Workshop summary

One Health Zoonotic Diseases Prioritization (OHZDP) for Multisectoral Engagement in Sudan

Khartoum, Sudan 24-26 Aug 2021

World Health Organization

One Health Zoonotic Disease Prioritization Process

LIST OF ABBREVIATION

CCHF: Crimean Congo Haemorrhagic Fever

CDC: United State Centers for Disease Control and Prevention

EMRO: Regional office for the Eastern Mediterranean

EU: European Union

FCDO: Foreign, commonwealth and Development Office

FAO: Food and Agriculture Organization of the United Nations

FMoH: Federal Ministry of Health

FMoAR: Federal Ministry of Animal Resources

HCENR: Higher Council of Environment & Natural Resources

ICRC: International Committee of the Red Cross

IGAD: Inter-governmental Authority on Development

SMoH: State Ministry of Health

SoAR: State Ministry of Animal Resources

NTDs: Neglected Tropical Diseases

OIE: World Organization for Animal Health

OHZDP: One Health Zoonotic Disease Prioritization

USAID: United States Agency for International Development

UN: United Nation

UNICEF: United Nation International Children's Emergency Fund

RVF: Rift Valley Fever

WHO: World Health Organization

Table of Contents

EXECUTIVE SUMMARY

The purpose of the OHZDP workshop for Sudan was to prioritize zoonotic diseases of greatest concern using a multisectoral, One Health approach with equal input from representatives of human, animal (livestock and wildlife), and environmental health sectors and other relevant partners. The specific workshop goals were to use a multisectoral, One Health approach to:

1. Prioritize zoonotic diseases of greatest concern
2. Develop next steps and action plans to address the priority zoonotic diseases in collaboration with One Health partners

Photo (1): Sudan Map

During the workshop, participants agreed on the final list of zoonotic diseases for prioritization for Sudan, defined the criteria for prioritization, and determined questions and weights relevant to each criterion. A total of 8 zoonotic diseases were identified as a priority by participants using a mixed methods prioritization process, the One Health Zoonotic Disease Prioritization Process, developed by the U.S. Centers for Disease Control and Prevention (CDC) (Appendix A).

After the participants selected the priority zoonotic diseases, they developed next steps and action to address the priority zoonotic diseases in collaboration with One Health partners.

Photo (2) Grazing trip. Eastern Sudan.

The priority zoonotic diseases for multisectoral, One Health collaboration for Sudan are:

- Rift Valley Fever
- Salmonellosis
- Dengue
- Rabies
- Brucellosis
- Crimean Congo Hemorrhagic Fever
- Zoonotic Avian Influenza
- Hepatitis E

This report summarizes the OHZDP process used to prioritize zoonotic diseases of greatest concern for Sudan, as well as next steps and action plans to jointly address zoonotic diseases using a multisectoral, One Health approach including human, animal, and environmental health ministries and other relevant sectors.

Photo (3) Cow's graze in the pastures of west of Sudan

PARTICIPATING ORGANIZATIONS

- Federal Ministry of Health (FMoH)
- State Ministry of Health (SMoH)
- Federal Ministry of Animal Resources (FMoAR)
- State Ministry of Animal Resources (SMoAR)
- Higher council of Environment and Natural Resources (HCENR)
- Ministry of Irrigation and Dams
- Ministry of Interior (General Administration of Wildlife Protection)
- International Agency of Atomic Energy (IAAE)
- Academia (Universities of Khartoum, Karrari and Bahry)
- Academia (Institutes of Endemic diseases, and Tropical Medicine institute)
- Food and Agriculture Organization of the United Nations (FAO) -Sudan Country Office
- World Health Organization (WHO) - Sudan Country Office
- World Health Organization (WHO)-Regional office for the Eastern Mediterranean (EMRO)
- European Union (EU) - Sudan Country Office
- Centers for Diseases Control (CDC) Atlanta
- Centers of Diseases Control (CDC) Africa
- World Organization for Animal Health (OIE) – AFRICA
- Foreign, Commonwealth and Development Office (FCDO) – UK

Photo (4) A mother and her children back from their trip to get water, North Kordofan

Table 1. Priority zoonotic diseases selected in Sudan

Zoonotic Disease	Agent	Human Disease Burden	Animal Disease Burden	Diagnostics, Treatment & Prevention
Rift Valley Fever	Viruses	In 2007/2008 outbreak 747 confirmed human cases including 230 deaths (case fatality 30.8%) were reported in Sudan	In 2019 outbreak 43 cases and 8 deaths reported	ELISA and RT-PCR are used for diagnosis in Sudan. The treatment is mainly supportive treatment while the main preventive measures are vector control and raising community awareness
Salmonellosis	Bacteria	In Khartoum state, a prevalence of 70.3% was detected in restaurant workers in a study conducted at 2010. Later on, 2015, a total of 437 stool samples obtained from children with diarrhoea were examined and 17 (4 %) tested positive for *Salmonella spp*	The prevalence of *S. enterica* was 2.4% in food, 7.1% in animals, 18.1% in chickens, 7.2% & in water in a study carried out in Khartoum state at 2010.	For diagnosis, faecal or blood cultures and serology are the used. The preventive measures used in Sudan include sanitation measures and safe food handling practices while different antimicrobials are used for treatment.
Dengue	Viruses	In 2019, a total of 1,197 suspected cases of dengue fever including five deaths (CFR=0.42%) were reported	NDF	RT-PCR used for diagnosis in Sudan. The treatment is mainly supportive treatment and main preventive measures are directed towards vector control and raising community awareness.
Rabies	Viruses	In the period 1992-2002, 108759 post-exposure treatments and 253 deaths reported in 6 states. From 2010 – 2019 there were 1915 Suspected cases and 35 reported deaths for the same period of time	From 2012 – 2019 there were 275 cases reported and 72 animals deaths	The diseases are diagnosed clinically and by using the IFA test, while the treatment includes appropriate wound cleaning and post-exposure prophylaxis with immunoglobulin. In addition, the preventive measures focus is on disease reporting and prevention and control of disease in animals via vaccination of private dogs, removal of stray dogs, quarantine of suspect cases as well as raising community awareness.
Brucellosis	Bacteria	Between 2011- 2019 13,866 cases were reported	High prevalence was recorded in	Serology (RBT), PCR and isolation of the bacteria are the

		including 43 deaths	cattle (76%), followed by camel (20%) (20%), goats (18%) and sheep (13%)	techniques used for Brucellosis diagnosis in Sudan. Available treatment in Sudan is the administration of antibiotics. Moreover, vaccination of animals and holding public awareness campaigns are the main preventive measures applied nationally.
Crimean Congo Haemorrhagic Fever	Viruses	During 2015-2016, out of 65 cases with haemorrhagic fever, 7 (11%) were confirmed as CCHF cases	Out of 299 randomly sampled cattle 21 (7.0%) were found +ve for CCHFV	ELISA, and RT-PCR are used for diagnosis. The treatment is mainly supportive treatment, and the main preventive measures are raising public awareness
Zoonotic Avian Influenza	Viruses	In Khartoum State, the avian influenza virus (H5N1) IgG antibodies were detected in 12% (7/60) among workers of case-farm group and 0% (0/30) in control-farm group	Seroprevalence study for AI virus type A in Chicken was conducted at 2007 in different localities in Sudan and revealed different percentages ranged from 71.4 to 100	Both PCR & ELISA tests are used for AI diagnosis and the treatment is mainly supportive one. The applied preventive measures are varied such as enhancing the farm biosecurity, wearing PPE, prevent contact with wildlife, stamping out, quarantine, movement control inside the country, disinfection/disinfestation, and poultry vaccination
Hepatitis E	Viruses	During 2020, 155 cases including 5 deaths were reported Red Sea, Gadarif, East Darfur, White Nile, River Nile, Kassala, Gezeira, and Blue Nile). In addition, 116/132 samples collected in the same year were HVE positive	NDF	PCR test is used for diagnosis. In addition, supportive treatment is administered to positive cases and the preventive measure is sanitation

BACKGROUND

The CDC and WHO define zoonosis (or zoonotic disease) as any disease or infection that is naturally transmissible from vertebrate animals to humans. Zoonoses can be caused by bacteria, parasites, fungi, or viruses.

Most known human infectious diseases and about three-quarters of newly emerging infections originate from animals. Zoonotic diseases that occur in large numbers can impact society in three main ways. Specifically, they:

1.Threaten the health of animals resulting in illness, loss of productivity, and death.

2.Threaten the livelihood of the population dependent on livestock as a major source of income.

3.Threaten the health of people, with ability to cause a large number of illness and death, which is associated with significant social and economic losses.

In general, zoonotic disease emergence could be facilitated by factors such as changes in ecology, microbial adaptation and change, human demographics and behavior, international travel and trade, intensity of agricultural practices, technology, and industry

In order to best address zoonotic diseases threats, a multisectoral, One Health approach is needed. One Health means a collaborative, multisectoral, and transdisciplinary approach working at the local, regional, national, and global levels with the goal of achieving optimal health outcomes recognizing the interconnection between people, animals, plants, and their shared environment.

SITUATION ANALYSIS

Zoonoses are of great public health concern in Sudan due to the high cross-border movement of people, livestock and wildlife and other drivers that increase the chance of disease emergence and spread. In addition to internal conflict, Sudan borders countries suffering from certain form of instability, unrest, and conflicts that often-triggered mass mobility of people and animals. Early detection and response to both emerging and neglected zoonotic diseases is vital to avoid detrimental effects on humans, global health security and economies.

The public health system reports zoonotic diseases through the Integrated Disease Surveillance System that has immediate and weekly reporting schedule while the animal health sector reports zoonotic diseases on immediate, weekly and monthly basis. Both systems have event-based reporting although suboptimal and require improvement.

In the past years, Sudan practiced commendable joint outbreak investigation for zoonotic events involving Ministries of Health and Animal Resources, which helped it to trace the source of infections and reduce the time of containment and resources.

Sudan has developed Plan of Action for brucellosis and Rift Valley Fever (RVF) surveillance and control to reduce spillover of these zoonoses into human population. Such plan of action includes public awareness and communication plan to encourage farmers, livestock keeping communities to report animal diseases. Livestock census for Sudan is outdated (1973). According to FAO estimates, with 33 m Livestock Units, Sudan is the second largest livestock population (after Pakistan, which has 71 m Livestock Units) among the WHO/EMRO countries (FAO-STAT, 2016).

Sudan has good inter-coordination mechanisms among relevant ministries and reports of disease outbreaks are shared timely. Rapid Response Teams, composed of both human and animal health experts for any suspected zoonotic outbreaks up to the administrative local units, regularly meet on quarterly basis, and more frequently during suspected zoonotic events. In 2015, a Memorandum Of Understanding (MoU) was signed between FMoH and FMoAR, for joint management of health emergency situations including development of joint strategy. Recently, Rapid Response Teams RRT have successfully managed the RVF,

Crimean Congo Hemorrhagic Fever (CCHF) and Brucellosis outbreaks through joint outbreak investigation with clear guidelines, defined roles, and responsibilities. Sudan has proven capacity to timely respond to more than 80 percent of zoonotic events on time (within 24-48 hours) through its strong epidemiology directorates assigned to address zoonoses which are located at both FMoH & FMoAR ministries. Besides regular coordination meetings organized among relevant sectors, the secondment of staff from one ministry to another is a great step for strengthening their bonds, and sustaining functional linkages. The national labs, also are linked and regularly share specimens and reports for major zoonotic outbreaks. Annually, Sudan undertakes surveillance in animals for zoonotic diseases that pose a national health risk.

Sudan has developed a "One Health" concept note to be implemented following approval from relevant authorities

In combating the threat of zoonotic diseases, there is a need for strengthening regional cooperation focusing on building state-level capacity for surveillance, detection, and rapid response in order to recognize, prevent, and treat emerging zoonotic diseases and reduce public health risk.

OHZDP WORKSHOP

To begin addressing zoonotic disease challenges in Sudan, a One Health Zoonotic Disease Prioritization workshop was held on August 24-26, 2021, in Corinthia Hotel, Khartoum. The purpose of the One Health Zoonotic Disease Prioritization workshop for Sudan was to prioritize zoonotic diseases of greatest concern using a multisectoral, One Health approach with equal input from representatives of human, animal (livestock and wildlife), and environmental health sectors and other relevant partners.

Photo (5) Advisors during group discussions

The specific workshop goals were to use a multisectoral, One Health approach to

1. Prioritize zoonotic diseases of greatest concern
2. Develop next steps and action plans to address the priority zoonotic diseases in collaboration with OneHealth partners.

Facilitator's training workshop

To build in-country capacity to conduct future One Health Zoonotic Disease Prioritization workshops, 12 local facilitators were trained on 22-23 Aug 2021, by WHO-EMRO on the One Health Zoonotic Disease Prioritization process from the following relevant One Health sectors and partners:

- Federal Ministry of Health
- Federal Ministry of Animals Resources
- Higher council of Environment & Natural Resources
- WHO-Sudan country office

Photo (6) Facilitator's training, handing over trainees' certificates.

Photo (7) Facilitator's training, group work.

WORKSHOP METHODS

The OHZDP process uses a mixed methods prioritization process developed by the (CDC) One Health Office. The methods have been previously described in detail (Appendix A). Workshop organizers began to prepare and plan for this workshop months in advance. During the workshop, participants first reviewed the initial zoonotic disease list to focus on for prioritization. A zoonotic disease was selected if it was known to be spread between humans and animals of concern for Sudan. Zoonotic diseases on human or animal reportable disease lists were included in the initial list. A list of 30 zoonotic diseases, shown in Table 2 of Appendix C, were considered during the workshop.

During the workshop, participants developed five criteria for ranking the 30 zoonotic diseases. Once the five criteria were developed, one categorical question was developed for each criterion through group discussion. The questions were developed to best measure each criteria. All questions had ordinal, binomial or multinomial answers. The ordinal nature is necessary for the scoring process and each answer choice was given a score, which was determined by the participants.

Voting members then individually ranked their preferences for the relative importance of each criterion. Each individual votingmember's ranking were then inputted into the OHZDP Tool by a facilitator and a group weight for each criteria was calculated. Facilitators and participants answered each question for each zoonotic disease using data that were identified through an extensive literature search, as well as information from WHO, OIE, ProMED, and other relevant websites. Data on disease transmission, severity, pandemic and epidemic potential, economic impact, prevention and control, and environmental impact were collected for each zoonotic disease. If information for a particular zoonotic disease was not available for Sudan, data from the region or globally were used. Over 412 articles were collected with zoonotic disease-specific information on transmission, severity, pandemic and epidemic potential, economic impact, prevention and control, and environmental impact for the country, region, and globally. These references were compiled and shared with all workshop participants.

After scoring all zoonotic diseases, decision tree analysis was used to determine the ranked zoonotic disease list. Each weighted criterion was applied across each question's answers for each zoonotic disease. The scores for all five questions for each zoonotic disease were summed. The largest raw score was then normalized giving that zoonotic disease a normalized score of 1. See Appendix C for a complete listing of raw and normalized scores for all zoonotic diseases that were considered for prioritization.

The zoonotic diseases with their raw and normalized scores were presented to the participants for discussion. Workshop participants then utilized the ranked OHZDP list to discuss and decide on a final priority list of 8 zoonotic diseases (Table 1). After the participants decided on the priority zoonotic diseases, participants developed next steps and action plans to address the prioritized zoonotic diseases.

CRITERIA AND QUESTION DESCRIPTION DEVELOPED

The criteria for ranking zoonotic diseases selected by the voting members in Sudan are listed in order ofimportance below. A description of how the questions assessed the criteria are listed below. For the fullquestion and answer choices, see Appendix D.

Rank	Criteria	Weight	Question Description
1	**Severity of the disease**	**0.39**	What is CFR and/Mortality rate of the Disease in human and animals in Sudan?
2	**Burden of the disease**	**0.28**	What is the prevalence of the disease in Sudan?
3	**Socioeconomic and environmentalimpact**	**0.12**	Does the disease have socio-economic and environmental impact in Sudan?
4	**Diagnostic capacity**	**0.11**	Are there existing diagnostic capacities (clinical / laboratory) to detect human & animal suspected cases in Sudan?
5	**Availability of control measures**	**0.10**	Are there available control measures to contain the disease in the country?

PRIORITY ZOONOTIC DISEASE LIST FOR Sudan

The 8 priority zoonotic diseases for multisectoral, One Health collaboration for Sudan are:

1. Rift Valley Fever
2. Salmonellosis
3. Dengue
4. Rabies
5. Brucellosis
6. Crimean Congo hemorrhagic Fever
7.
8. Zoonotic Avian Influenza
9. Hepatitis E

Photo (8) Voting members during voting process

NEXT STEPS AND ACTION PLANS

After finalizing the list of priority zoonotic diseases, workshop participants discussed next steps and action plans to address the prioritized zoonotic diseases using a multisectoral, One Health approach. Participants were first asked to develop next steps and action plans for how to address the priority diseases using a multisectoral, One Health approach then to develop specific next steps for their sectors. A summary of the recommendations developed by all participated sectors follows:

1. Multisectoral, One Health Coordination Mechanism

1. Establish One Health forum with institutional coordination mechanisms between the three sectors (health, animal resources, environment)
   a- Define the structure, terms of references, responsibilities, and SOPs
   b- Define a framework for planning including budget and M&E
2. Coordinate the community-based activities with the planned activities of the official bodies.

2. Surveillance (Passive and active)

1- Timely sharing of information among the three sectors
2- Update the current list of reportable diseases to include the prioritized diseases.
3- Update the case definition for the zoonotic diseases included in the notifiable diseases list.
4- Conduct an epidemiological study from One Health perspective.
5- Build staff capacity in developing plans, data analysis and interpenetration, sample collection and transportation.
6- Develop and update a slandered data collection tools/format.
7- Train and engage the community to enhance early detection and reporting of public health events.
8- Update signals for alert reporting.
9- Use electronic platforms.
10- To benefit from the meteorological information in early preparedness.
11- Establish integrated surveillance system for vector borne diseases among the three sectors.

3. Laboratory

1. Build the national capacities of both public health and veterinary sectors reference laboratories for diagnosis of zoonotic diseases
2. Enhance lab equipment and maintenance renewal
3. Develop Lab Information Management System (LIMS) and network.
4. Strengthen capacities of the public health and veterinary laboratories at regional and or state level.
5. Ensure Sustainable supply of kits and reagents.
6. Meet the requirements to get External Profeciancy Testing (PT) and accreditation
7. Establish a biosafety level 3 lab for concern diseases with a certification.
8. Apply laboratory- based surveillance.
9. Establish vaccine production unit for rabies and enhance advanced brucella vaccine production.
10. Conduct joint applied research under One Health Concept.
11. Establish transportation and communication system to link central and state labs in human and animal sectors.

4. Outbreak Response

1. Conduct situation analysis as first step of outbreak response
2. Organize meetings with identified key players to gain their commitment and ensure their effective engagement and leadership for joint response missions
3. Ensure coordinated response at federal, state and locality levels
4. Establish joint rapid response teams (RRT)
5. Develop training modules, protocols and SOPS for RRT
6. Case management including adherence to protocols of diagnosis and treatment, infection prevention control and laboratory diagnosis
7. Activate laws, regulations and local acts to control animal movements during outbreaks
8. Implementation of vaccination and quarantine policies as preventive measure to protect healthy animals during out breaks
9. Advocate for risk communication plans
10. Implement joint health promotion and veterinary extension activities
11. Implement Water, sanitation and hygiene (WASH) at locality level
12. Monitoring and evaluation of response activities through carrying out After Action Review

5. Preparedness and Planning

1. Capacity building in prevention, detection and response activities
    - Training of Rapid response teams
    - Training for medical cadres in protocols of diagnosis and treatment (Example: brucella – Salmonella)
2. Develop and update investigation and sampling forms
3. Develop manuals – guidelines - Protocols and SOPs
4. Develop integrated action plans for each high priority zoonotic disease
5. Conduct Surveillance for vector borne diseases in human-animal interface
6. Conduct Serological surveillance for under reported diseases (brucella – Salmonella)
7. Strengthen and expand Community Based Surveillance for awareness (CAHWs)
8. Strengthen laboratory diagnostic capacity and capability for detection of zoonotic diseases (supplies preposition – rapid test provision – upgrading and expansion of laboratories service at national and state level).
9. Introduce poultry vaccination policy for Avian Influenza.
10. Preposition of medicines and medical supplies (drugs and equipment).

6. Work force

1- Conduct gap analysis to assess existing human resources (identifying level of experience, skill, trainings and tasks of assigned staff) in all concerned sectors at national and subnational

2- Establish a national workforce development strategy for capacity-building of staff in all sectors with focus on the following areas:
    - Surveillance
    - Early preparedness
    - Outbreak response
    - Coordination and One Health Concept
    - Laboratory

Photo (9) Surveillance group present next steps

Multisectoral Action Plan

Each One Health sector and relevant partners present at the workshop agreed on the above-mentioned recommendations from the working groups and make suggestions for specific next steps that ministries could take to improve multisectoral activities in preparedness, surveillance, laboratory capacity, outbreak response, coordination, work force and M&E. A summary of the next steps suggested by each sector were included under these main pillars as the following action plan with shared roles and responsibilities of each sector supported by stakeholders:

Activities	Objectives of Activity	Expected outcomes	Responsible Ministries	Stakeholders
Pillar 1: Multisectoral, One Health Coordination Mechanism				
One Health Plat forum workshop	To establish and endorse the One Health Plat forum	list of members of One Health Plat forum with TORs	FMOH, FMOAR, HCINR	WHO, FAO, CDC, EU
Multisectoral One Health Integrated Plan Workshop	To prepare and agree on join planning and collaboration at human-animal & environment interface	joint action plan among human-animal and environment sectors	FMOH, FMOAR, HCINR	WHO
Develop guidelines/SOPs for coordination of one health issues to do with surveillance, preparedness and response among human-animal-environment sectors.	To Revisit, translate and disseminate SOPs/guidelines that help improve coordination of one health activities among the three sectors which is required by JEE/IHR	Improved coordination among one health partners in Sudan	MOH, MOAR, HCINR	WHO
Train focal persons from national and selected States on SOPS/guidelines required for coordination of one health activities	To orient State focal persons on the new developments and concepts related to one health and zoonosis as part of continuous capacity building to the States	Improved awareness and commitment of State focal persons for one health	FMOH, FMOAR	WHO
Organize One Health Conference during 2021 International ONE HEALTH Day (3rd Nov 2021) to share scientific papers on major zoonotic diseases and their impact on economy and public health in Sudan	To bring important One Health issues to the public attention to help address shared health threats at the human-animal-environment interface in Sudan.	Improved public awareness on One Health related issues in Sudan	FMOH, FMOAR HCINR, MOHE	WHO, FAO, CDC, EU, UNICEF
Conduct regular Coordination meetings between relevant technical directorates	To coordinate and follow up the joint activities	4 quarterly meetings per year annually quarterly	FMOH, FMOAR HCINR	
Strengthen coordination between NPHL&VRL	To enhance diagnosis of zoonotic diseases, and Improve AMR detection.	MOU endorsed with roles and responsibilities	FMOH, FMOAR, MOHE (Atomic Agency Authority)	WHO, IAAE
Pillar 2: Surveillance				
Support updating list of notifiable/reportable zoonotic diseases informed by OHZDP outcome in human and animal sectors	-To update list of reportable/notifiable diseases in human and animal sectors informed by OHZDP outcome -To update case definition & investigation forms of notifiable diseases	-Updated list of reportable/notifiable zoonotic diseases in human and animal sector -Updated formats of case definition & investigation forms	FMOH, FMOAR	WHO
Include prioritized zoonotic diseases of greatest concern in Sudan into Community Based Surveillance training manual and signals of event-based surveillance	To improve detection of zoonotic diseases of greatest concern in Sudan through community volunteers	Improved awareness and detection of zoonotic diseases of greatest concern in Sudan	FMOH, FMOAR	WHO
Improve timely & regular reporting of health events	To exchange reliable information on public	-Number of reports shared on time	FMOH, FMOAR	WHO, FAO (ECTAD),

	health events of concern	among the three sectors -Developed electronic platform to receive signals from the three sectors - Established integrated surveillance system for vector borne diseases among the three	HCINR	IGAD& EU
Support updating vector mapping and strengthen vector surveillance system	To update vector composition and distribution in Sudan	Updated Sudan vector distribution map	FMOH,	GF, WHO
Pillar 3: Laboratory				
Train laboratory technicians from Veterinary and NPHL from Federal and States level on diagnosis of VHFs and Brucellosis in Sudan	To build the national /subnational capacity to diagnose zoonotic diseases of greatest concern in Sudan	-Trained laboratory technicians in States affected by zoonotic diseases of concern -Introduced vector incrimination as early predicting tool for VHF outbreaks	FMOH, FMOAR MOHE (Atomic Agency Authority. ZODIAC)	WHO, FAO, IAAE
Develop sustainable system to provide laboratory supplies, reagents and testing kits to build diagnostic capacities	To build testing capacity for national and most affected States	Functional national and State laboratories	FMOH, FMOAR MOHE (Atomic Agency Authority. ZODIAC)	WHO, FAO, IAAE
Develop Lab Information Management System (LIMS) and network	To enhance reporting, analysis and dissemination of lab data.	Functional Management System in place	FMOH, FMOAR	WHO, FAO, RKI
Establish Vaccine production unit for rabies and enhance advanced brucella vaccine production	To protect health of human and livestock	Number of vaccine units produced Number of people and livestock immunised	FMOH, FMOAR	WHO, FAO
Establish transportation and communication system to link central and state labs in human and animal sectors	To ensure fast and safe mechanism of samples delivery leads to early detection of outbreaks.	Well established system in place between federal and states laboratories and epidemiology departments	FMOH, FMOAR	WHO, FAO, Private sector
Establish a biosafety level 3 lab for concern diseases with a certification	To perform diagnosis of pathogens under a set of precautions that protects personnel, environment and community	A certified, well-constructed building with all equipment (PPEs,) and SOPs	FMOH, FMOAR	WHO, RKI FAO, IAAE
Pillar 4: Outbreak Response				
Coordinated response at federal, state and locality levels	-Establish trained joint rapid response teams (RRT) -Develop training modules, protocols and SOPS for the RRT	-Number of trained teams deployed to respond - modules, protocols and SOPS prepared	FMOH, FMOAR HCENR	WHO, RKI
Activate laws, regulations and local acts to control animal movements during outbreaks	-Control measures applied protected by laws	- Number of laws activated - action taken	FMOH, FMOAR Ministry of Interior, Local councils,	

			Ministry of Justice	
Implementation of vaccination and quarantine policies as preventive measure to protect healthy animals during outbreaks	- Ensure immunized livestock -Prevent spread of disease out the outbreak foci	-Number of animals vaccinated - Number of animals quarantined	FMOAR	FAO ICRC
Case management including adherence to protocols of diagnosis and treatment, infection prevention control and laboratory diagnosis	-Ensure timely and proper diagnosis and treatment of cases	-Number of health facilities apply the protocol -Healthy individuals -Lab tests performed and results	FMOH	WHO, MSF, WORLD BANK
Advocate for risk communication plans Implement &joint health promotion and veterinary extension activities	-To communicate the risk of zoonotic diseases, AMR, other public health events among three sectors, stakeholders and community	- Number of Awareness campaigns conducted - Number of messages delivered to community	FMOH, FMOAR HCENR Media	WHO, UNICEF, SADAGAT
Implement WASH and sanitation at locality level	-To prevent water borne disease	- Number of packages of intervention conducted	FMOH, HCENR	WHO, UNICEF
Apply integrated vector management interventions	- To reduce vector population density and control vector borne diseases transmission.	- Reduced vector population density - Reduced vector borne diseases transmission	FMOH, FMOAR	WHO, partners
Monitoring and evaluation of response activities	-To analyze gaps, identify /best practices, and areas for improvement and contributing factors -To identify areas for improvement	-After Action Review workshop conducted	FMOH, FMOAR HCENR	WHO
Pillar 5: Preparedness and Planning				
Strengthening the capacity of cadres in the three sectors to tackle zoonotic diseases from one health approach	-To build the capacity in prevention, detection and response activities	- Number of cadres trained (RRT) - Number of protocols of diagnosis and treatment developed/updated (Example: brucella – Salmonella)	FMOH, FMOAR HCENR	WHO, FAO, EU, RKI
Train joint RRT from human-animal-environment to investigate and response to epidemic alerts for prioritized zoonotic diseases of greatest concern in Sudan	To improve one health partnership and coordination towards joint alert investigation and response to prioritized zoonotic diseases of greatest concern in Sudan	Joint RRT trained from human-animal-environment to investigate and response to epidemic alerts for prioritized zoonotic diseases of greatest concern in Sudan	FMOH, FMOAR, HCENR	WHO
Develop integrated action plans for each high priority zoonotic disease	-To tackle zoonotic disease	- A plan developed activities and implemented	FMOH, FMOAR HCENR	WHO, FAO, EU

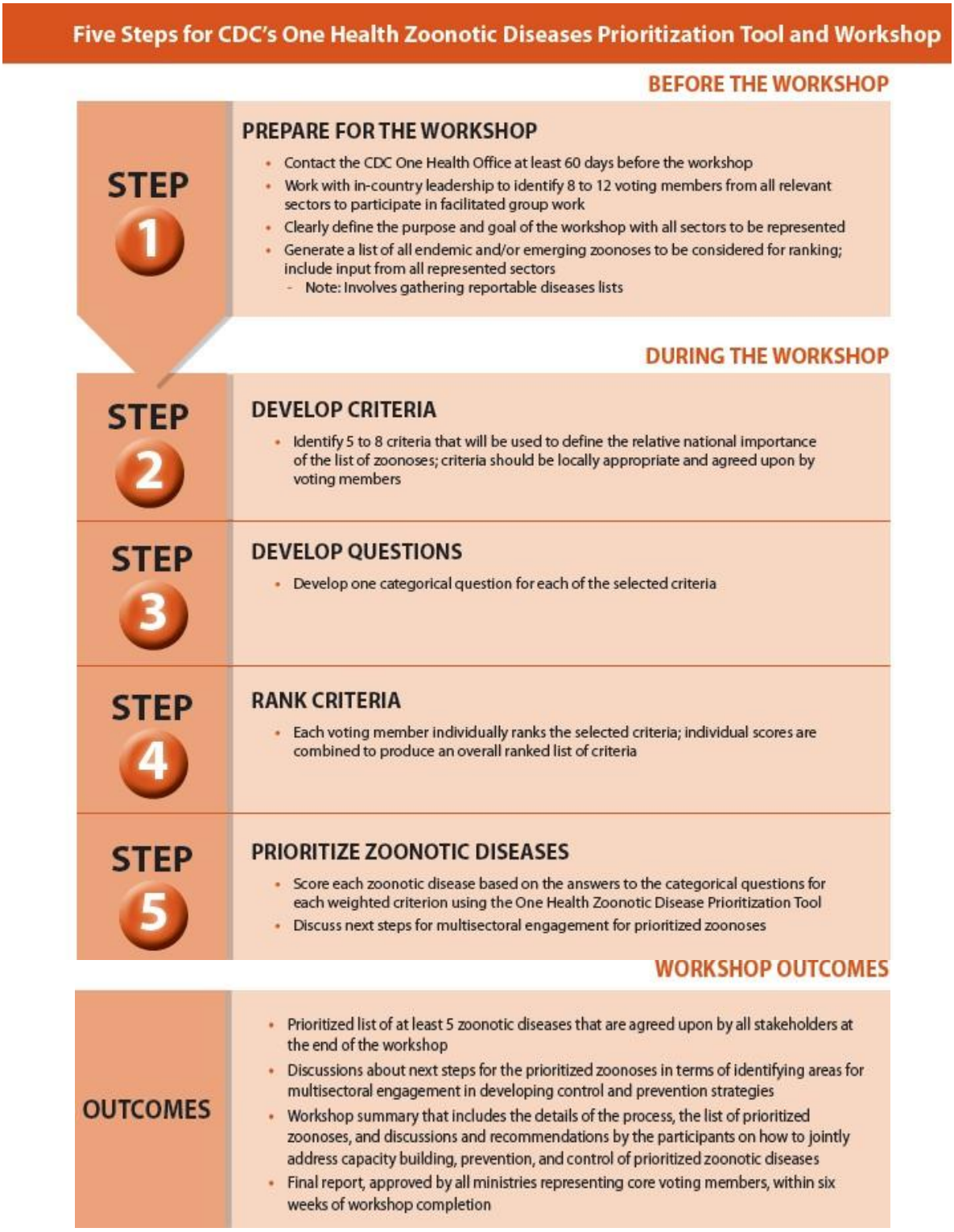
Develop and update disease profile, investigation and sampling forms, manuals guidelines, Protocols and SOPs for zoonotic diseases	-To prepare for rapid and integrated response to zoonotic diseases	-Number of documents prepared, endorsed and disseminated	FMOH, FMOAR HCENR	WHO, IGAD, RKI
Preposition of medicines, medical supplies, rapid tests, insecticides, and vector control supplies.	-Upgrading of health facilities -Upgrading of laboratories service at national and state level	-Adequate buffer stock available	MOH	WHO
Support awareness raising on Rabies	-To raise public awareness and improve vaccination against rabies	-Awareness campaigns conducted - Number of animals vaccinated	- FMOH, FMOAR -MOAR	WHO, FAO, SADAGAT, UNICEF, ICRC
Develop joint risk communication strategy for prioritized zoonotic diseases of greatest concern in Sudan among human-animal and environment sectors	-To improve risk communication towards prioritized zoonotic diseases of greatest concern in Sudan	-Zoonotic diseases of high concern risk mitigated	FMOH, FMOAR -MOAR	WHO, FAO, UNICEF
Take advantage of Meteorological information in the three sectors	-To enhance forecasting for vector borne diseases and other natural disasters	-Metrological data shared and analyzed	FMOH, FMOAR Metrological authority	NASA, IGAD, FAO, OIE, WHO
Pillar 6: Work force				
Mapping workforce at national, subnational and private sector in terms of number, skills, qualifications	-To check the potentials to implement plans -To fill the gabs in different sectors	- A list of all available work force per sector/profession/specialization/experience /skills	FMOH, FMOAR MOHI & SR	WHO, OIE, FAO
Conducting training needs assessment for the three sectors	-To define the areas that need to be strengthened	-A list of courses available and useful to build the capacities of cadres	FMOH, FMOAR Universities, Medical, Environment and Veterinary councils	WHO, OIE, FAO, EU, USAID& CDC Africa
Develop and conduct Continuous Professional Training in one health	-To increase knowledge and practice in one health aspects	- A list of courses available and useful to build the capacities of cadres	FMOH, FMOAR Universities, Medical, Environment and Veterinary councils	WHO, OIE, FAO, EU, USAID, CDC & CDC Africa

Photo (10) WHO (WR, Emergency lead) and FMOH in discussion with UN resident coordinator after closing session

APPENDIX

Overview of the One Health Zoonotic Disease Prioritization Process

HTTPS://WWW.CDC.GOV/ONEHEALTH/GLOBAL-ACTIVITIES/PRIORITIZATION.HTML



One Health Zoonotic Disease Prioritization Workshop Participants for Sudan

B.1 Voting Members

Number	Name	Organization	Title/Position
1	Dr. Babiker Ahmed Ali	Federal Ministry of Health	Emergency and Epidemics Control Adviser
2	Mrs. Maaza Abasher	Federal Ministry of Health	Head of Surveillance unit
3	Dr. Rasheeda Hamed	Federal Ministry of Health	Head of National TB reference laboratory
4	Dr. Hanadi Awad	Federal Ministry of Health	Head of Zoonotic diseases unit
5	Mr. Adil Khalifa	Environmental Health- Federal Ministry of health	Head of Environmental health and food safety
6	Dr. Elamir Gafer Saad	Federal Ministry of Animal Resources	General Director of Animal Health and Epizootics
7	Dr. Faiza Awad Elkarim	Federal Ministry of Animal Resources	Head of Public Health and Zoonotic Diseases Dire
8	Dr. Ali Gaddal	Federal Ministry of Animal Resources	Director of Central Veterinary Research Laboratory
9	Dr. Haitham Fadalla Eltaib	Federal Ministry of Animal Resources	Head of Epizootics Control Directorate
10	Dr. Aisha Elfaki	Environmental health- Wild life center	Researcher
11	Dr. Khitma Elawad Mohammed	Environmental health- Higher council of Environmentand Natural resources	Director General of sustainability of natural resource
12	Mr. Mohamed Souliman Elnaw	Environmental health- Ministry of interior	Wild life Officer

B.2 Advisors/Observers

Number	Name	Organization	Title/Position
1	Prof. Mubark Elkarssani	karray University	Virologist
2	Prof. Khitma Elmalik	Faculty of veterinary Medicine- Khartoum University	Professor at the preventive medicine department
3	Prof. Adil salman	Bahry University	Head of One Health center
4	Dr. Shahinaz Bedri	National Public Health Laboratory	Head of National Public Health Laboratory
5	Dr. Alfatih Malik	Faculty of Medicine -Khartoum University	Associated professor
6	Dr. AL Rasheed Abdalla Ali	Faculty of Public Health/ Khartoum University	Associated professor

7	Mr. Gedlu Mekonnen	FAO	Technical Advisor. ECTAD
8	Dr. Ammar Mohamel Elamin Has	International Agency of Atomic Energy	Director of Directorate of Organization & Technic
9	Dr.Faiza Mohamed Osman	Institute of Endemic Diseases	Head Epidemiology, Nutrition &Refugees Health
10	Dr. Mubarak Mustafa Abderahma	Tropical Medicine Institute	Director of Institute
11	Dr. Shahd Osman	FETP	Technical Advisor
12	Dr. Nada Margani	EU	Technical Advisor
13	Mr. Ayman Ahmed	WHO	Technical officer (Vector control)
14	Dr. Elamin Abu Elaas	National Public Health Laboratory	Public Health Laboratory
15	Dr. Lubna Mohamed Abdalla	Wild life Research Center	Wild life Sector
16	Dr. Elham Abdallah	Ministry of Animals Resources (Federal)	Researcher
17	Dr. Hanan Yousif	Ministry of Animals Resources (Federal)	Veterinary Preventive
18	Dr. Tamador Elhassan	Ministry of Animals Resources (Federal)	Virologist
19	Dr. Areeg Magzoub Mohamed	Ministry of Health (Federal)	NTDs PSM Focal person
20	Ms. Khadiga Adam Mohammed	Ministry of Health (Federal)	Head of Information department
21	Mr. Mohammed Sid Ahmed	Ministry of Irrigation and Dam	Head of Environmental department
22	Dr. Suliman Jamal	Ministry of Health (Federal)	Head of Surveillance Department
23	Mr. Talha Elssir Algaily	Ministry of Health (Federal)	Head of IHR department
24	Dr. Layla Hammad Elneel	Ministry of Health (Federal)	Head of Response department
25	Mrs. Tahani Adam	Ministry of Health (Federal)	Health Quarantine officer
26	Dr. Mohamed Abdalhafiz Alkhidi	Ministry of Health (Federal)	General Directors of Emergency and Epidemics Co
27	Ms. Jihan Eissa Hamad	Ministry of Health Khartoum state	Head of Surveillance Department
28	Dr. Awatif Abdalgader	Higher council of Environment	Director of Marine Administration
29	Mr. Khalfalla Alassad	Federal Ministry of Health	Head of Partnership NTDs

B.3 Trained In-Country Facilitators

Number	Name	Organization	Title/Position
1	Dr. Sara Mohammed Elhassan	Federal Ministry of Health	Zoonoses Diseases Coordinator
2	Mrs. Mayada Esmail Ebrahim	Federal Ministry of Health	Public Health officer
3	Mr. Omer Elbaderi	Federal Ministry of Health	Surveillance officer
4	Dr. Kawther Hassan Mohamed	Federal Ministry of Health	Researcher

5	Dr. Nada Mohammed Hassan	Federal Ministry of Animals Resources	Reporting officer
6	Dr. Egbal Hewit alla Abdalla	Federal Ministry of Animals Resources	Zoonotic diseases Department officer
7	Dr. Hala Hussin Ahmed	Federal Ministry of Animals Resources	Epidemiology department officer
8	Dr. Maha Ibrahim Khogali	Federal Ministry of Animals Resources	Researcher
9	Mrs. Nazik Salah Eldein	Higher Council of Environment &Natural Resources	Researcher
10	Mr. Elmustafa Babiker	Federal Ministry of Health	Head of Vector control Department
11	Mr. Mohammed Abdalla Abdalmaged Alhassan	WHO-Sudan country office	Surveillance officer-IHR & PoE

B.4 External Facilitators or Other Key Staff

Number	Name	Organization	Title/Position
1	Dr. Heba Mahrous	WHO-EMRO	Technical officer-One Health
2	Dr. Mahgoub Hamid	WHO-EMRO	Technical officer-IHR
3	Mrs. Nazik Elsheikh	WHO-EMRO	Technical officer-IHR
4	Dr. Betigel Habetwold	WHO-Sudan country office	Public health specialist

B.5 Workshop Organizers

Number	Name	Organization	Title/Position
1	Prof. Abdelhameed Ahmed Elfadil	National Consultant	Prof of Epidemiology. Faculty of Veterinary Medicine Sudan University of Science & Technology
2	Dr. Habtewold, Betigel	WHO-Sudan country office	Public health specialist
3	Mr. Mohammed Abdalla Abdalmaged Alhassan	WHO-Sudan country office	Surveillance officer-IHR & PoE
4	Dr. Hanadi Awad	Federal Ministry of Health	Head of Zoonotic Diseases Unit
5	Dr. Sara Mohammed Elhassan	Federal Ministry of Health	Zoonoses Diseases Coordinator

Ranked Zoonotic Disease List of One Health Zoonotic Prioritization Process in Sudan.

Number	Disease	Etiologic Agent	Raw Score	Final Score
1	Rift Valley Fever	Rift Valley Fever virus (Phlebovirus)	0.682	1
2	Coronavirus Disease 2019 (Covid-19)	Coronavirus (SARS-Cov-2)	0.617	0.905
3	Salmonellosis	*Salmonella Spp*	0.574	0.843
4	Dengue	Dengue	0.564	0.828
5	Rabies	Rabies virus (Lyssaviruses)	0.525	0.771
6	Brucellosis	*Brucella Spp* (*Abortus, Melitensis*)	0.524	0.769
7	Crimean Congo Hemorrhagic Fever	Crimean Congo Hemorrhagic Fever	0.484	0.71
8	Ebola Hemorrhagic Fever	Ebolavirus	0.405	0.594
9	Zoonotic Avian Influenza	Influenza Virus A	0.38	0.557
10	Hepatitis E	Hepatitis Virus E	0.379	0.556
11	Anthrax	*Bacillus Anthracis*	0.34	0.499
12	Escherichia Coli Infection	Escherichia Coli	0.338	0.496
13	Rotavirus	Rotavirus	0.329	0.483
14	Yellow Fever	Yellow Fever Virus (flavivirus)	0.316	0.464
15	Middle East Respiratory Syndrome (MERS)	MERS Coronavirus	0.305	0.448
16	Tetanus	*Clostridium Tetani*	0.302	0.443
17	Chikungunya	Chikungunya Virus (CHIKV)	0.301	0.442
18	Toxoplasmosis	*Toxoplasma Gondii*	0.273	0.401
19	Bovine Tuberculosis	*Mycobacterium Bovis*	0.248	0.364
20	Severe Acute Respiratory Syndrome (SARS)	Severe Acute Respiratory Syndrome	0.213	0.313
21	West Nile Fever	West Nile Fever (Flavivirus)	0.195	0.287
22	Dracunculiasis (Guinea-Worm Disease)	*Dracunculus Medinensis*	0.187	0.275
23	Shigellosis	*Shigella Spp (Dysenteriae, Flexneri*)	0.118	0.173
24	Leptospirosis	*Leptospira Interrogans*	0.104	0.152
25	Listeriosis	*Listeria Monocytogenes*	0.104	0.152
26	Leishmaniosis	*Leishmania Donovani, Leishmania Major*	0.103	0.151
27	Cysticercosis	*Taenia Saginata*	0.064	0.094
28	Sarcoptic mange	*Sarcoptic Scabiei*	0.064	0.094
29	Echinococcosis (Hydatid Disease)	*Echinococcus Granulosus*	0.053	0.078
30	Trypanosomiasis	*Trypanosoma Spp (Brucei, Rhodesiense*)	0.025	0.037

Criteria and questions developed for ranking the zoonotic diseases

Criteria A: Severity of the disease (Criteria weight = 0.394)

Question: What is CFR and/Mortality rate of the Disease in human and animals in Sudan?

Assumptions: Low in human = 0 to less than 5 % High in human = 5% and more

Answers:

A. Low in both Human and Animal (0)
B. Low in human and high in animals (1)
C. High in humans while low in animals (2)
D. High in both (3)

Criteria B: Burden of the disease (Criteria weight = 0.276)

Question: What is the prevalence of the disease in Sudan in the last 10 years?

Assumptions: Low in human = 0 to less than 5 % High in human = 5% and more

Answers:

A. Low in both (0)
B. Low in human and high in animals (1)
C. High in human and low in animals (2)
D. High in both (3)

Criteria C: Availability of control measures (Criteria weight =0.101)

Question: Are there available control measures to contain the disease in the country?

Assumptions: Available for both human and animal cases

Answers:

A. All measures are available (0)
B. At least three measures available (1)
C. At least two measures available (2)
D. At least one measure available (3)
E. No measures available (4)

Criteria D: Diagnostic capacity (Criteria weight = 0.112363)

Question: Are there existing diagnostic capacities (clinical / laboratory) to detect human & animal suspected cases in Sudan?

Assumptions: Diagnostic capacities include labs, staff, equipment's, and diagnostic kits

Answers:

A. High at both animal and human sides (0)
B. Limited capacities at one side (human/animal) and high at the other (1)
C. Limited at both human and animal sides (2)
D. Limited at one side (human/animal) while no capacity exists at the (3)
E. No capacity at both animal and human sides (4)

Criteria E: Socioeconomic and environmental impact (Criteria weight = 0.11689)

Question: Does the disease has socio-economic and environmental impact in Sudan?

Assumption: No assumption

Answers:

A. Low socioeconomic and environmental impact (0)
B. Low environmental while high socioeconomic impact (1)
C. High environmental impact and low socioeconomic impact (2)
D. High socioeconomic and environmental impact (3).

References

1. Hassan OA, Ahlm C, Sang R & Evander M (2011). The 2007 Rift Valley Fever Outbreak in Sudan. PLoSNegl Trop Dis 5(9): e1229. doi:10.1371/journal.pntd. 0001229.

2. Tariq A. Madani,1 Yagob Y. Al-Mazrou,1 Mohammad H. Al-Jeffri,1 Amin A. Mishkhas et al.(2003). Rift Valley Fever Epidemic in Saudi Arabia: Epidemiological, Clinical, and Laboratory Characteristics. Clinical Infectious Diseases; 37:1084–92.

3. Elfadil AAM, Musa SM, Alkhamis MH, Almujalli DM & Al Ahmed KS (2004). Epidemiologic Study on Rift Valley Fever in the Southwest of Kingdom of Saudi Arabia. J. Sc. Tech., Vol. 5 (1), 110-119.

4. Elfadil AA, Hasab-Allah KA, Dafa-Allah OM & Elmanea AA (2006). The persistence of Rift Valley fever in the Jazan region of Saudi Arabia. Rev. sci. tech. Off. int. Epiz., 25 (3), 1131-1136.

5. Seufi AM & Galal FH (2010). Role of Culex and Anopheles mosquito species as potential vectors of rift valley fever virus in Sudan outbreak, 2007. BMC Infectious Diseases 10:65http://www.biomedcentral.com/1471-2334/10/65

6. Ndiaye E, Fall G, Gaye A, Ndeye Sakha Bob NS, Talla C, Diagne CT, Diallo D, Yamar BA, IbrahimaDia I, Kohl A, Sall AA & Diallo M (2016). Vector competence of Aedes vexans (Meigen), Culex poicilipes (Theobald) and Cx. quinquefasciatus Say from Senegal for West and East African lineages of Rift Valley fever virus. Parasites & Vectors 9:94 DOI 10.1186/s13071-016-1383-y

7. Lwande OW, Paul GO, Chiyo PI, Eliud Ng'ang'a, Otieno V, Obanda V & Evander M. (2015). Spatio-temporal variation in prevalence of Rift Valley fever: a post-epidemic serum survey in cattle and wildlife in Kenya. Infection Ecology & Epidemiology, Dec. 2015.

8. Hartman, A. (2017). Rift valley fever. Clinics in Laboratory Medicine. 37(2), 285-301. [Full text but PDF not available at https://www-clinicalkey-com.proxy.library.emory.edu/#!/content/playContent/1-s2.0-S0272271217300069?returnurl=null&referrer=null]

9. Chevalier, V., M. Pepin, L. Plee, and R. Lancelot, 2010: Rift Valley fever – a threat for Europe? Euro. Surveill. 15, 1–11.

10. "RVF outbreak 2007/8 final report, 2008 FMOH.

11. Gerdes, G. H. (2004). Rift valley fever. Revue scientifique et technique-Office International des Epizooties, 23(2), 613-624.

12. Center for Food Security and Public Health. (2015). Rift Valley Fever: Infectious Enzootic Hepatitis of Sheep and Cattle. Retrieved from http://www.cfsph.iastate.edu/Factsheets/pdfs/rift_valley_fever.pdf

13. Ahmed A, Dietrich I, LaBeaud AD, Lindsay SW, Musa A, &Weaver SC. (2020). Risks and challenges of arboviral diseases in Sudan: The urgent need for actions. Viruses. Jan; 12(1):81.).

14. Sudan Federal Ministry of Animal Resource, Epidemic Control, information unit, Report 2010 - 2020

15. Outbreak maps Follow-up report No.: 4, Report reference: OIE Ref: 32800, Report Date: 31/12/2019, Country: Sudan"

16. "Sulieman AE, Dafallah FE, Abdel-Rahman EH &Alshammari NI et al. (2020). Isolation, Identification and Characterization of Salmonella spp. from Chicken purchased at Wad Madani City, Gezira State, Sudan. Adv. Life Sci. 8(1): 98-102.www.als-journal.com/ISSN 2310-5380/ November 2020

17. Mamoun IE, Khalafalla AI, Bakheit MR &Agab HA (1992) Salmonella Enteritidis in Sudan. Revue Elev Vet Med Pays Trop, 45(2), 137-138.

18. Elhussein AA, Nourelmadinah MM, Elsaid SM, Sidig MA, et al. (2010). Prevalence of Salmonellaa enterica subspecies enterica Serovars in Khartoum State, Sudan. Research Journal of Microbiology, 1-8.

19. Shereen AM, Marin P, Kankya C, Mugasa CM, Nasinyama G &Jubara A (2017). Prevalence and antibiotic susceptibility of salmonella at the human-chicken interface in Wau, South Sudan. Sch J Agric Vet Sci; 4(4):146-154. http://saspjournals.com/sjavs.

20. Fadlalla IM, Hamid ME, Ahmed G. Abdel Rahim AG & Ibrahim MT (2012). Antimicrobial susceptibility of Salmonella serotypes isolated from human and animals in Sudan. Journal of Public Health and Epidemiology. Vol. 4(1), 19-23. Available online at http://www.academicjournals.org/jphe DOI: 10.5897/JPHE11.143

21. Tadesse G, Mitiku H, Teklemariam Z &Marami D (2019). Salmonella and Shigella Among Asymptomatic Street Food Vendors in the Dire Dawa city, Eastern Ethiopia: Prevalence, Antimicrobial Susceptibility Pattern, and Associated Factors. Environmental Health InsightsVolume 13: 1–8. DOI: 10.1177/1178630219853581.

22. Kassaye BK, Hassen SJ, Leja KA &BiniamTsegaye B (2015). Study on Prevalence and Distribution of Salmonella Isolates from Apparently Healthy Sheep and Goats Slaughtered at Addis Ababa Abattoir Enterprise, Ethiopia. J Veterinar Sci Technol 6: 268. doi: 10.4172/2157-7579.1000268

23. EL Hussein, A.A., Nor Elmadiena, M. M.A., Elsaid, S.M and Siddig, M.A.M.(2010).Prevalence of Salmonella enterica subspecies enterica Serovars in Khartoum State, Sudan. Research Journal of Microbiology, 5(10):966-973

24. CFSPH. (2013, January). Ehrlichiosis and Anaplasmosis: Zoonotic Species. Retrieved from http://www.cfsph.iastate.edu/Factsheets/pdfs/ehrlichiosis.pdf.

25. Amir S, Hadi A & Gunnar S (2015). Microbial aetiology of acute diarrhoea in children under five years of age in Khartoum, Sudan, Journal of Medical Microbiology 64, 432–437

26. "Eldigail MH, Abubaker HA, Khalid FA, Abdallah TM, et al. (2020). Recent transmission of dengue virus and associated risk Factors among residents of Kassala state, eastern Sudan. Public Health 20:530 https://doi.org/10.1186/s12889-020-08656-y

27. WHO, Weekly Epidemiological Monitor, Volume 10; Issue no 49; 03 December 2017

28. Soghaier MA, Mahmood SF, Pasha O, Azam SI, et al. (2013). Dengue fever in a border state between Sudan and Republic of South Sudan: Epidemiological perspectives. Journal of Public Health and Epidemiology, Vol. 5(8), 319-324, DOI: 10.5897/JPHE2013.0533

29. Elaagip AE, Alsedig K, Altahir O, Ageep T, et al. (2020). Seroprevalence and associated risk factors of Dengue fever in Kassala state, eastern Sudan. PLOS Neglected Tropical Diseases. https://doi.org/10.1371/journal.pntd .0008918

30. WHO, Disease outbreak news, 22 November 2019

31. Hussen MO, Sayed ASM & Abushahba MFN (2020). Sero-epidemiological study on Dengue fever virus in humans and camels at Upper Egypt. Veterinary World, EISSN: 2231-0916, Available at www.veterinaryworld.org/Vol.13/December-2020/6.pdf

32. Usman A, Ball JD, Rojas DP, Berhane A, Ghebrat Y, et al. (2016). Dengue fever outbreaks in Eritrea, 2005–2015: A case for strengthening surveillance, control and reporting. Glob. Health Res. Policy, 1, 17

33. De thoisy B, Dussart, P, Kazanji M. (2004). Wild terrestrial rain forest mammals as potential reservoirs for flaviviruses (yellow fever, dengue 2 and St Louis encephalitis viruses) in French Guiana. Royal Society of Tropical Medicine and Hygiene. 98: 409-412.

34. WHO.(2017). Global, regional, and national age-sex specific mortality for 264 causes of death, 1980–2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet. 16(390): 1151–1210

35. Federal Ministry of Health, Emergency & Epidemic Control - DF outbreak 2019-20 final report, 2020

36. https://reliefweb.int/report/sudan/outbreak-update-dengue-sudan-17-december-2019

37. Vasilakis N, Cardosa J, Hanley KA, Holmes EC & Weaver SC (2012). Fever from the forest: prospects for the continued emergence of sylvatic dengue virus and its impact on public health. Published in final e"Johnson N,
38. McElhinney LM, Ali YH, Saeed IK & Fooks AR (2004). Molecular epidemiology of canid rabies in Sudan: evidence for a common origin of rabies with Ethiopia. Virus Res, 104 (2): 201-5. doi: 10.1016/j.virusres.2004.04.006.

39. Hameid OA (1991). Rabies in Sudan: an epidemiological review. Vet Rec, 28(3): 61-2. doi: 10.1136/vr.128.3.61.

40. Ali YH, Saeeed I, Wigdan HA & Ali EB. (2006). Epidemiology of Rabies in Sudan. Jour of Anim Vet Advances, 5 (3), 266-270.

41. Johnson N, Mansfield KL, DA, Marston DA, WilsonT, Goddard T, Selden D, Hemson G, Edea L, van Kesteren F, Shiferaw F, Stewart AE, SilleroZubiri, Fooks AR (2010). A new outbreak of rabies in rare Ethiopian wolves (Canis simensis). Arch Virol 155:1175–1177. DOI 10.1007/s00705-010-0689-x.

42. Ngugi JN, Maza AK, Omolo OJ &Obonyo M (2018). Epidemiology and surveillance of human animal-bite injuries and rabies post-exposure prophylaxis, in selected counties in Kenya, 2011–2016. BMC Public Health 18:996. https://doi.org/10.1186/s12889-018-5888-5.

43. Deressa A, Ali A, Beyene M, Selassie BN,Yimer E, Hussen K, Deressa A, Ali A, Beyene M, Selassie BN, Yimer E, Hussen K (2018). The status of rabies in Ethiopia: A retrospective record review.Ethiop. J. Health Dev, 24(2), 128-132.

44. Jemberu WT, Molla W, Almaw G, Alemu S (2013). Incidence of Rabies in Humans and Domestic Animals and People's Awareness in North Gondar Zone, Ethiopia. PLoSNegl Trop Dis 7(5): e2216. doi:10.1371/journal.pntd.0002216

45. Dzikwi A A, Kuzmin I I, Umoh J U, Kwaga J K, Ahmad A A, & Rupprecht C E (2010). Evidence of Lagos bat virus circulation among Nigerian fruit bats. J. Wildl. Dis. 46:267–271

46. Hayman D T, Fooks A R, Horton D, Suu-Ire, R, Breed A C, Cunningham A A, & Wood J L (2008). Antibodies against Lagos bat virus in megachiroptera from West Africa. Emerg. Infect. Dis. 14:926–928.

47. Kuzmin I V, Niezgoda M, Franka R, Agwanda B, Markotter W, Beagley J C, Urazova O Y, Breiman R F, & Rupprecht C E (2008b). Lagos bat virus in Kenya. J. Clin. Microbiol. 46:1451–1461

48. Hampson K, Coudeville L, Lembo T, Sambo M, Kieffer A, Attlan M, Barrat J, Blanton JD, Briggs DJ, Cleaveland S & Costa P. (2015). Estimating the global burden of endemic canine rabies. PLoS neglected tropical diseases. Apr 16; 9(4):e0003709.

49. Jemberu WT, Molla W, Almaw G & Alemu S. (2013). Incidence of Rabies in Humans and Domestic Animals and People's Awareness in North Gondar Zone, Ethiopia. Rupprecht CE, ed. PLoS Neglected Tropical Diseases.; 7(5):e2216. doi:10.1371/journal.pntd.0002216.]

50. Ali Y. (2002). Outbreak of rabies in South Darfur, Sudan. Article in The Veterinary record, June 2002 DOI: 10.1136/vr.150.19.610 Source: PubMed"dited form as: Nat Rev Microbiol. ; 9(7): 532–541. doi:10.1038/nrmicro2595"

51. "Badri AM & Mohamed SG (2018). Sero-Prevalence and Molecular Detection of Brucellosis among Febrile

Patients in West Darfur State, Sudan. Mol Biol 7: 204. doi:10.4172/2168-9547.1000204

52. Gaafar NA, Ismaeel AA, Elduma AH, Saeed ES & Hamid ME. (2013). Seroprevalence of Brucellosis among people in contact with livestock in suburban Khartoum, Sudan. Ann Trop Med Public Health.

53. Gorish BMT, Othman AES & Basheir SMEK (2020). Seroprevelance of Brucella Species Antibodies in Blood Samples of Cows in Some Farms of Khartoum State, 2019. J Clin Virol Res, 2020;1:03.

54. Zein El abdin S, Elnour Angara T, Elfadil AAM , El Sanousi EM & Ibrahim AM (2014). Prevalence and Risk Factors of Ruminants Brucellosis in Jabel Aolia Locality, Sudan. Sudan University of Science and Technology.

55. Mohamed, EGS, Elfadil AAM & El Sanousi EM (2015). Epidemiological Study of Brucellosis in Camels (Camelus dromedarius) in Khartoum State, Sudan. Inter J Vet Sci, 4(1): 39-43. www.ijvets.com

56. Mohamed EM, Elfadil AAM, El-Sanousi EM, Ibrahaem HH, Mohamed-Noor SE, Abdalla MA & Shuaib YA (2018). Seroprevalence and risk factors of caprine brucellosis in Khartoum state, Sudan, Veterinary World, 11(4): 511-518.

57. Shuaib YA, Mansour ME, Ibrahaem HH, Mohamed-Noor SE, Boukhari MI, Issa MH, El-Sanousi EM, Suliman SE, El-Fadil AAM & Abdalla MA (2018). Sero-prevalence of sheep brucellosis in three different locations in Kassala state. J Dairy Vet Anim Res. 7(2):53–57.

58. Ericfevre KM, Charleswaisma MCE, Michael Thrusfeild & Welburn SC (2011). Herd prevalence of bovine burcellosis and analysis of risk factors in cattle in urban and preurban area of kampala economic zone, Uganda, BioMed central 1746-6148/60

59. Musa MT (2005). Brucellosis in Some Wildlife in Darfur States, Sudan. The Sudan J .Vet. Res. , 20: 69-71

60. Elzer, P.H., Smith, J., Roffe, T., Kreeger, T., Edward, J. & Davis D (2002). Evaluation of brucella abortus strain RB51 and Strain19 in Pronghorn antelope, Ann NY Acad. Sci., 969:102-105

61. Sohn AH, Probert WS, Glaser CA, Gupta N, Bollen AW, Wong JD, Grace EM & McDonald WC. (2003). Human neurobrucellosis with intracerebral granuloma caused by a marine mammal Brucella spp. Emerg Infect Dis. 9(4):485–488

62. McDonald WL, Jamaludin R, Mackereth G, Hansen M, Humphrey S, Short P, Taylor T, Swingler J, Dawson CE, Whatmore AM, et al. (2006). Characterization of a Brucella sp. strain as a marine-mammal type despite isolation from a patient with spinal osteomyelitis in New Zealand. J Clin Microbiol. 44(12):4363–4370.

63. Scholz HC, Hubalek Z, Sedlacek I, Vergnaud G, Tomaso H, Al Dahouk S, Melzer F, Kampfer P, Neubauer H, Cloeckaert A, et al. (2008). Brucella microti sp. nov., isolated from the common vole Microtus arvalis. Int J Syst Evol Microbiol. 58(Pt 2):375–382.

64. Godfroid J (2002). Brucellosis in wildlife. Revue Suisse de Zoologie. Rev Sci Tech Off Int Epiz; 21: 27786

65. Massey PD, Polkinghorne BG, Durrheim DN, Lower T, Speare R (2011). Blood, guts and knife cuts: reducing the risk of swine brucellosis in feral pig hunters in north-west New South Wales, Australia. Rural Remote Health; 11: 1793.

66. Muma JB, Lund A, Siamudaala VM, Munang'andu HM, Munyeme M, Matope G, et al. (2010). Serosurvey of Brucella spp infection in the kafue lechwe (kobus leche kafuensis) of the kafue flats in Zambia. J Wildlife Dis; 46: 10639

67. Dean, AS, Crump L, Greter H, et al. (2012). Global burden of human brucellosis: A systematic review of disease frequency. PLoS Neglected Tropical Diseases, 6(10), e1865. doi:10.1371/ journal. pntd.0001865

68. Tadesse G (2016) Brucellosis Seropositivity in Animals and Humans in Ethiopia:A Meta-analysis. PLoSNegl Trop Dis 10(10):e0005006.doi:10.1371/journal.pntd.0005006"

69. Bower HD, El Karsany M, Alzain M, Gannon B, et. al. (2019). Detection of Crimean-Congo Haemorrhagic Fever cases in a severe undifferentiated febrile illness outbreak in the Federal Republic of Sudan: A retrospective epidemiological and diagnostic cohort study. PLoSNegl Trop Dis 13(7): e0007571. https://doi.org/10.1371/journal.pntd.0007571.

70. Rahden P, Adam A, Mika A & Jassoy C (2019). Elevated Human Crimean–Congo Hemorrhagic Fever Virus Seroprevalence in Khashm El Girba, Eastern Sudan. Am. J. Trop. Med. Hyg., 100(6), 1549–1551. doi:10.4269/ajtmh.18-0977.

71. Suliman HM, Adam IA, Saeed SI, Abdelaziz SA, Haroun EM & Aradaib IE (2017). Crimean Congo hemorrhagic fever among the one-humped camel (Camelus dromedaries) in Central Sudan. Virology Journal, 14:147. DOI 10.1186/s12985-017-0816-3

72. Adam IA, Mahmoud MAM &Aradaib IE (2013). A seroepidemiological survey of Crimean Congo hemorrhagic fever among Cattle in North Kordufan State, Sudan. Virology Journal, 10:178. http://www.virologyj.com/content/10/1/178

73. Sang R, Lutomiah J, Koka H, Makio A, Chepkorir E, et. al. (2011). Crimean-Congo Hemorrhagic Fever Virus in Hyalommid Ticks, Northeastern Kenya. Emerging Infectious Diseases, www.cdc.gov/eid, Vol. 17, No. 8, 1502-1505.

74. Ergönül, Ö. (2006). Crimean-Congo hemorrhagic fever. Lancet Infectious Diseases. https://doi.org/10.1016/S1473-3099(06)70435-2

75. Spengler J R, Bergeron É, & Rollin P E (2016). Seroepidemiological Studies of Crimean-Congo Hemorrhagic Fever Virus in Domestic and Wild Animals. PLoS Neglected Tropical Diseases. https://doi.org/10.1371/journal.pntd.0004210

76. Swanepoel R, Struthers J, Shepherd A, McGillivray G, Nel N & Jupp P (1983). Crimean-Congo hemorrhagic fever in South Africa. Am. J. Trop. Med. Hyg. 32(6), 1407e1415. PMID: 6418019

77. Estrada-Pena A, Palomar AM, Santib ~ anez, P, S ~ anchez, N, Habela MA & Portillo A (2010). Crimean-Congo hemorrhagic fever virus in ticks, Southwestern Europe, Emerg. Infect. Dis. 18 (1), 179e180. http://dx.doi.org/10.3201/eid1801.111040. PMID: 22261502

78. Aslam S, Latif M, Daud M, Rahman Z, Tabassum B, Riaz M, & Husnain, T. (2015). Crimean Congo hemorrhagic fever: Risk factors and control measures for the infection abatement (Review). Biomedical Reports. https://doi.org/10.3892/br. 2015.545

79. El-Azazy OME & Scrimgeour EM (1997). Crimean-Congo haemorrhagic fever virus infection in the Western Province of Saudi Arabia. Trans. R. Soc. Trop. Med. Hyg., 91, 275–278.)

80. "Mohammed E, Elhag WI, Mohammed AB (2018). Serofrequency of Avian Influenza Virus (H5N1) Among Poultry Farms Workers in Khartoum-Sudan. International Journal of Innovative Science and Research Technology. Volume 3, Issue 1, 497-501.

81. Ali W. Ali H, Kheir SAM & Ballal A (2007). Serological Survey of Type A Avian Influenza Antibody in Chicken Sera in Sudan Using Indirect ELISA. Research Journal of Animal and Veterinary Sciences, 2: 12-14.

82. Wegdan HA, Intisar KS, Shaza MM, Algezoli OA, et al. (2016). Investigation on Influenza Virus A Infection in Different Animals in Sudan. Sudan Journal of Science and Technology. vol. 17 No. 2, 57-64.

83. Fadel HM & Afifi R (2017). Investigation of avian influenza infection in wild birds in Ismailia and Damietta cities, Egypt, Veterinary World, 10(6): 695-701. doi: 10.14202/vetworld.2017.695-701

84. OIE. (2017). OIE Situation Report for Avian Influenza, (March), 1–8. Retrieved from

http://www.oie.int/fileadmin/Home/eng/Animal_Health_in_the_World/docs/pdf/OIE_AI_situation_report/OIE_SitRep_Avian_Influenza_Report_4_2017.pdf

85. Twabela AT, Tshilenge GM, Sakoda Y, Okamatsu, M, et al. (2018,). Highly Pathogenic Avian Influenza A (H5N8) Virus, Democratic Republic of the Congo, 2017. Emerg. Infect. Dis. 24, 1371–1374

86. Ofula VO, Franklin AB, Root JJ, Sullivan HJ, Gichuki P, Makio A, et al. (2013). Detection of Avian Influenza Viruses in Wild Waterbirds in the Rift Valley of Kenya Using Fecal Sampling. Vector-Borne Zoonoses, 13, 394–400.

87. Simulundu E, Ishii A, Igarashi M, Mweene AS, et al. (2011). Characterization of influenza A viruses isolated from wild waterfowl in Zambia. J. Gen. Virol., 92, 1416–1427.

88. WHO. (2017a). Influenza (Seasonal). Retrieved January 29, 2018, from http://www.who.int/mediacentre/factsheets/fs211/en/

89. http://www.cidrap.umn.edu/news-perspective/2013/01/study-puts-global-2009-pandemic-h1n1- infection-rate-24

90. WHO. (2017b). Influenza (Avian and other zoonotic). Retrieved January 29, 2018, from http://www.who.int/mediacentre/factsheets/avian_influenza/en

91. Sudan Federal Ministry of Health, Emergency & Epidemic Control-HV 2019- 2020 final report, 2020.

92. Sudan Federal Ministry of Animal Resource, Epidemic Control, information unit, Reports 2010-2020.

93. Twabela AT, Tshilenge GM, Sakoda Y, Okamatsu M, et al. (2018). Highly Pathogenic Avian Influenza A(H5N8) Virus, Democratic Republic of the Congo, 2017, Emerging Infectious Diseases • www.cdc.gov/eid • Vol. 24, No. 7, July 2018

94. Boccia D, Guthmann J-P, Hilde KlovstadH, Hamid N, et al. (2006). High Mortality Associated with an Outbreak of Hepatitis E among Displaced Persons in Darfur, Sudan. Clinical Infectious Diseases; 42:1679–84.

95. Rayis DA, Jumaa AM, Gasim GI, Karsany MS & Adam I (2013). An outbreak of hepatitis E and high maternal mortality at Port Sudan, Eastern Sudan. Pathogens and Global Health, VOL. 107 NO. 2.

96. Azman AS. Bouhenia M, Iyer AS, Rumunu J, et al. (2017). High Hepatitis E Seroprevalence among Displaced Persons in South Sudan. Am. J. Trop. Med. Hyg., 96(6), 1296–1301.doi:10.4269/ajtmh.16-0620.

97. Abebe M, Ali I, Ayele S, Overbo J, et al. (2017). Seroprevalence and risk factors of Hepatitis E Virus infection among pregnant women in Addis Ababa, Ethiopia. PLoS ONE 12(6): e0180078. https://doi.org/10.1371/journal.

98. Modiyinji AFM, Bigna JJ, KenmoeS, Simo FBN, et al. (2021). Epidemiology of hepatitis E virus infection in animals in Africa: a systematic review and meta-analysis. BMC Veterinary Research,17:50.
99. https://doi.org/10.1186/s12917-021-02749-5.

100. Katagwa M, Ssemadaali MA, Tumwine G, Majalija S & Mugisha L. (2017). Seroprevalence of Hepatitis E virus in slaughter pigs and practices of abattoir workers in Kampala, Uganda. The Pan African Medical Journal,

101. Mahrous H; Redi N; Nguyen N; Al Awaidi S; Mostafavi E, Samhouri D. One Health operational framework for action for the Eastern Mediterranean Region, focusing on zoonotic diseases. East Mediterr Health J. 2020;26(6):720–725. https://doi.org/10.26719/emhj.20.017

102. All photos are from Sudanese Photographer Facebook group with permission

Photo (11) Birds in Blue Nile Khartoum

The End