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RESEARCH ARTICLE

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EVALUATION OF THE INTEROPERABILITY OF HEALTH SURVEILLANCE SYSTEMS IN CAMEROON

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ABSTRACT

Interoperability in health refers to the ability of two or more health information systems or components to exchange information on the basis of standards, and to use the information thus exchanged. The aim of this study was to assess the level of maturity of interoperability between the entities that produce health information within the framework of the "One Health" approach. The methodology adopted consisted in carrying out a cross-sectional descriptive study from March to October 2020. The study was conducted in the key departments in charge of epidemiological surveillance in the Ministries of Human Health, Animal Health and Environmental Health. The Health Information Systems Interoperability Maturity Toolkit was used to determine the level of maturity of the interoperability of health information systems across the areas of leadership and governance, human resources and information and communication technologies. Gephi software was used to assess data sharing between surveillance networks. The results of the study reveal the existence of a national health surveillance system in two sectors (human health and animal health). The actors of these systems share data among themselves, but also with other networks such as laboratories and the national observatory on climate change. The field of leadership and governance is emerging in Cameroon, with a maturity level of interoperability equal to 2/5. The field of human resources is infancy, with a level of maturity equal to 1/5. The field of information and communication technologies is infancy, with a level of maturity equal to 1/5. In general, interoperability is therefore at its beginnings in Cameroon. In view of these results, the definition of a legal framework for data sharing and interoperability of health information systems by the Cameroonian government and the ministries concerned is crucial, as well as the training of personnel and the allocation of the necessary resources, in order to promote decision-making oriented in the joint fight against diseases within the framework of the "One Health" approach.

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INTRODUCTION

Humanity has always faced the spread of infectious agents and the risk of pandemics, but in the last ten years, this spread has been increasing [1]. Indeed, every four months, an emerging or re-emerging infectious disease is identified [2]. According to the World Organization for Animal Health (WOAH), 60% of human pathogens are of animal origin and 75% of these agents are at the origin of emerging diseases that can infect humans [3]. Although human medicine allows the treatment of human cases related to these diseases, it does not allow the prevention and anticipation of epidemic risk. To effectively reduce these risks, actions must take into account the interdependence between three health fields: human, animal and

environmental health [4]. To this end, international organizations promote the "One Health" approach [5]. Cameroon, due to its central position, is a hot spot for the outbreak of new diseases, including zoonotic diseases. In order to better prevent and control all priority zoonotic diseases in Cameroon, the Government has developed the National Strategy One Health and the National Program for the Prevention and Fight against Emerging and Re-emerging Zoonoses [6]. Despite the implementation of the One Health concept in Cameroon, the information systems that underpin the concept are largely fragmented [8]. In order to operationalize the One Health concept, it is important that several sectors collaborate. In the health field, the information system on which any surveillance system is based, is made up of actors, tools and methods that interact at different stages of the health information production process, i.e. data

collection, aggregation, storage, analysis and sharing [10]. However, to ensure information exchange, systems must be interoperable [11]. Interoperability in health refers to the ability of two or more health information systems or components to exchange information based on standards, and to use the information thus exchanged [8].

Objective: Thus, given the critical importance of health information systems at both the national and international levels, the work proposes to assess the interoperability of health surveillance systems in Cameroon by evaluating the level of maturity of interoperability between the entities that produce health information within the framework of the One Health approach in Cameroon. Specifically, the objectives were to:

- Mapping the links for data sharing between the different surveillance networks,
- Conduct a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis of data sharing and information systems interoperability,
- Determine the level of maturity of systems interoperability in Cameroon.

METHODOLOGY

Type and location of study: Through a descriptive cross-sectional study in the city of Yaoundé, Centre-Cameroon region, where the administrative and technical supervision of key ministries involved in disease surveillance is located, during a 10-month period from January to October 2020. Thus, the following sectors were targeted for the work. The technical directorates and structures of that sectors are directly involved in disease surveillance in Cameroon, according to the decrees creating the different ministries and structures (Table 1).

Table 1. Structures who participate in the study

Sectoral ministries	Directions/services
1. Ministry of Livestock, Fisheries and Animal Industries (MINEPIA)	<ul style="list-style-type: none"> • Directorate of Veterinary Services ; • Cameroon Animal Disease Epidemiological Surveillance Network (CADESN) ;
2. Ministry of Public Health (MINSANTE)	<ul style="list-style-type: none"> • Directorate for Disease Control, Epidemics and Pandemics (DLMEP); • National Public Health Observatory (ONSP); • Health Information Unit (CIS);
3. Ministry of Forests and Wildlife (MINFOF)	<ul style="list-style-type: none"> • Directorate of Wildlife and Protected Areas (DFAP) ;
4. Ministry of Environment, Nature Protection and Sustainable Development (MINEPDED)	<ul style="list-style-type: none"> • Environnemental Information and Documentation Center (CIDE) ; • National Climate Change Observatory (ONACC) ;
5. Ministry of Scientific Research and Innovation (MINRESI)	<ul style="list-style-type: none"> • Centre for Research on Emerging and Re-emerging Diseases (CREMER) ;
6. National Program for the Prevention and Control of Emerging and Re-emerging Zoonoses (PNPLZER).	

Directorate of Veterinary Services (DVS): The attributions of the DVS are contained in the Decree N°2012/382 of September 14, 2012, on the organization of Ministry of Livestock, Fisheries and Animal Industries (MINEPIA). The DVS is, among others, responsible for:

- The validation and application of contingency plans against animal diseases.
- Veterinary sanitary inspection of foodstuffs of animal and fishery origin and the fight against zoonoses.

Cameroon Epidemiological Network for Animal Diseases (CENAD): CENAD came into being following the Decision N°00513/MINEPIA of September 09, 2014 on the creation, organization and operation of the Cameroon Epidemiological Network for Animal Diseases. It has a national technical group assisted by a Permanent Secretariat.

The Network's missions include:

- Epidemiological surveillance of priority diseases for early detection, determination of their importance and evaluation of control measures applied;
- Capacity building of animal health staff in epidemiological surveillance and alert response.

Wildlife and Protected Areas Directorate (WPAD): It comprises two sub-directorates: the sub-directorate for wildlife conservation and the sub-directorate for wildlife development and exploitation. The responsibilities of the WPAD are set out in Decree No. 2005/099 of April 6, 2005 on the organization of Ministry of Forestry and Wildlife (MINFOF):

- The elaboration and implementation of the Government's wildlife policy;
- Continuous monitoring of the wildlife heritage.

Disease, Epidemic and Pandemic Control Directorate (DEPCD): The attributions of the DEPCD are contained in the Decree N°2013/093 of April 03, 2013, on the organization of Ministry of Public Health (MINSANTE). These attributions include, among others:

- The coordination of epidemiological surveillance;
- Cross-border health surveillance.

Health Information Unit (HIU): The HIU is one of the MPH structures related to digital health. It is composed of a head of the unit and two assistant researchers. Its attributions, which are contained in the Decree N°2013/093 of April 03, 2013 on the organization of the MPH, concern among others:

- The design and monitoring of the implementation of the health information system,

- The collection and processing of health statistics, in conjunction with the ONSP.

National Public Health Observatory (NPHO): The NPHO was created by Prime Ministerial Decree N°2010/2952/PM of November 1, 2010, on the creation, organization and operation of the National Public Health Observatory. The general mission of the NPHO is related to:

- Alert and healthwatch;
- The centralization, analysis and implementation of social and health information, databases and the establishment of databases of public health problems.

Center for Information and Documentation on the Environment (CIDE): The responsibilities of the CIDE are contained in Decree N°2012/431 of October 1, 2012 on the organization of Ministry of Environment, Nature Protection and Sustainable Development

(MINEPDED). Placed under the authority of a head of cell, the CIDE is among others responsible for:

- The management of geographic information systems on the environment, nature protection and sustainable development;
- Liaison with existing networks and information systems in the environment, nature protection and sustainable development sector.

It includes: the environmental information system section, the documentation section, and the clearinghouse section.

National Observatory on Climate Change (NOCC): The NOCC was created in 2009 by Decree N°2009/410 of December 10, 2009. Its reorganization took place by Decree No. 2019/026 of January 18, 2019, giving it the status of a public institution of a scientific and technical nature. The NOCC is responsible, among other things:

- Establishing relevant climate indicators for monitoring environmental policy;
- Collecting, analyzing and making available to public and private decision makers, as well as to various national and international organizations, reference information on climate change in Cameroon.

The NOCC is placed under the technical supervision of the Ministry in charge of the Environment and under the financial supervision of the Ministry in charge of Finance with a General Management at its head.

Center for Research on Emerging and Re-emerging Diseases (CRERD)

CRERD is a structure of international scope. It is in charge of operational research studies (whose results directly benefit populations) and fundamental research (whose results bring major knowledge for the advancement of science) among others on:

- The origin of human immunodeficiency virus and the emergence of new viruses;
- The study of zoonotic diseases within the framework of the Laboratoire Mixte International (LMI).

This laboratory, which is at the service of Cameroon and the countries of the Central African sub-region, has a technical platform with a sub-regional vocation for fundamental and operational research.

National Program for the Prevention and Fight against emerging and Re-emerging Zoonoses: The Zoonoses Program came into being following the Decree N°028/CAB/PM of April 04, 2014 on the creation, organization and functioning of the Zoonoses Program. It is responsible for the prevention and control of zoonoses through the "One Health" approach, by developing early detection mechanisms. As such, its mission is, among others:

- To ensure health watch, investigation and response against emerging and re-emerging zoonoses;
- To ensure the promotion and appropriation of the concept of "One Health" through a "multisectoral" and "multi-actor" approach.

The Program has a Strategic Orientation Committee, a Technical Committee and a Permanent Secretariat.

Study materials

Administrative and regulatory documents: In the framework of this work, a number of documents were used. These include:

- Decrees on the organization of MINEPIA, MINSANTE, MINFOF, MINEPDED;

- Text on the creation, organization and functioning of CENAD, NPHO, NOCC, CRERD, Zoonoses Program
- Evaluation report of the animal disease surveillance system in Cameroon;
- Cameroon's "One Health" National Strategy
- Zoonotic diseases prioritization document according to the "One Health" approach;
- One Health" communication plan ;
- Cameroon's National Digital Health Strategic Plan 2020-2024;
- Surveillance tools of existing surveillance systems;
- District Health Information Software (DHIS-2) platform (<https://www.dhis-minsante-cm.org>);
- Cameroon Animal Health Information System (CAHIS) platform (<http://www.cahis.cm>);
- International Health Regulations (IHR), Integrated Disease Surveillance and Response guide (IDSR).

Interview Tools: The assessment is based on the Health Information Systems Interoperability Maturity Toolkit [8]. It focuses on three areas of interoperability, namely: leadership and governance, human resources and information and communication technologies. The objective of this work is to assess the level of interoperability maturity between the entities that produce health information within the framework of the "One Health" approach in Cameroon. An interview guide for collecting information based on the Health Information System Interoperability Maturity Toolkit [8] was developed to be able to fill out the interoperability matrix. Also, a questionnaire was developed to analyze the collaboration and the flow of information exchange between the different actors.

Analysis material

The following software was used during our work:

- Data entry software: Excel version 2013;
- Data analysis software: Excel version 2013, Gephi version 0.9.2

METHODS

This work was carried out in three main phases. It consists of a pre-survey phase, a survey phase and a post-survey phase which consisted of data analysis.

Pre-survey phase: During the pre-survey phase, we obtained research authorizations from the "Université des Montagnes (UdM)" to facilitate our introduction into the departments of MINEPIA, MINSANTE, MINEPDED and MINFOF. This phase involved the development of the interview guide and questionnaire, which were tested before administration. The guide had two sections: the first related to the identification of stakeholders and the second related to the assessment of the areas of interoperability (leadership and governance, human resources, technology). The questionnaire included information on the origins, recipients and partners of the data.

Survey phase: Data collection took place through a semi-structured interview using the interview guide, a tape recorder and a camera if necessary. For the identification of health surveillance systems, the data collected concerned the name of the system, the priority diseases of the system, the type of surveillance carried out, the functioning of the system and the circuit of data produced from the base of the health pyramid. For the sharing of information between the actors of the surveillance networks, the variables collected concerned the origin of the data, the recipients of the data and the data partners, each variable being followed by its weight in the network. Regarding the level of interoperability maturity, we collected data for each of the sub-domains and domains listed in Table. This same data was used for the analysis. During the collection phase, the information provided was

supported by documents attesting to the information. We were also able to collect all the documents that we exploited and synthesized their content. During the interview, information was collected from several individuals within the same epidemiological surveillance department; this information was complementary according to their position in the surveillance pyramid. The information was compiled and transformed into global information for each structure.

Post-survey phase :data analysis: The study data were entered and analyzed using Microsoft Excel version 2013 and Gephi version 0.9.2. With regard to the information sharing circuit, we performed a network analysis. To do this, the data collected within each structure was entered into the Excel version 2013 spreadsheet and then analyzed using Gephi version 0.9.2 software. The Gephi software allowed us to visualize the different networks. Each network is made up of two components:

- The nodes: representing the actors composing the network;
- The links: representing the relationships between these actors.

For each node in the network, a weight was assigned by the respondents.

to the tool's scoring guide [8], in order to inform the tool's matrix on interoperability. We proceeded as follows:

- The first step consisted in determining the level of each of the 18 sub-domains on a scale from 1 to 5 (emerging to optimized) using the answers from the exchanges with the managers of the different structures;
- The second step consisted in determining the level of each domain by averaging the scores of its respective sub-domains.

Finally, these scores were totaled to determine the level of maturity for health information system interoperability in Cameroon in relation to the score obtained. The results were represented for all levels of domains and sub-domains using radar graphs. The radar chart allowed us to show the overall results for the three domains and each sub-domain. Based on the results, we were able to pull out the SWOT analysis. All interoperability subdomains with a score above 2 were considered as the strengths of the system. Those with a score lower than 2 were considered as weaknesses of the system. Non-system-dependent strengths represented opportunities. Weaknesses not dependent on the system were threats.

Table 2. Domains and sub-domains of interoperability

Domain	Sub-domain
Leadership et gouvernance	Governing structure of the SIS
	Guidance tools on interoperability
	Data exchange mechanism
	Data ethics
	Business continuity
	Monitoring and evaluation of interoperability
	Management of financial resources
	Mobilising financial resources
Human resources	Human resources policy
	Human resources capacity
	Human resources capacity development
TIC	National SIS architecture
	Technical standards
	Data management
	SIS subsystems
	System care and maintenance
	Communication network
	Computer equipment

Table 3. Assessment of the maturity level of the components

Levels	Description of the Levels
Level 1 : Born	The country lacks SIS capacity or does not follow the processes in a systematic way. SIS activities occur haphazardly or are isolated or ad hoc efforts.
Level 2 : Emerging	The country has defined SIS structures but they are not systematically listed. No formal or ongoing monitoring or evaluation protocol exist.
Level 3 : Established	The country has listed SIS structures. These structures are functional. Indicators for performance monitoring, quality improvement and evaluation of activities are used systematically.
Level 4 : Institutionalized	Government and stakeholders use a national HIS and follow standard practices.
Level 5 : Optimized	Government and stakeholders regularly review interoperability activities and modify them to adapt to changes.

The weight was determined on a scale of 1 to 10, with 1 being the lowest weight and 10 the highest, based on the frequency of submission, timeliness, or completeness of the data. We presented the links according to the weight of the node in the monitoring network. The size of the nodes was proportional to the actor's weight in the network. Actors with high weight were grouped in the center of the network. Based on this data, a directed graph showing the flow of exchanges between actors was constructed, either in terms of data sent or received (unidirectional arrow), or in terms of exchanges with different actors (bidirectional arrow). One of the main interests of using Gephi to map our data was the possibility offered to use many calculations related to graph theory to apply them to our data. This allowed us to appreciate the elements of the different networks that are the most central, the most distant, the best connected to the different monitoring networks and to understand the links and the points to be improved. The level of maturity was assessed according

RESULTS

Mapping of linkages between surveillance networks

Description of the target population: The interrelationship between the stakeholders in the information exchange is presented in Figure. In total, we obtained 108 actors and 244 links between these actors. The analysis involved the national public health surveillance system of the DEPCD of MINSANTE, the national animal health surveillance system of the DVS of MINEPIA: CENAD, NPHO, NOCC and National Public Health Laboratory (NPHL).

Analysis of the interrelation between the actors of the surveillance network: The analysis shows that there are relationships between actors in the Cameroon surveillance network, either in terms of sending or receiving (one-way arrow) or in terms of data exchange

(two-way arrow). We obtained a directed graph showing the direction of the relationship (one-way or two-way) between the actors in the network as shown in Figure. We observe groupings around the different epidemiological surveillance networks: CENAD-DVS, DEPCD, NPHO, NOCC and NPHL. These structures not only carry a lot of weight, but also some partners such as WHO, CDC and UNICEF for human health; FAO, PRODEL, WOAAH and AU-IBAR for animal health; ASECNA, PULCI, GIZ, UNDP and CUSO for environmental health. The network actors exchange epidemiological surveillance data either by telephone call, e-mail, or during workshops.

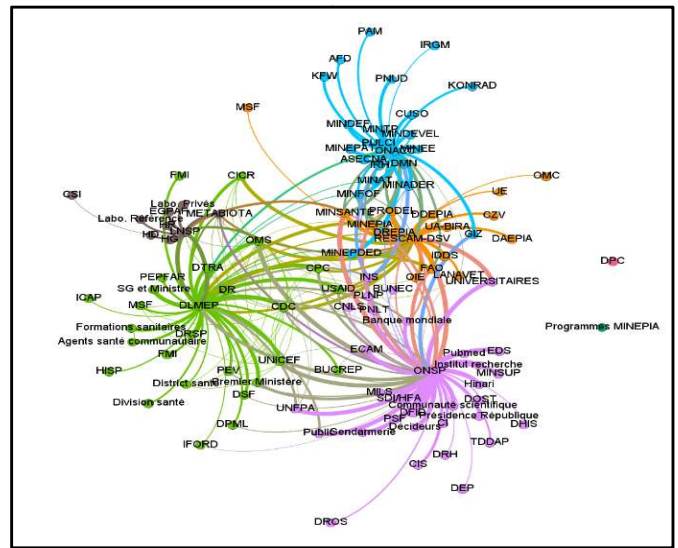
Table 4. Distribution of actors interviewed by structure

Structure	Nombre de d'acteurs interviewés	Total
MINEPIA		
DSV	8	9
RESCAM	1	
MINSANTE		
DLMEP	5	13
CIS	3	
ONSP	5	
MINFOF		
DFAP	2	2
MINEPDED		
CT	1	
CIDE	1	4
ONACC	2	
MINRESI		
CREMER	1	1
PNPLZER	2	2
Total	31	31

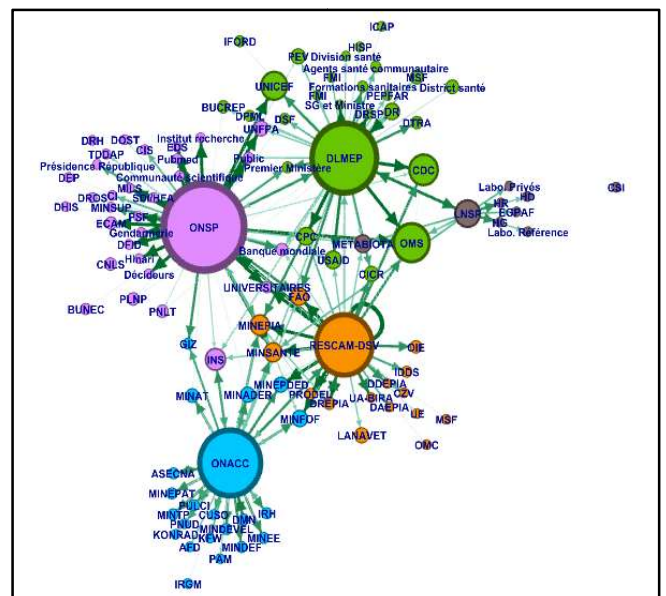
The analysis of the network shows that CENAD has a strong link with its basic structures according to the organization of the health pyramid: regional delegation, departmental delegation, district delegation, zootechnical and veterinary center, national veterinary laboratory. Although it receives its data from all these structures, it should be noted that it shares a close link with the regional delegation in terms of receiving and sending data. It frequently sends its data to the Ministry (MINEPIA), the WOAAH, MINFOF, MINSANTE, MINEPDED, and academics. Its partners are : FAO, PRODEL and AU-IBAR. In addition to these, the WOAAH, the WHO and the CDC. It also shares links with other surveillance networks in the country (NPHO, DEPCD, NOCC). The analysis of the network shows that there is a strong link between the DEPCD and its basic structures, mainly the Regional Delegation of Public Health, and secondarily the health districts and the health facilities according to the organizational chart for the collection and feedback of data/information. It frequently sends its data to the general secretariat and to the minister (MINSANTE), to the first ministry and to WHO. It also maintains links with the NPHO, the NPHL and the NOCC. Its partners are: WHO, CDC, UNICEF and USAID.

Analysis of the NPHO's network shows that the NPHO maintains relations with MINSANTE structures such as the DEPCD, as well as with the country's other surveillance networks such as CENAD ; from the latter, it collects data for publication at the national level (Presidency of the Republic, Prime Ministry, decision-makers, the public, the scientific community, research institutes, the Ministry of Higher Education, and academics) and at the international level such as the WHO. The NPHO also collects information directly from the border health station, the Centre Pasteur du Cameroun, websites (Pubmed, Hinari), platforms (ARIS of AU-IBAR, WAHIS of WOAAH, DHIS-2 of MINSANTE). Its main partners are: WHO, CDC, UNICEF, GIZ. Analysis of the NOCC network shows that the NOCC maintains relationships with several structures, including local structures and ministries such as: Directorate of National Meteorology, Hydraulic Research Institute, Ministry of Agriculture and Sustainable Development (MINADER), MINEPDED, MINFOF, MINSANTE, MINEPIA, Ministry of Territorial Administration (MINAT) ; but also international structures such as: Agency for Aviation Safety in Central Africa and Madagascar (ASECNA), Emergency Flood Control Project (PULCI). There is also a link

between NOCC and other monitoring networks such as CENAD. Its main partners are : GIZ, UNDP, CUSO. The analysis of the national laboratory network shows that the NPHL collects data from public hospitals (HG, HR) and private laboratories according to the health pyramid. It exchanges data with the DEPCD. Its partners are: METABIOTA, WHO and CDC.



Picture 1. Information sharing between epidemiological surveillance actors in Cameroon



Picture 2. Orientated graph of the health surveillance network in Cameroon

Strengths, Weaknesses, Opportunities, Threats (SWOT) Analysis of Data Sharing and System Interoperability: Table 6 shows the strengths, weaknesses, opportunities and threats to data sharing and interoperability of surveillance systems in Cameroon.

Determining the level of interoperability: The results are classified by interoperability domain: leadership and governance, human resources, and technology. For each domain, the levels of the sub-domains are presented as follows:

Leadership and Governance domain: The assessment of the components of the Leadership and Governance domain is shown in Figure 3. The health information system leadership structure subdomain scored 4/5, the data ethics subdomain scored 3/5, and the data exchange mechanism and interoperability guidance tools subdomains scored between 2/5 and 3/5.

Table 5. List of abbreviations

AFD :French Development Agency	<i>HISP : Health Information System Program</i>
ANTIC :National Agency for Information and Communication Technologies	HR :Hôpital Régional
ASECNA :Agency for Aviation Safety in Central Africa and Madagascar	<i>IBAR : International Bureau of Animal Resources (Union Africaine)</i>
<i>AU-IBAR : African Union International Bureau of Animal Resources</i>	<i>IDDS : Infectious Disease Detection and Surveillance</i>
BAD :African Development Bank	INS : Institut National des Statistiques
BUNEC :National Civil Registry Office	IFORD : Institut de Formation et de Recherche Démographique
BUCREP :Central Bureau of Census and Population Studies	IRGM : Institut des Recherches Géologiques et Minières
<i>CDC : Center for Disease and Control</i>	IRH : Institut de Recherche Hydraulique
CICR :International Committee of the Red Cross	<i>KFW : Kreditanstalt für Wiederaufbau</i>
CNLS :National AIDS Control Committee	MINADER : Ministère de l'Agriculture et du Développement Durable
CPC :Pasteur Center of Cameroon	MINAT : Ministère de l'Administration Territoriale
CSI :Integrated Health Center	MINDEF : Ministère de la défense
CZV :Zootechnical Veterinary Center	MINDEVEL : Ministère du Développement Local
DAEPIA : Délégation d'Arrondissement de l'Elevage, des Pêches et des Industries animales	MINEE : Ministère de l'Eau et de l'Energie
DDEPIA : Délégation Départementale de l'Elevage, des Pêches et des Industries Animales	MINSUP : Ministère de l'Enseignement Supérieur
DEP : Division des Etudes et des Projets	MINTP : Ministère des Travaux Publics
DFID :Department For International Development	MINTRANSPORT : Ministère des Transports
DMN : Direction de la Météorologie Nationale	MSF : Médecins sans Frontières
<i>DNC : Dream Network Company</i>	ODD : Objectifs pour le Développement Durable
DOST : Direction de l'Organisation des Soins et de la Technologie Sanitaire	OMC : Organisation Mondiale du Commerce
DPC : Direction de la Protection Civile	PAM : Programme Alimentaire Mondial
DPML : Direction de la Pharmacie, du Médicament et des Laboratoires	PEV : Programme Elargi de Vaccination
DREPIA : Délégation Régionale de l'Elevage, des Pêches et des Industries Animales	PM : Premier Ministre
DRH : Direction des Ressources Humaines	PNLP : Programme National de Lutte contre le Paludisme
DROS : Division de la Recherche Opérationnelle en Santé	PNLT : Programme National de Lutte contre la Tuberculose
DRSP : Délégation Régionale de Santé Publique	PNUD : Programme National des Nations Unies pour le Développement
DSF : Direction de la Santé Familiale	PNUE : Programme National des Nations Unies pour l'Environnement
<i>DTRA : Defense Threat Reduction Agency</i>	PRODEL : Projet de Développement de l'Elevage
ECAM :Entreprises du Cameroun	PSF : Postes de Santé aux Frontières
EDS : Enquêtes Démographiques et de Santé	PULCI : Projet d'Urgence pour la Lutte Contre les Inondations
<i>EGPAF : Elizabeth Glaser Pediatric AIDS Foundation</i>	TDDAP : Tackling Deadly Diseases in Africa
FIT : Front Inter Tropicaux	RENALAB : Réseau National des Laboratoires
FMI : Fond Monétaire International	UE : Union Européenne
FOSA : Formations Sanitaires	<i>UNFPA : Fond des Nations Unies pour la Population</i>
<i>GIZ : Deutsche Gesellschaft für Internationale Zusammenarbeit</i>	<i>UNICEF : Fond des Nations Unies pour l'Enfance</i>
HD : Hôpital de District	
HG : Hôpital Général	

Table 6. SWOT analysis of data sharing and interoperability

<p>Strength</p> <ul style="list-style-type: none"> • Sectoral bodies in charge of sectoral SIS • Strong national political will (CIS) • Mechanisms for intersectoral collaboration in case of zoonoses • National Ethics Committee and professional orders • Sectoral HIS covered by ministry budgets • SIS in human and animal health sectors • Computer equipment in the sectors 	<p>weakness</p> <ul style="list-style-type: none"> • No integrated national data management system • Lack of regulatory framework for interoperability of sub-systems • No automated procedures for sharing • cross-sectoral procedures for data management, access and use • Limited financial resources • No technical infrastructure and protocols • Limited hardware
<p>Opportunities</p> <ul style="list-style-type: none"> • National 'One Health' strategy • DHIS guidance documents • Access and use of analyzed data in sectors. • Financial support from • Partners • Human resources of computer training schools • Support from MINPOSTEL, ANTIC • Support from technical partners 	<p>Threats</p> <ul style="list-style-type: none"> • Lack of vision for a single SIS • Risks of cyber attacks • Lack of a common vision for the establishment of a single SIS • -Average coverage of the territory in terms of internet connection • -No plans to renew equipment

The subdomains of business continuity, financial resource mobilization, interoperability monitoring and evaluation, and financial resource management scored less than 2/5.

Human resources domain: From the assessment of the components of the human resources domain, we obtained Figure 4. All human resources subdomains (policy, capacity, and capacity development) each scored 1/5.

Information and Communication Technology domain (ICT): In assessing the components of the ICT domain, we scored 3/5 for each of the data management and communication network subdomains. The computer hardware sub-domain scored between 2/5 and 3/5. The other subdomains (subsystem of the health information system,

national health information system architecture, system maintenance, and technical standards) scored less than 2/5 (Figure).

Interoperability maturity level assessment for each domain: The analysis conducted resulted in a score of 2/5 for the Leadership and Governance domain, 1/5 for the Human Resources domain, and 1/5 for the Information and Communication Technology domain. The maturity levels obtained by domain and sub-domain of interoperability are expressed in Table.

DISCUSSION

The analysis of the health surveillance network revealed that there are linkages between the actors and their partners. This could be

explained by the important role that these actors and partners play in disease surveillance in Cameroon, through their technical and financial support. The analysis of the National Animal Health Surveillance System (NAHS) and National Public Health Surveillance System (NPHS) network showed that the actors have a strong link with their base structures. This could be explained by the fact that it is the grassroots structures that ensure the collection and reporting of data. The NAHS and NPHS structures are almost the same due to the fact that human and animal health actors work together in the fight against zoonoses. In addition, the analysis of the NPHO network showed a strong dependence of MINSANTE structures, particularly the DEPCD and its surveillance system on disease data. This could be explained by the fact that the NPHO is an organization under the authority of MINSANTE. The analysis of the NOCC network showed a strong importance of international structures in the acquisition of analytical data. This is understandable given the specificities of local structures. The strengths identified for data sharing and interoperability of health surveillance systems showed that interoperability of systems is possible in Cameroon. This could be justified by the fact that with the advent of ICTs and the modernity we are currently experiencing, the need for digital technology is more pressing in all areas in general and in health in particular, to ensure better management and monitoring of disease cases. Also, this is possible with the support of technical and financial partners.

The field of interoperability leadership and governance is emerging in Cameroon. This could be justified by the fact that there is a governing body for the health information system in both the human, animal and environmental health sectors, with evidence of their appointment. Also, Cameroon has a national law on data protection (Law N°2010/012 of December 21, 2010 on cybersecurity and cybercrime in Cameroon), but it is not specific to health. However, in this law, the elements of Article 1 could be relevant to health (trust in electronic communication networks and information systems; protection of the fundamental rights of individuals, in particular the right to human dignity, honor and privacy, as well as the legitimate interests of legal persons). Administrations exchange data or information, although there are no automated exchange procedures. Also, a national strategic plan for digital health 2020-2024 has been developed, contributing to the achievement of universal health coverage and covering seven axes, including standards and interoperability. Our results are different from those obtained in Kenya (2019) where the area of leadership and governance is established. This difference could be explained by the fact that Kenya has strategic documents that guide the implementation of digital health and interoperability interventions, and Kenya's constitution and national health law adequately provide for digital health. Kenya has identified key health information system interoperability standards guidelines and produced a draft interoperability framework for health data and health data management, which applies across government and health service providers and is supported by several ministries. The field of human resources is still nascent in Cameroon. This could be justified by the fact that there are no reference documents at the national level that explicitly outline human resource policies and strategies for interoperability.

Those working on health information system (HIS) activities are often overburdened and their roles are not clearly defined. In addition, there is no staff training program on interoperability. For data sharing or analysis by epidemiological surveillance actors in Cameroon, a minimum of epidemiological and computer knowledge is required, and is included in the capacity building plans for HIS staff. Our findings corroborate those in Zanzibar (2020) and RWANDA (2020) where countries lack a human resource policy or strategic plan that identifies the HIS, digital HIS, and interoperability skills and functions needed to support the national digital HIS. There are also gaps in skill sets at all levels, and staff capacity is not sufficient to carry out digital health and HIS interoperability work. The ICT field is nascent in Cameroon. This result could be justified by the fact that Cameroon has not put in place a national HIS enterprise architecture and technical standards for health data exchange have not been

defined. The data management subdomain has the highest level (equal to 3) due to the fact that the human health information system is electronic and based on DHIS 2. The animal health system (CAHIS) is still under development and will soon be operational throughout the country. Some ICT sub-domains, such as communication networks and availability of computer equipment, have maturity level 2 attributes that have been achieved but are not yet fully met. Since significant improvements need to be made to support the various ministries in terms of computer equipment (servers, computers) and internet networks at both the central and deconcentrated levels, these areas could be strengthened by providing the ministries with the necessary equipment. To strengthen these aspects, we could capitalize on the IT units of the various ministries and structures and have a more specific role for the Ministry of Posts and Telecommunications (MINPOSTEL) with National Agency for Information and Communication Technologies (ANTIC) and Ministry of Communication (MINCOM). Our results differ from those obtained in Rwanda (2020) where the country has implemented evidence-based interoperability strategies, policies, standards and guidelines. Rwanda also has a strong technology infrastructure that serves as an important foundation for strong connectivity and support for IT operations and maintenance.

CONCLUSION

This study, which assessed the interoperability of health surveillance systems in Cameroon, reached the following conclusions:

- The existence of a national health surveillance system in two health sectors in Cameroon, one in human health and the other in animal health;
- The actors in the health surveillance network in Cameroon share links with each other, but also with other administrations or organizations. Within the framework of health surveillance systems in Cameroon, it is impossible to do without CENAD, DEPCD, NPHO, NOCC, NPHL, and their main partners (WHO, CDC, UNICEF, FAO) who are the main actors for information sharing;
- The area of leadership and governance is emerging in Cameroon, with an interoperability maturity level of 2/5. The areas of human resources and information and communication technologies are still emerging, with an interoperability maturity level of 1/5.

Based on these results, we can say that interoperability is incipient in Cameroon. The definition of a legal framework for data sharing and interoperability of health information systems by the Cameroonian government and the ministries concerned is crucial, as is the training of personnel and the allocation of the necessary resources in order to facilitate decision-making in the joint fight against diseases in the framework of the "One Health" approach. Taking into account the observations made and the results obtained in this work, our recommendations are addressed to: the Cameroonian government, partners and ministries.

To the public authorities

- Define the legal framework for interoperability and information sharing under the "One Health" approach;
- Develop a regulatory framework for health data security.
- Establish or extend the competencies and missions of the Zoonoses Program to implement the "One Health" platform in order to facilitate the sharing of data between the actors involved.

To the Ministries (MINEPIA, MINFOF, MINSANTE, MINEPDED)

- Establish an institutional and technical framework for collaboration between surveillance systems.

- Formulate a strategy to improve the financing of surveillance actions and activities in each sector and the sharing of surveillance data.
- Strengthen surveillance using the "One Health" approach in the sectors.

Ministerial Partners

- Support the country in the operationalization of surveillance systems and their continuous improvement by taking into account all sectors of the "One Health" approach.
- Equip, train and support the actions of the sectors in the dual role of surveillance and control of diseases and public health events at all levels of the health pyramid (central, intermediate and local) ;
- To support the network of laboratories for the early detection of pathogens from epidemiological surveillance.

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