to the non-existence of a mechanism for the reprography of collection tools at the level of the IPCI and the departments, which is still dependent on external financing, ii) the poor availability of computer equipment for the management of health data due to the absence of a plan for the equipping and renewal of computer equipment.

With regard to data quality, we note i) the absence of texts on the creation and organization of a health information management service (HIMS) at the level of the IPCI and the one on the creation and organization of a body of data managers; ii) the inadequacy of personnel dedicated to data management; iii) the inadequacy of internal quality control of the data collected within the national reference laboratories; iv) the inadequacy of a mechanism for quality assurance and use of the data for decision-making.

Regarding resources, the issue of infrastructure, operational equipment and other resources is a real challenge in laboratories in general and reference laboratories in particular. The lack of adequate laboratory facilities makes laboratory diagnosis of infectious diseases difficult in many parts of the African continent.[33] This is why the Ivorian government has undertaken to build the Center for the Study of Pathogens with Severe Infectious Risks (CEPRIS) which is a P3/P4 laboratory.

For technical laboratory practices, despite the relatively good coverage of technical services, particularly molecular biology, sequencing, isolation, culture and serology, the supply of laboratory services remains limited by various factors, including: (i) the weakness of laboratory infrastructure; (ii) the inadequacy of preventive and curative maintenance of equipment and dysfunctions in the supply of reagents and essential consumables; and (iii) weaknesses in quality assurance and quality control protocols and in the management of laboratory information.

At the service level, the IPCI's NRCs are tools for diagnosis and microbiological confirmation of diseases with epidemic potential in humans and animals in accordance with the recommendations of the Integrated Disease Surveillance and Response Guide (IDSR) of Côte d'Ivoire.[34]

Disease diagnosis activities are carried out in the various NRCs of the IPCI to facilitate and improve the management of the main pathologies under surveillance and with epidemic potential. Mechanisms of exemption

(free of charge) and subsidy in the management of the diagnosis of these diseases have been put in place. In this context, the monitoring and evaluation of laboratory capacity requires a standardized approach and methodology.[35]

4.1. Study Limitations

This study has some limitations. Our tool focused essentially on the existence of some laboratory activities necessary for surveillance and to quickly identify related laboratory needs as well as the public health functions of the NRCs.

4.2. In Perspective

The results of the evaluation could be used to develop a work plan aimed at improving surveillance and laboratory detection of diseases preventable by vaccination and diseases with epidemic potential in Côte d'Ivoire.

5. Conclusion

A regular assessment of the NRCs using an in-house tool will enable the measurement of the technical capacities of the NRCs to establish a package of general and specific activities to meet their country-wide burden. Strengthening the capacity of national public health laboratories, and in particular molecular biology and or genomic capacity for communicable disease surveillance, will strengthen the NRCs for the detection of other diseases and increase the country's capacity to detect, respond to, and rapidly contain public health emergencies at their source, thereby improving global health security to meet international standards. Despite the implementation of the SLMTA and SLIPTA programs in Côte d'Ivoire, none of our IPCI NRCs has ISO 15189 accredited after almost two decades of existence.

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Availability of Data and Materials

The datasets generated and analyzed for this study are not publicly available but can be obtained upon request from the corresponding author.

Declarations Ethics Approval and Consent to Participate

consent was obtained from all participants.

Disclaimer

The views expressed in this article are the authors' own, not an official position of the collaborating institutions or the funding agency responsible and no official endorsement should be inferred.

Consent for Publication

Not applicable.

Competing Interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Abréviations

ASLM	African Society of Laboratory Medicine
CDC	Center for Disease Control
CEPRIS	Center for the Study of Pathogens with Severe Infectious Risks
NRC	National Reference Centers
COVID-19	Corona virus disease 2019
EQA	External Quality Assessment
GF	Global Fund
HIMS	health information management service
IDSR	integrated disease surveillance and response.
IHR	International Health Regulations
IPCI	Institut pasteur de Côte d'Ivoire
IT	Information technology
IATA	International Air Transport Association
ISO	International Organization for Standardization
LIMS	Laboratory Information Management System
MSS	Microbiological Safety Station
NRL	National Reference Laboratories
NRC	National Reference Centers
PEPFAR	Presidential Emergency Plan for the Fight against AIDS
QMS	Quality Management System
RT PCR	Reverse Transcriptase Polymerase Chain Reaction
	SARS Cov-2 Severe Acute Respiratory Syndrome Corona Virus 2
SLIPTA	Stepwise Laboratory Improvement Process Towards Accreditation
SLMTA	Strengthening Laboratory Management Toward Accreditation
SOP	Standard Operating Procedures
TIP	Technical Implementation Partner
WB	World Bank
WHO	World Health Organization

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