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Prioritization of Zoonotic Diseases in the Democratic Republic of the Congo, 2016

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Abstract

Introduction: The Democratic Republic of the Congo (DRC) is a vast country with 77 million inhabitants and presents several risk factors for the emergence and re-emergence of zoonotic diseases. Over the past four decades, it has experienced several epidemics such as those caused by the viruses of Ebola, Marburg, Monkeypox, yellow fever… In a context of limited resources to face all zoonoses, it was crucial to prioritize them in order to direct the few available resources to those that have a great impact on human and animal health.

Methods: A 2-day workshop for prioritizing zoonotic diseases using a semi-quantitative approach developed by CDC was organized in the five steps: (1) Elaboration of a list of zoonoses to prioritize, (2) Elaboration of prioritization criteria, (3) Formulation of categorical questions for each criterion, (4) Ranking of criteria, and (5) Ranking of zoonotic diseases.

Results: In order of importance, six criteria were selected: 1) Severity of the disease (in humans), 2) Extent of the disease, 3) Potential for transmission, 4) Capabilities of diagnosis, 5) Capabilities of disease prevention and control, and 6) Socio-economic impact of the disease. The following six diseases have been prioritized in DRC: 1) Rabies, 2) Haemorrhagic fevers, 3) Influenza virus infections, 4) Salmonellosis 5) Monkeypox and 6) Arboviral diseases.

Conclusion: The prioritization of zoonoses was an opportunity for experts in animal health, human health and wildlife to work together within the framework of "One Health" by setting common targets for their interventions.

Keywords: Prioritization; Zoonoses; Democratic Republic of the Congo

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Introduction

Man lives in close relationship with animals that are domesticated or chosen as pets, or selected as living ornamentations as well [1]. The latter can carry transmissible pathogenic germs that can be harmful to one's health, and therefore, are often overlooked threats [1,2]. In addition, the activities carried out by humans in various fields such as urbanization, building of infrastructures, logging, agropastoral work, mining, and trade modify ecosystems and increase exposure to zoonoses [1,3].

By definition, zoonoses are diseases that are naturally transmitted from animals (vertebrates) to humans [4]. About three-quarters of new emerging infections come from animals [5,6]. These diseases manifest themselves in endemic or epidemic form. They have a harmful socio-economic impact by affecting human health and animal health, causing diseases, death, loss of productivity and incomes [3,7].

The Democratic Republic of Congo (DRC) is a vast country of 2,345,000 km^2, having a 9,165 km long border with 9 countries and a population of 77 million (in 2015). It presents several risk factors for the emergence and re-emergence of zoonotic diseases, including:

- The presence of several national parks and reserves sheltering wild animals and birds
- The situation of the country in connection with the seasonal migration of birds from Asia and Europe, mostly the Rift Valley where biotopes are favorable for them
- The frequent contacts between humans and animals, both domestic and wild, especially in rural areas

- The risky practices related to the handling and consumption of game
- The weakness of the epidemiological surveillance system at the borders
- The lack of epidemiological surveillance coordination between human health and animal health

The recent history, the DRC has experienced several epidemics due to zoonotic diseases, of which the most noticeable are the seven outbreaks of the Ebola virus that occurred between 1976 (Yambuku) and 2014 (Likati) [8], the outbreak of Marburg virus haemorrhagic fever between 1998 and 2000 [9] and numerous epidemic-endemic cases of Monkeypox [10]. As recently as 2016, an epidemic of yellow fever from Angola spread to the Province of Kongo Central and the eastern part of Kinshasa.

Although there is a list of zoonoses in DRC, it was imperative to prioritize them so that they are targets for both human health and animal health interventions, in a context of insufficient available resources. The prioritization of zoonotic diseases is an integral part of the Global Health Security Agenda, which aims to make the world safer and more secure by strengthening countries' capabilities to prevent and control health threats. [11,12]. This agenda is an initiative for the implementation of the "One Health" approach emphasizing the interactions between animals, humans and their diverse environments [13-17]. Adopted in 2007 by the international community through the tripartite alliance between the Foods and Agriculture Organization of the united Nations (FAO), the Word Organization for Animal Health (OIE) and the World Health Organization (WHO) [18,19], the concept of "One Health" is part of the global health safety framework, which has following objectives:

- Predict
- Detect
- Respond to outbreaks of infectious diseases

In order to address the challenges related to these diseases in DRC, a workshop was held in Kinshasa, DRC in July 2016 with the objective of identifying priority zoonoses as major public health problems, requiring a synergistic and cross-cutting response involving animal health, the environment, and human health actors.

The objective of this writing was to describe the process followed to prioritize zoonotic diseases in DRC, to present and to discuss the results obtained at the end of that workshop.

Methods

The prioritization of zoonotic diseases took place during a workshop that brought together 40 delegates from each of the following sections: human health, agriculture, fishing and animal husbandry, environment and nature conservation, wildlife, research and university education with expertise in zoonotic diseases. As material, a semi-quantitative tool, developed by the Centers for Disease Control and Prevention (CDC), was used. This methodology is described in detail by Rist [20]. The technique was modified to suit the profile of participants and to make better use of the allotted time.

Before the beginning of the workshop, four facilitators (two from the human health sector and two from the animal health sector) were trained by CDC experts on the methodology to be used during the workshop. In turn, they briefed a group of eight experts. This panel of experts then supervised the working group sessions led by other workshop participants and handled the prioritization tool made available to them.

The prioritization process began with the finalization of a list of zoonotic diseases to prioritize made from two separate lists, each of them came from two relevant sectors (human health and animal health). This new list was limited to eleven common diseases found on these two previous lists (**Table 1**).

After elaborating the list of eleven zoonotic diseases to prioritize, the workshop participants then identified the criteria for the quantitative ranking of these diseases. To do this, three heterogeneous workgroups, comprised of representatives from each sector, were formed. These groups worked on a list of seven criteria, of which five should be retained for the priority-setting process. For each identified criterion, a categorical question was also reformulated during the group sessions discussion. All selected questions should have binomial (yes/no) or ordinal multinomial responses (1-5%, 5-10%, 10-20%, etc.).

Each group presented their criteria with proposed questions and responses, which were then discussed and adopted in plenary. The experts of the panel selected the criteria retained according to the order of importance by using the One Health Zoonotic Disease Priorization (OHZDP) tool. Their work made it possible to determine the weight of each criterion for the final ranking of priority diseases by the analytical hierarchy process [21-25]. For each participant, the Confidence Ratio Final (CRF) was automatically calculated by the OHZDP tool to assess the rating logic of the criteria. A CRF greater than 0.1 reflects inconsistency in the rating of criteria.

This panel of experts used data collected from an in-depth review of the literature, as well as information collected from WHO, OIE and ProMED websites. These data concerned the incidence, prevalence, morbidity, disability adjusted life years (DALYs), and mortality of the eleven selected zoonotic diseases. In case of lack of data on a particular zoonotic disease for DRC, those of other Central African countries were used. If, on the other hand, regional data were not available, global data on the disease were used. For the African region, more than 70 articles were used to collect information.

A decision tree in Microsoft Excel was used to determine the final ranking of diseases. Each weighted criterion was applied to all diseases, and scores were assigned based on the answer to each question. Data specific to the country, to the African region and to the world compiled previously for all zoonotic diseases considered were used to determine appropriate answers for some questions. Answers to other questions were obtained by consensus of the expert group [26,27] using their local knowledge of a disease. The scores for all questions were summed and then

Table 1: Lists of Priority zoonotic diseases or pathogens for human and animal sectors.

	Animal Health Priority	Human Health Priority	Common Animal and Human Heath Priority
1	Anthrax	Anthrax	Anthrax
2	Avian Influenza	Avian Influenza	Avian Influenza
3	Bovine Tuberculosis	Bovine Tuberculosis	Bovine Tuberculosis
4	Brucellosis	Filovirus	Filovirus
5	Crimean-Congo Hemorrhagic Fever	Monkeypox	Monkeypox
6	Cysticercosis	Plague	Plague
7	Escherichia coli	Rabies	Rabies
8	Filovirus	Rift Valley Fever	Rift Valley Fever
9	Monkeypox	Salmonellosis	Salmonellosis
10	Plague	Schistosomiasis	Trypanomiases
11	Rabies	Thyphus	Yellow Fever
12	Rift Valley Fever	Trypanomiases	
13	Salmonellosis	Yellow Fever	
14	Streptococcus suis		
15	Trypanomiases		
16	Yellow Fever		

normalized in such way that the highest final score was 1. In this way, the list of zoonotic diseases and their normalized scores were discussed by the members of expert panel, which resulted in a final list of priority zoonotic diseases in DRC.

Ethics

The approval of the ethics committee was not solicited as the activity was not a research involving human subjects. The data used is accessible to public. The individual who participated in the workshop came to represent their institutions that were invited. Data collection and analysis were anonymous.

Results

Out of a total of 18 diseases or pathogens, eleven were selected on the list of zoonoses to prioritize. Of these diseases or pathogens, six are of viral origin and five of bacterial origin (**Table 1**).

Regarding the prioritization criteria, six of the seven proposed in the working document were selected. These are:

- The severity of the disease (in humans).
- The extent of the disease.
- The potential for transmission.
- The capability of diagnosis.
- The capability for prevention and control.
- The socio-economic impact.

The criterion on bioterrorism was not retained.

As regards the formulation of the categorical questions relating to the selected criteria, a list of six questions was finalized and adopted in plenary, among which four having binomial responses and two ordinal responses (**Table 2**).

As for the ranking of the criteria according to their weight by the eight panel experts, the results obtained at the end of the analytical hierarchy process show that the severity of the disease ranks first, while the socio-economic impact is at the bottom of the ranking, with a final weight of 0.18 and 0.15 respectively (**Table 3**). However, one participant had a final CRF of 0.36 (greater than 0.1).

The ranking of the eleven zoonoses using the decision tree in descending order of the scores after combining all six criteria is as follows (**Table 4**):

The top six on the list were:

- Rabies
- Haemorrhagic fevers (Ebola and Marburg)
- Influenza virus infections
- Salmonellosis
- Monkeypox
- Arboviral diseases

These six zoonoses have been considered as priority in DRC and should be the prime target of epidemiological surveillance, research and other interventions related to prevention, detection and response to epidemics.

Discussion

Criteria selected for ranking of zoonotic diseases

The criteria selected by the panel of experts in DRC have been ranked according to their level of importance as follow:

The severity of the disease in humans: This is the criterion that has the highest priority.

After discussing whether the severity of the disease in humans and animals should be considered in the same way, the group of experts chose to limit the question of the severity of the disease in humans where data on lethality rate were more available. Diseases with a lethality rate greater than 50% received the total weight of the criterion equal to 3. Less serious human diseases received lower scores.

Table 2: Criteria for selecting priority zoonoses.

1. Severity of the disease in DRC (weighting of the criterion = 0.18) o What is the lethality rate in humans? ▪ 0 à<1% (0) ▪ ≥1 à 10% (1) ▪ >10 à<50% (2) ▪ ≥50% (3)
2. Extent of the disease in DRC (weighting of the criterion = 0.17) o Has a case of the disease (human or animal) been reported in the last 10 years? ▪ No (0) ▪ Yes (1)
3. Potential for transmission of the disease in DRC (weighting of the criterion = 0.17) o Is human to human transmission possible in DRC? ▪ No (0) ▪ Yes (1)
4. Capabilities of diagnosis (weighting of the criterion = 0.16) o Is there a test for laboratory diagnosis in DRC? ▪ No (0) ▪ Yes (1)
5. Capability of prevention and control (weighting of the criterion = 0.16) o Is a vaccine against the disease available? ▪ No (0) ▪ Yes (1)
6. Socio-economic impact of the disease (weighting of the criterion = 0.15) o What is the socio-economic impact of the disease in DRC ▪ Low (0) ▪ Medium (1) ▪ High (2)

Table 3: Distribution of the weighting of each criterion and its rank according to expert panel participants.

Participant (P)	P1	P2	P3	P4	P5	P6	P7	P8	Total P
Severity	0.41-1	0.35-1	0.42-1	0.42-1	0.38-1	0.39-1	0.06-4	0.43-1	0.18-1
Extent	0.28-2	0.35-1	0.21-2	0.07-4	0.10-3	0.27-2	0.03-5	0.23-2	0.17-2
Potential of Transmission	0.15-3	0.17-3	0.10-3	0.21-2	0.26-2	0.10-3	0.11-3	0.10-3	0.17-3
Diagnosis	0.08-4	0.09-4	0.07-4	0.10-3	0.04-4	0.03-5	0.22-2	0.05-4	0.16-4
Prevention-control	0.06-5	0.05-5	0.03-5	0.03-5	0.04-4	0.04-4	0.42-1	0.03-5	0.16-5
Socio economic impact	0.02-6	0.03-6	0.02-6	0.02-6	0.19-3	0.17-3	0.02-6	0.02-6	0.15-6
***FCR**	0.05	0.04	0.06	0.06	0.03	0.36	0.06	0.06	

*Final Consistency Ratio

Table 4: Final results of the prioritization and normalized score for each zoonotic disease in the DRC.

Rank	Disease	Score of the disease	Final Normalized Score
1	Rabies	1.067627865	1
2	Haemorrhagic Fevers (Ebola, Marburg)	0.917298461	0.859193069
3	Influenza	0.734718585	0.688178539
4	Salmonellosis	0.701414764	0.656984318
4	Monkeypox	0.701414764	0.656984318
6	Arboviral diseases	0.629636535	0.589752812
7	Plague	0.608713831	0.570155436
8	Trypanosomiases	0.592303047	0.554784178
9	Anthrax	0.47534422	0.445233996
10	Rift Valley Fever	0.413752839	0.387544061
11	Bovine tuberculosis	0.314827969	0.294885493

The extent of the disease: The high prevalence of the disease in human or animal populations was the second most important criterion. After discussion, it was determined that accurate data on the prevalence of many diseases were not available in DRC. Thus, the panel chose to assign a high weight to this criterion if cases of a disease were reported in the last 10 years. Diseases with no-case reported recently received a score of 0.

The potential for transmission of the disease: The epidemic threat posed by a continuous human-to-human transmission was considered the third most important criterion for zoonotic diseases in DRC. The diseases with known human-to-human transmission received the total weight of the criterion equal to 1, while other diseases received a score of 0.

The laboratory capabilities for diagnostic tests: Diseases for which a laboratory confirmation test was available in DRC were the fourth prioritization criterion. The panel of experts had a discussion about whether the question should encompass local, national and international reference tests and whether laboratory tests of human health and animal health should be considered together. The final decision was to give the total weight of the criterion to diseases for which a laboratory test for human disease was available in DRC. Diseases for which only tests for animals were available or which required samples to be referred to an international laboratory received a score of 0.

The capabilities of disease prevention and control: The ability to prevent and control a disease has been the last but one criterion to receive high weight. The discussion within the group of expert panel was whether this criterion should include the existence of medical countermeasures such as immunizations and medicine treatments or whether it should take into account the existence of control programs that currently are operational in the country. The consensus of the panel focused on the existence of the vaccine and ignored the presence of interventions that were underway. Hence, the diseases for which a vaccine was available received the maximum weight of the criterion that was 1, and the other diseases received a score of zero.

The socio-economic impact of the disease in DRC: The socio-economic impact of a disease is the criterion that has obtained the lowest weight. The group of experts agreed that this was an important consideration for prioritization. Hence it was added as a sixth criterion to the list whereas it was a question of choosing five. Due to the lack of available data on the social and economic aspects of diseases concerned with prioritization, the group discussed each disease independently and agreed to give a value of 2 for a disease with a high socio-economic impact, a value of 1 for an average impact and a value of 0 for a low impact. The judgment was based on the local expertise of the panel members.

In the context of DRC, the panel considered that bioterrorism was not a relevant criterion in view of the current absence of such threats. Moreover, in the course of similar prioritization works on zoonotic diseases, the literature review reports a variety of criteria that have been used according to the context of each country the concerned and the purpose of the prioritization process [28].

One of the eight participants had a consistency ratio of 0.36, which is greater than 0.1 acceptable limit described by Saaty [22]. This would mean that he was not consistent in the priority scale given to the criteria.

The list of zoonotic diseases and their normalized scores was presented to the group for discussion. The panel of eight representatives from different sectors voted on a final list of zoonotic diseases. Rabies, viral haemorrhagic fevers (Ebola and Marburg), avian flu, salmonellosis infections and monkeypox obtained the highest five scores. The expert panel group chose to include arboviral diseases that received the 6th score on the final list. It also thought it was important from surveillance viewpoint that influenza should encompass both avian and porcine varieties and that filoviruses should be expanded to haemorrhagic fevers, including Rift Valley fever and Crimean-Congo haemorrhagic fever.

After finalizing the list of priority diseases, workshop participants discussed recommendations and other actions that could be taken to face the six selected zoonotic diseases of which the most important were:

- Using selected priority diseases to mobilize and utilize available funds within the framework of the intersectoral working group on these diseases
- Not limiting the scope of surveillance activities for these diseases to DRC and share information on reported cases and epidemics with neighboring countries
- Sharing results of research studies on these diseases with students in public health and veterinary services
- Using these diseases as an opportunity for students research projects that can lead to publications or fundraising for the research
- Holding regular meetings bringing together all stakeholders involved in advancing global health security projects and use a results-based approach to evaluate internationally-funded projects
- Urging DRC government to work with scientists when emergencies outbreak and to learn from past events
- Raising awareness of people living in remote areas about the risks of zoonotic diseases.

As limitations to this work, it should be pointed out that insufficient data are available on zoonotic diseases as observed in some sub-Saharan countries such as Kenya [29], Ethiopia [30], and the subjective nature of the experts in selecting and weighting of the criteria, who sometimes made use of estimates based on data from other countries, the influence of certain experts whose views might affect the opinions of other experts during discussions. Although the prioritization of zoonoses in DRC was completed by the elaboration of the list of priority zoonoses, the impact of the weighting of criteria and the participation of the panel members in the final ranking [23], was not sought.

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