 doi:10.20944/preprints202009.0453.v1

One Health Landscape in Sub-Saharan African Countries

Folorunso O. Fasina[1], Olubunmi G. Fasanmi[2], Yilma Makonnen[3], Charles Bebay[4], Bernard Bett[3], Kristina Roesel[3]

1 Emergency Centre for Transboundary Animal Diseases (ECTAD), Food and Agriculture Organization of the United Nations (FAO), Dar es Salaam, United Republic of Tanzania & Department of Veterinary Tropical Diseases, University of Pretoria, Onderstepoort, South Africa

2 Department of Veterinary Laboratory Technology, Federal College of Animal Health & Production Technology, Ibadan, Oyo State, Nigeria.

3 FAO Sub-Regional Office for Eastern Africa, Food and Agriculture Organization of the United Nations, Addis Ababa, Ethiopia

4 Emergency Centre for Transboundary Animal Diseases (ECTAD), Food and Agriculture Organization of the United Nations (FAO), Nairobi, Kenya

5 International Livestock Research Institute, Nairobi, Kenya &ILRI/BMZ One Health Research, Education, Outreach and Awareness Centre (OHRECA), Kenya.

Suggested journal: BMJ Global Health.

Keywords: one Health; Africa; public health; animal health; environment health; zoonosis; emerging and re-emerging diseases; food safety; antimicrobial resistance; toxicosis.

Corresponding author

Email: Folorunso.fasina@fao.org; Tel.: +255 686132852 (FO Fasina)

Abstract: 298 words

Manuscript: 4,993 words.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 19 September 2020 doi:10.20944/preprints202009.0453.v1

Abstract

An evaluation of emerging issues in One Health (OH) in Sub-Saharan Africa was undertaken to map the existing OH initiatives in Sub-Saharan African (SSA) countries. Desk review, expert opinions survey, limited interviews and wider consultations with selected OH stakeholders were conducted. The strengths, weaknesses, opportunities and threats to OH initiatives were identified. OH influence, interest and impacts were evaluated. One Health is transiting from multidisciplinary to transdisciplinary concepts and OH viewpoint should move from 'proxy for zoonoses', to include issues of climate change, nutrition and food safety, social sciences, geography, policy and planning, economics, welfare and well-being, antimicrobial resistance (AMR), vector-borne diseases, toxicosis and pesticides issues. While the identified major strengths should be boosted, the weaknesses should be addressed.

OH Networks in SSA were spatially and temporally spread across SSA and stakeholders were classified as key, latent, marginal and OH defenders. Imbalance in stakeholders' representation led to hesitation in buying-in from stakeholders who are outside the main networks. Theory of change, monitoring and evaluation frameworks, and tools to standardized evaluation of OH policies is needed for sustained future of OH and the future OH engagement should be outputs and outcomes-driven and not activity-driven.

National roadmap for OH implementation and institutionalization is necessary and proofs of concepts in OH should be verified and scaled-up. Dependence on external funding is unsustainable and must be addressed. Necessary policy and legal instrument to support OH nationally and sub-nationally should be implemented taking cognizance of contemporary issues like urbanization, endemic poverty and other emerging issues. Utilizing current technologies and OH approach to address ongoing pandemic of COVID-19 and other emerging diseases is desirable. Finally, OH implementation should be anticipatory and not reactive to significantly benefit budgeting and contain disease outbreaks in animal sources before the risk of spillover to human can be envisaged.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 19 September 2020 doi:10.20944/preprints202009.0453.v1

INTRODUCTION

One Health (OH) is the collaborative effort of multiple disciplines working locally, nationally, and globally, to attain optimal health for people, animals and the environment[1,2]. Incontestably, humans coexist with animals in a complex, yet interdependent relationship. These relationships present opportunities to share resources and diseases that influence public, animal and environment health as well as human socio-economic well-being[3]. To achieve the goals of OH and address potential or existing global and transnational health risks, OH-related policies and solutions should be systematic, coordinated, collaborative, multidisciplinary and cross-sectoral in outlooks[4,5]. Identified health risks associated with known interfaces include: diseases (zoonotic[6,7], emerging & re-emerging[8], vector-borne), toxicosis, climate change and pesticides[4,9,10] among others.

Notably, OH has gained tractions in the past two decades. The rapid adoption of One Health concepts globally has resulted in more than 100 OH networks, with some 24 initiatives previously reported from Africa[11]. Currently, the major foci of OH platforms are coordination, organization, collaboration, communication, capacity building, information sharing, tool development and joint research[11] (appendix 1). However, a standardized evaluation tool for OH policies at all levels needs to be developed.

The detailed history of One Health has been described[12,13] (Table 1) and the ongoing COVID-19 pandemic is likely to profoundly influence the broader adoption of OH concepts. A critical but concise analysis of the COVID-19 pandemic suggests that numerous OH-related concepts and policies are being promoted. First, the ecological perspective on the virus originally established a conundrum among the human-bat-pangolin and live bird market in Wuhan, China[14-18]. Secondly, the approach to manage COVID-19 pandemic was primarily discipline-centric (public health) and disaggregated by geographies (China, Iran, Italy, etc.), a situation where a country's infection is seen as the country's problem alone. For instance, the advent of COVID-19 pandemic was seen as a health problem limited to the People's Republic of China, and little attention was paid to it by many policy makers globally. However, as of 23rd August 2020, at least 216 countries/territories have been affected with at least 23,057,288 cases in humans and 800,906 deaths[19]. Undoubtedly, the response to COVID-19 pandemic should be inter-disciplinary, trans-disciplinary and multi-sectoral. To address unprecedented challenges like COVID-19 and future public health events and emergencies, such One Health approach is needed. In the current work, we explore the OH landscape across Sub-Saharan African (SSA) countries using multi-method approach and report our findings.

MATERIAL AND METHODS

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 19 September 2020 doi:10.20944/preprints202009.0453.v1

Definition of the study area and Development of a questionnaire and an online survey

In this study, SSA geographically refers to an area in the African continent, south of the Sahara comprising of 46 member States of the African Union (Figure 1)[20]. A questionnaire was developed and validated by three experts to capture essential data and key inputs on One Health activities and initiatives, influence, interest, impacts and view that motivate One Health in Africa. It was pretested among 7 professionals from the field of public and animal health. The questionnaire has structured questions with a Likert-scale scoring (scale of 1 – 5) for One Health Interest, One Health Influence and One Health Policy Power, the likely impact of organizations on One Health (low-moderate-high), identified One Health stakeholders, and the total numbers of stakeholders influenced by each organization. It also consisted of semi-structured questions including 1) perceived weakest link to successful OH implementation, and 2) area of best investment in OH. The questionnaire is available online (https://www.surveymonkey.com/r/M66QTTF), or in paper copies where online data cannot be accessed.

One Health Interest is defined as the passion and commitment of an organization/person in ensuring that systematic and continued collaborative, multi-sectoral, and transdisciplinary approach is utilized between multiple disciplines/sectors to deliver OH activities at all levels. One Health Influence is the individual's organization spheres of power to significantly impact on One Health-related decisions implemented locally or nationally. One Health Policy Power relates to organizational ability to influence investments, laws, rules and regulations that ultimately shapes and governs the way people and organizations act and interact between each other and with the government to "address complex challenges that threaten human and animal health, food security, poverty and the environments"[21].

Desk Review of literature and Expert opinion Survey

Available peer-reviewed and grey literature on OH in SSA were reviewed. Specifically, all available information on OH-related to SSA was searched for in two global peer databases (Google Scholar and PubMed) using the relevant search terms related to or closely aligned with OH (appendix 2). Also, the strengths, weaknesses, opportunities and threats to OH (SWOT) were extracted from various reports. These details were used to validate opinions gathered through questionnaire survey and stakeholders' interviews, and used to map all identified OH initiatives per sub-region.

Using the developed questionnaire, a total of 57 participants/experts were interviewed through snowball sampling method until no new theme/issue was mentioned. Using the. Responses were obtained from individuals and groups of professionals from various African countries and fields such

as: public health, animal health, environment health, wildlife experts, etc. Selected experts may/may not reside in Africa but have worked in the field of One Health in Africa.

Statistical analysis

Data were processed in Microsoft Excel version 2013 (Microsoft Corporation, Redmond, WA, USA). Descriptive statistics were performed to measure central tendency or variability of the data. Mean, median, mode and standard deviations were generated for all values using online statistical tool, OpenEpi (https://www.openepi.com/Mean/CIMean.htm). Pairwise correlation was conducted in Stata version 9 (StataCorp LLC, College Station, TX, USA). Using the One Health Interest and Influence scores, the One Health Quadrant map was produced to categorize all identified stakeholders into key, latent and marginal stakeholders and One Health defenders. For spatial mapping of One Health initiative in SSA, verified data were submitted to the Geographic Information System (GIS) laboratory, Institute of Resource Assessment (IRA), University of Dar es Salaam.

Results

A total of 145 One Health initiatives were identified across SSA and these were broadly classified as listed in appendix 1. East Africa has significantly more One Health initiatives/activities (n = 101) compared with other sub-regions: Southern Africa (n = 85), Central Africa (n = 65) and West Africa (n = 64) (Figure 2). These initiatives were national, regional, continental or global and many of the initiatives cut across more than one sub-regions. Coordination, duplication and effective monitoring and evaluation of platforms appeared to be a major challenge among the different initiatives.

Fifty-five (55) organizations or professional groupings were identified with relevant OH agenda including those with high, moderate or low impact on One Health using the self-rated scores (Table 2). Additionally, the stakeholders and professionals grouped into major One Health quadrants (key stakeholders, latent stakeholders, marginal stakeholders and defenders of One Health initiatives; Figure 3). Among the key stakeholders are the global/continental public and animal health authorities (WHO, FAO, ILRI, AFROHUN, ACDC), programmes (FELTP/ISAVET), national ministries responsible for public and animal health and the local government authorities (Figure 3). The medical and veterinary regulatory boards, state, county and provincial authorities, and other ministries were identified as latent stakeholders. Marginal stakeholders include the policy makers, the law enforcers, public and

private human and veterinary laboratories, and the local non-governmental organization among others (Figure 3). The livestock farmers, poultry farmers and breeders, national emergency management authorities and the medicine control councils are among the One Health defenders. Using pairwise correlation of interest, influence and power-policy, only the interest and influence scores have good correlation (correlation score = 0.71, $p < 0.0001$) but policy-power was poorly correlated with interest (correlation score = 0.17, $p = 0.27$) and influence (correlation score = 0.18, $p = 0.25$).

Misconceptions, gaps and issues in One Health (OH)

Constant dynamics and events occur in One Health and new issues continue to emerge as other fields adopt OH strategies. These rapid evolutions and transformations in the fields and disciplines utilizing OH, has led to some misconceptions about OH[11,22]. It is perceived by a school of thought as a single discipline, whereas it is a concept implemented through an interdisciplinary approach. Furthermore, the concept is not species- or discipline-specific but an approach that should be developed in components and contextually, to fit into each and every topic, while its applications should be modified to fit into changing scenarios, as the need arise[23,24].

The majority of the identified OH Networks globally are academic (78%) or government bodies (22%) and approximately a third of them have narrow perspectives (human-animal health issues only)[11,25]. It is important to see OH issues beyond the prism of human-animal health and, instead, to include all sectors and stakeholders in the planning and implementation that utilizes OH approach. This reductionist view and imbalance in stakeholders' representation often translate into narrow perspectives in addressing OH issues and the lack of buying in from other stakeholders during implementation.

In SSA, the One Health Networks collaborate less; it does not usually involve the clearly defined theory of change and to date, the monitoring and evaluation (M&E) frameworks for OH issues are non-existent globally[11]. This gross lack of a clear framework for M&E will likely result in lack of direction and the conduct of many One Health activities without key outputs and outcomes in mind. Despite the efforts in the areas identified in appendix 1 to date, the OH concept has mileages to gain in the areas of joint surveillance and monitoring, disease controls, emergency interventions, disaster interventions and recoveries among others.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 19 September 2020 doi:10.20944/preprints202009.0453.v1

Developments in One Health Initiatives in Sub-Saharan African and the funding mechanisms

One health concept is quite suitable and adaptable to SSA as it can facilitate cross-sectoral, cross-disciplinary engagement and produce outcomes at cheaper costs[26,27]. However, the funding for most (> 90%) of the One Health initiatives across Africa has originated largely from outside the continent with some partial co-funding from national governments. Although there were at least 24 One Health Networks previously identified in Africa, many of the networks and institutions involved in One Health in Africa have their headquarters based in Europe or America with the exception of ILRI and SACIDS[11,28]. With rapid development of more OH initiatives, some relatively new and upcoming institutions are taking roots in Africa, although without a sustained funding system (Appendix 1).

Selected Examples of One Health Initiatives in Sub-Saharan African

While One Health initiatives are spread across SSA, selected examples of One Health implementation are highlighted below:

1. The Coordinating Office for the Control of Trypanosomiasis in Uganda (COCTU) is a OH initiatives with documentary evidence in Africa. The COCTU has been implementing joint Human African Trypanosomiasis (HAT), animal trypanosomiasis and Glossina species (tsetse fly) control in Uganda for almost three decades[29]. Despite the milestones and achievements, it continues to face financial challenges for its sustainability. Its name and associated perceptions also challenged its operation in other areas and fields, e.g. vector-borne disease like Rift Valley fever (RVF).

2. Kenya established a multi-sectoral committee to develop preparedness planning and efforts at mitigating the potential introduction and spread of HPAI H5N1 in Kenya. This body also responded to an outbreak of RVF in the Eastern Africa Region during 2006–2007[30]. This coordinated efforts between the Ministry of Health (MoH) and Ministry of Agriculture, Livestock, and Fisheries (MALF), joint coordination and communication, built human capacity especially through the Field Epidemiology and Laboratory Training program (FELTP) and other sustained collaboration with other US programmes led to the development of a fully functional BSL-3 laboratory at KEMRI and the formation of a national One Health coordinating office, the Zoonotic Disease Unit (ZDU) in 2012[30,31].

3. On December 12, 2005, the Federal Government anticipatorily inaugurated a Technical Committee of Experts for the prevention and control of HPAI H5N1 outbreak in Nigeria. By February 8, 2006, the first case of HPAI H5N1 in poultry in Africa was reported, the national government rapidly set up a National Inter-Ministerial Steering Committee on Avian Influenza (NISCAI) and the National Technical Committee on Avian Influenza (NTCAI). This Technical Committee coordinated and implemented

emergency action plan and strategy proposed for the prevention and control of the outbreak[32]. However, these bodies faded away with the elimination of the HPAI H5N1 in Nigeria and did not get institutionalized[29]. Also, the FELTP programme has since kick-started in October 2008 and is facilitating joint human-animal-environment and laboratory-field joint investigations and interventions[33].

4. The rabies intervention in Tanzania has benefitted from multiple partnership, academic programmes and research interventions. The wildlife ecosystems of Serengeti, Selous and few others have benefitted from funding from the Bill and Melinda Gates Foundation (BMGF) for a rabies elimination programme in Tanzania covering 23 high-risk districts[29]. The research group from the University of Glasgow and GARC had delivered several rabies interventions both in Tanzania's Mainland and the Islands of Zanzibar using OH approach[34-41]. Using innovative OH approach involving practitioners and students of One Health, FAO had partnered with the government of Tanzania to deliver rabies control in Moshi, Kilimanjaro Region[27,42]. The challenges with project-based deliveries remain the sustainability, national ownership and resource limitations[29].

5. Currently, the Food and Agriculture Organization through the Global Health Security Agenda's Zoonotic Diseases and Animal Health in Africa (GHSA-ZDAH) funded by the United States Agency for International Development (USAID) has been supporting many One Health interventions through policy documents, control strategies, protocols, evaluations, national veterinary laboratories strengthening, epidemio-surveillance capacity building, workforce development and AMR. These activities are expected to continue into the foreseeable future.

In terms of observed weakest links, 27 themes were identified ranging from issues with weak collaborations and coordination, inadequate human and material resources, lack of decentralization to subnational levels, limited data, data concealment, inadequate representation of some sectors and misconceptions about OH among others (Table 3). For areas of best investment in OH in SSA in order to promote OH implementation, the following were identified areas: strengthening intersectoral and multidisciplinary collaborations, building national and subnational capacities in One Health, investment in research and software for reporting and interoperability, joint outbreak response, support for decentralization of OH office at national-subnational levels, support for setting up One Health champions and stakeholders committees at national-subnational levels, financing of One Health interdisciplinary and transdisciplinary research, support for the development of MoUs and legal document, establishment of specific undergraduate/postgraduate track of training in OH, and sensitization on OH at community levels (Table 3). Importantly, the weakest link for OH implementation in Africa as well as the future foci and plans, should resources be made available for

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 19 September 2020 doi:10.20944/preprints202009.0453.v1

implementation will need a more qualitative evaluation. This opportunity should be used to avoid pitfalls that have delimited the success of previous OH efforts (Table 3).

Strengths, weaknesses, opportunities and threats (SWOT) Analysis

One Health has made a lot of inroads in SSA. It has also been impacted by certain enablers and hindrances. While the summary are available below, details are tabulated in Appendix 3. The summarized gaps observed in OH implementation in Africa include but are not limited to the following:

1. Information sharing, communication and collaborations among the various sectors of One Health is very poor among disciplines and sectors. No stakeholder should be left in the fringe of participation. Challenges must be evaluated comprehensively and all necessary stakeholders must be brought in as active players in interdisciplinary engagement for problem assessment, stakeholder mapping and in the design and implementation of OH solutions.

2. Proliferation of data and multiple platforms for information capturing that are mostly multichotomous. This largely emanated from the data capture systems created differently for each sector without a consideration for other field. Quality data must be accessible and verifiable from a centralized source and reporting formats.

3. Preparedness and response to disease outbreaks, emergency interventions, disaster interventions and recoveries, policy development, community engagement and M&E for OH initiatives are dissimilar across African countries or are inexistent in some countries, especially those without external assistance to develop such intervention. Where these are available, they are often not tested or evaluated through drills, simulations and after action reviews.

4. Lack of institutional development and adequate human resource as well as lack of OH capacity building in the different sectors. Usually, in most Sub-African countries, public health capacities are ahead of the animal health and environment health capacities. These dissimilarities have often serve as barriers to harmonized interventions between sectors.

5. Duplication of roles and efforts among sectors serve as hindrance to effective implementation of OH initiatives and effective participation of government ministries. Having a centralized and harmonized multi-sectoral platform will promote interdisciplinary facilitation of one healthiness in addressing AMR, surveillance and other issues in SSA.

6. Many ministries and government departments and parastatals are understaffed. Majority of the personnel though may also be qualified in their professional disciplines, are not always competent or

skilled enough in the utilization of OH approach, and where they are competent, they may lack the wherewithal to perform/implement OH effectively.

7. The greater majority of the OH stakeholders continue to depend on external funding and sponsorships. Although the government may dedicate some budget to OH issues, there is paucity of national sponsorship and partnership in the field of OH. Also, over-reliance on technical assistance and subject matter experts/specialists from international organizations and foreign countries can become a limitation and create dependency.

8. Absence of or deficiency of regulations, policy documents, legal instruments and memorandum of understanding on the involvement of vertical and horizontal engagements is a weakness.

9. Quality laboratory services which is an essential component of healthcare system remains weak due to several factors. Most national laboratories do not meet the accreditation standards under the quality management system, capacities are limited, skills are not regularly updated and laboratory diagnostic facilities are limited or unavailable to deliver efficient and prompt diagnosis, particularly, during emergencies and in outbreak situations. This is particularly so, in the subnational systems of low to lower-middle income and conflict-impacted countries in SSA[43,44]. Furthermore, regional and sub-regional-level reference laboratories that should support national efforts are often not available.

10. Cross-border OH initiatives and efforts have been launched in many border areas across Africa, and are largely championed by continental or regional economic commissions (RECs) like the AU, AU-IBAR, ACDC, ECOWAS, WAEMU, MRU, ECCAS, CEMAC, COMESA, IGAD, AMU, EAC, SADC, SACU etc., the follow-up actions and implementation of outcomes arising from the reforms have often suffered neglect because of lack of interests, differences in country-level policies and lack of political will. These sub-regional and regional-led efforts can be utilized to promote OH and both national and subnational system can take advantage of these bodies to implement national-level One Health initiatives.

11. Since the ministries implement their activities based on dedicated and gazetted budget lines, and because OH is a relatively new concept compared to traditional public, animal and environment health implementation frameworks, as well as the policy and socio-economic environments, OH platforms often have none to insufficient allocations to actualize approved OH activities. Currently, the donor-funded OH budget is unsustainable because with the donors, future funding environment may be inconsistent and uncertain. Necessary legal and policy instrument for prioritizing national funding for planning and implementation of OH initiatives must be created.

12. There are no systemic disease surveillance system; but if present, the communication and information exchange among the systems and the reporting channels is less than desirable.

13. While selected African countries have functional One Health platforms, sometimes, the lack of subnational platforms hinders OH coordination. Moreso, most subnational governmental systems in Africa have limited competencies and subject matter expertise in the workforce to implement OH approach and integrate multi-sectoral work. While formulation and coordination as well as legal backing often take place at the national level, field implementation resides with the subnational system. Therefore, the subnational system should be carried along in the national OH platform.

14. With multiple OH initiatives in SSA, there is a need to set up and formalize joint coordination mechanisms and plan of action for all activities and issues needing OH intervention.

15. The set-up costs, as well as the cost of acquisition, implementation and maintenance of ICT infrastructure and modern technologies to support OH are usually high and untenable in most SSA. Lamentably, the back-up infrastructure like electricity is inconsistent in several countries to support technologies.

16. Some countries face economic and socio-political instabilities/insecurities etc. In such countries, prioritizing OH initiative is hardly given any consideration because of limited access to service delivery and lack of resources even though those populations may be more vulnerable to disease events.

17. Innovative approach at co-delivering OH in the veterinary, medical, public health, socio-economics, policy and anthropology schools appears lacking. Teaching workforce capacities and focused curriculum need to improve using partner like the Africa One Health University Network (AFROHUN) formerly One Health Central and Eastern Africa (OHCEA).

18. Currently, the private practitioners outside of the main government systems contribute minimally or do not contribute to and participate in OH initiatives. Stimulus to facilitate inclusion of private stakeholders should be implemented by national OH champions.

19. Presently, policymakers at the national and subnational levels of governments have a somewhat poor understanding of and are not familiar with concepts of OH. Enlightenment on OH should be done for these cadres for purposes of advocacy and adequate information. This should address the issue of low prioritization and poor funding of One Health initiatives.

20. To date, most OH initiatives and networks in SSA have kick-started as a fall-out of project or sporadic sequel of single of few OH activities. In these situations, the governance and management structure may not have been thought through and the existing government policies, legal documents, SOPs and strategies may not have been thoroughly considered before the implementation of national One Health platforms. Where this is the case, a review of the foundational basis for the national One

Health platforms is necessary to fix outstanding issues in order to have broad based support and gain political goodwill of all OH stakeholders.

21. Operational research (OR) in OH is lacking largely. There is a need to implement OR that considers trans-disciplinary/interdisciplinary engagements and activities. Such initiative must be based on real-life problem and not abstract. Additionally, the inclusion of outcome-based engagement that utilizes monitoring and evaluation as basis for OH programme design is warranted.

22. Inadequate inclusion of the ecosystem health dimension in the OH platform left gaps in effectively addressing some underlying drivers of disease emergence such as deforestation, change in agricultural practices, etc.)

Comprehensive reports on the summaries above are available in peer-reviewed repositories and national documents[4,28,29,43-46].

**ACDC = African Centers for Disease Control and Prevention; AMU = Arab Maghreb Union; AU IBAR = African Union Inter-African Bureau for Animal Resources; CEMAC = Economic and Monetary Community of Central Africa; CILSS = Permanent Inter-State Committee for Drought Control in the Sahel; COMESA = Common Market for Eastern and Southern Africa; ECOWAS = Economic Community of West African States; IGAD = Inter-Governmental Authority on Development; MRU = Mano River Union; SADC = South African Development Community; SACU = South African Customs Union; WAEMU = West African Economic and Monetary Union*.

Discussion

To date, inter-ministerial and interdisciplinary protection of mandates and inadvertent but underlying turf wars remain a main challenge for the effective take-off of OH in Africa. Ministries and government departments will need to consider issues of OH as beyond territorial protection and open-up to other disciplines/sectors in order to jointly deliver cost-effective solutions. Evidence abounds to show that zoonotic diseases and threats of potential epidemics can facilitate national and regional emergence of OH initiatives[29], and professionals must learn to utilize such OH opportunities to deliver services. Clear national-subnational roadmap should be developed in the delivery of OH concept taking cognizance of previous pitfalls for sustenance and set-back associated with initiatives implemented to date[29]. Such intervention is possible and has been exemplified with PMP and national rabies control strategies[47,48].

National OH platforms will continually suffer setbacks, deliver externally-programmed outcomes and risk unsustainability if the dependence on donor-funding ocntinues[11,29]. The necessary policy and legal instrument should be put in place per country, regionally and continentally in order to facilitate the

push towards full implementation of OH in SSA. Connolly[49] had earlier discussed the OH in the context of urbanization and global disease threats, and emphasized that OH implementation is possible in Africa and elsewhere if strong mutuality of commitment to OH agenda at the supranational (global and continental) and micro (national and subnational, including individual) levels is assured. Of particular interest is the poverty intermixes and peri-urban/rural development, these are important interfaces where intense human-animal-environment interactions are occurring. Also, these locations typically have poor service deliveries, poor sanitation, high human and animal population densities, poor living standards and huge social inequalities[49]. National and subnational authorities should concentrate on improving local capacities and implementing infrastructural developments that align with OH objectives and facilitate its implementation at local levels. Such intervention may be blended with the identification of local and national champions who can serve as launching pads to deliver OH concepts[11,29].

Human capacity development at local level and integrating the concepts of OH at all levels of informal and formal trainings – right from primary up to tertiary levels – as well as in periods of in-service trainings will assist in ingraining the concept of OH - an example of sub-tertiary OH concept is already in parts of North America where curricula are in place for facilitating OH approach at primary and secondary levels of education.

Africa has been considered as hotspot for various emerging infectious diseases and future global pandemic threats particularly because of its forested tropical regions, land-use changes, socio-economic changes and wildlife biodiversity[50-53]. Besides, OH can deliver the most efficient and cost effective policies for disease prevention; policy interventions; environmental friendly consideration and socio-politically-adapted management. From the African perspective, three reasons why OH remains a viable solution for SSA have been identified including the following: 1) Africa has burden of infectious and zoonotic diseases at the interfaces coupled with growing food insecurity, threatened livelihoods and endemic poverty; these portend threats to national and continental economic growth; 2) The growing convergence of technology and strategy in surveillance, prevention and management for diseases can be leveraged using One Health approach ; 3) The best intervention remains those that are regional-led and all-inclusive[54]. This is the strongest detection, prevention and defense mechanism that can be built against emerging threats posed by those drivers of bio-threats identified above[55].

The future of OH institutionalization will be dependent upon removing barriers associated with reductionist viewpoints. There is a need to consider comprehensive broad-based OH in all instances during service deliveries. Policy makers, politicians, communication experts, socio-economists, social scientists and other fields cannot be considered as necessary only during the implementation and

post-mortem analysis of OH issues. They should be included right through the whole of OH approach, right from the planning to execution.

Conclusion

The national ministries and subnational authorities, relevant in the One Health context in SSA should consider the development of country's own OH database. The education system should consider prioritizing and integrating key OH concept in the Primary and Secondary schools' education curricula. Interdisciplinary problem solving – approach including documentation and regular brainstorming should be engaged at all levels. Emphasis should be placed on the 'whole-of-society-approach' and social organizations; single viewpoint approach will never comprehensively solve any problem. In typical dogma, a solution is chosen first before consideration for the problem. However, in science, effort should be made to first identify and analyze the problem before the proposition of solution, and this should be followed-up by permanently re-evaluating, deconstructing and reconstructing the proposed solutions. Finally, it should be known that OH is not targeted at one single final solution but a set of solutions which need regular reviews and re-evaluation.

Recommendations

In the current scenario of 1) rapidly spreading infectious diseases like the ongoing COVID-19 and past highly pathogenic avian influenza H5N1 among others, and in view of 2) available technologies (Skype, Microsoft Teams, Zoom, Google Hangouts etc.), and 3) limited resources available in Africa to facilitate travels, gathering and conferencing, online collaborative meetings may be utilized to facilitate, strengthen and make functional OH-related meetings. Such virtual platforms and networks of individuals from different background can be used to share diverse perspectives on each single topic[55]. Such multiple sources of information should enable the reconsideration and re-evaluation of line discipline's positions and ideologies. It makes for opportunities to positively push boundaries of understanding beyond one's own confines of expertise and facilitates contributions from persons with diverse knowledge, whose voice may have been drowned in physical meetings.

Also, OH mode of delivery should be through the problem-based discussion forum or problem-based learning method[56]. The evaluation of complex health problems and delivery of people-oriented solutions using the multi-prong approach of health, geography, communication, policy, financing and other fields should be the goal of each OH approach[23,27]. Such discussion should transcend all political, ethnic, religious and other primordial considerations.

Regular reviews and re-curriculation of tertiary institution programmes to perpetually strengthen the concept of OH and facilitate cross-learning outcomes should be adopted across Africa. Furthermore, all trainings should incorporate cross-disciplinary delivery of research outcomes. Online and physical training module and joint classes can be used to facilitate commitments, collaborations and synergies among students and professionals in order to push the frontiers of trans-disciplinary networks. Importantly, the adoption of elements of inter-disciplinary training at junior levels of education (primary and secondary schools) should be implemented. The implementation of these recommendations should assist in remodeling current workforce and in producing future professionals who are trans-disciplinary in thinking and approach.

The WHO, FAO and OIE, as well as the United Nations Environment Programme (UNEP) are working together to facilitate cross-sectoral collaboration at global level in order to manage multiple issues at the human-animal-environment interface to improve global health security[57]. The regional and national authorities in SSA should adopt this type of joint working relationship and collaboration to 1) foster cross-sectoral collaboration at the human-animal-environment interface among the different relevant sectors; 2) develop capacity and promote practical, evidence-based, and cost-effective implementation of tools and mechanisms for all One Health activities and issues, and assisting countries in their implementation; and 3) support the development of relevant policies, strategies and sustainable programmes to prevent and reduce risks and manage outbreaks[57].

A list of key terms and acronyms used in the manuscript are available in appendix 2. The questionnaire is also available in MS word version as supplementary material.

One Health Research, Education, Outreach and Awareness Centre (OHRECA) is available in the following link: https://www.ilri.org/research/facilities/one-health-centre.

Acknowledgements

This report is an output from the desk review and survey conducted across the continent to map the existing One Health Initiatives in SSAn countries and regions. We acknowledged the intense contributions and review provided by Prof Ariel L. Rivas and inputs of Dr. Irene Lukassowitz. The International Livestock Research Institute (ILRI), Kenya & Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (The Federal Ministry of Economic Cooperation and Development), Germany, as well as the Management of the One Health Research, Education, Outreach and Awareness Centre (OHRECA) are thanked for sponsorship of this work. Elias Ponsiano assisted in the production of One Health Quadrant map and Folorunso Fatai Adisa did some editorial review.

References

1. AVMA, 2020. One Health — a New Professional Imperative. Available at: https://www.avma.org/news/reports/one-health-summary. Accessed 23 April 2020.
2. CDC. One Health, 2020. Available at: https://www.cdc.gov/onehealth/index.html. Accessed 23 April 2020.
3. World Health Organization (WHO). Zoonoses: Managing public health risks at the human-Animal-environment interface, 2020a. Available at: https://www.who.int/zoonoses/en/. Accessed 26 April 2020
4. Kimani T, Kiambi S, Eckford S, *et al*. Expanding Beyond Zoonoses: The Benefits of a National One Health Coordination Mechanism to Address Antimicrobial Resistance and Other Shared Health Threats at the Human-Animal-Environment Interface in Kenya. *Rev Sci Tech.* 2019; 38(1): 155-171, DOI:10.20506/rst.38.1.2950.
5. Yasobant S, Patel K, Saxena D. Hastening One health collaboration in Gujarat, India: A SWOT analysis. *J Public Health Policy Plann.* 2019; 3(2):22-24. https://www.alliedacademies.org/articles/hastening-one-health-collaboration-in-gujarat-india-a-swot-analysis-11538.html
6. Salyer SJ, Silver R, Simone K, *et al*. Prioritizing Zoonoses for Global Health Capacity Building-Themes from One Health Zoonotic Disease Workshops in 7 Countries, 2014-2016. *Emerg Infect Dis*. 2017;23(13):S55-S64. doi:10.3201/eid2313.170418 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5711306/
7. Elelu N, Ayedun JO, Mohammed IG, *et al.* Neglected zoonotic diseases in Nigeria: role of the public health veterinarian. *Pan Afr Medical J*. 2019; 32:36.10.11604/pamj.2019.32.36.15659 https://www.panafrican-med-journal.com/content/article/32/36/pdf/36.pdf
8. Muzemil A, Fasanmi OG, Fasina FO. African perspectives: modern complexities of emerging, re-emerging, and endemic zoonoses. *J. global health* 2018; 8(2), 020310. https://doi.org/10.7189/johg.08.020310
9. World Health Organization (WHO). Lead Exposure in African Children: Contemporary Sources and Concerns, 2015. Available at: https://apps.who.int/iris/bitstream/handle/10665/200168/9780869707876.pdf;jsessionid=C12F889544BC4A9B147D43D134A8B4E0?sequence=1. Accessed 04 April 2020.
10. CDC. Lead Poisoning Investigation in Northern Nigeria, 2016a. Available at: https://www.cdc.gov/onehealth/in-action/lead-poisoning.html. Accessed 04 April 2020.
11. Khan MS, Rothman-Ostrow P, Spenser J, *et al*. The growth and strategic functioning of One Health networks: a systematic analysis. *Lancet Planet Hlth* 2018; 2: e264–73.https://reader.elsevier.com/reader/sd/pii/S2542519618300846?token=73207B52741FF46A7C6717539D1C3182AC21140B7C26CA2A0DC574B80B869B20AD04F8FC712E88E56904393200EBFC88
12. Bresalier M, Cassidy A, Woods A. In: One Health: The Theory and Practice of Integrated Health Approaches, 2015. (Zinsstag J, Schelling E, Waltner-Toews D, Whittaker M, Tanner M, Eds.), CAB International, Wallingford, UK, pp 1-15.
13. Killewo J. Wicked Health Problems and the One Health Approach in Tanzania, 2019. Professorial Public Lecture Series October 2019, Muhimbili University of Health and Allied Sciences, Tanzania, 45p.

14. Bonilla-Aldana DK, Dhama K, *et al*. Revisiting the One Health Approach in the Context of COVID-19: A look into the Ecology of this Emerging Disease. *Adv. Anim. Vet. Sci.* 2020; 8(3): 234-237, http://dx.doi.org/10.17582/journal.aavs/2020/8.3.234.237
15. Zhang T, Wu Q, Zhang Z. (2020). Probable Pangolin Origin of SARS-CoV-2 Associated With the COVID-19 Outbreak. Curr Biol, 6;30(7):1346-1351.e2. doi: 10.1016/j.cub.2020.03.022.
16. Zhang T, Wu Q, Zhang Z. Probable Pangolin Origin of SARS-CoV-2 Associated With the COVID-19 Outbreak. *Curr Biol*. 2020; 30(8):1578. doi: 10.1016/j.cub.2020.03.063.
17. El Zowalaty ME, Järhult JD. From SARS to COVID-19: A previously unknown SARS-CoV-2 virus of pandemic potential infecting humans–Call for a One Health approach. *One Hlth*. 2020; 9: 100124, https://doi.org/10.1016/j.onehlt.2020.100124
18. Rothan HA, Byrareddy SN. The epidemiology and pathogenesis of coronavirus disease (COVID-19) outbreak. *J Autoimmunity*, 202; 109: 102433, https://doi.org/10.1016/j.jaut.2020.102433.
19. World Health Organization (WHO). WHO Coronavirus Disease (COVID-19) Dashboard. Available at: https://covid19.who.int/. Accessed 23 August 2020.
20. United Nations. Map of Africa indicating areas covered by SSA 2020. https://unstats.un.org/unsd/mi/africa.htm. Accessed 20.04.2020.
21. FAO. One Health, 2011: Food and Agriculture Organization of the United Nations Strategic Action Plan. Rome, FAO. Available at: http://www.fao.org/3/al868e/al868e00.pdf. Accessed 08 August 2020.
22. Manlove KR, Walker JG, Craft ME, *et al*. "One Health" or Three? Publication Silos Among the One Health Disciplines. PLoS Biol. 2016; 14(4): e1002448. https://doi.org/10.1371/journal.pbio.1002448.
23. Little A. One Health: From theory to practice. *Canadian Vet J*. 2012; 53: 435–436.
24. Rüegg SR, Nielsen LR, Buttigieg SC, *et al*. A Systems Approach to Evaluate One Health Initiatives. *Front. Vet. Sci*. 2018; https://doi.org/10.3389/fvets.2018.00023.
25. Essack SY. Environment: the neglected component of the One Health triad. Lancet Planetary Hlth, 2018; 2:e264, https://doi.org/10.1016/S2542-5196(18)30124-4.
26. Rwego IB, Babalobi OO, Musotsi P, *et al*. One Health capacity building in SSA. *Infect Ecol Epidemiol*. 2016; 6:34032. doi:10.3402/iee.v6.34032 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5131459/
27. Fasina FO, Mtui-Malamsha N, Mahiti G, *et al*. Where and When to Vaccinate? Interdisciplinary Design and Evaluation of the 2018 Tanzanian Anti-Rabies Campaign: Biogeography-based Vaccination Planning. *Int J Infect Dis*., 2020;S1201-9712(20)30169-7. https://doi.org/10.1016/j.ijid.2020.03.037.
28. Onyango D, Fascendini M, Wieland B, *et al*. One health policy context of Ethiopia, Somalia and Kenya: One Health Units for Humans, Environment, Animals and Livelihoods (HEAL) Project, 2019 . Nairobi, Kenya: ILRI. Available at: https://www.ilri.org/publications/one-health-policy-context-ethiopia-somalia-and-kenya-one-health-units-humans. Accessed on 23 April 2020.
29. Okello AL, Bardosh K, Smith J, Welburn SC. One Health: Past Successes and Future Challenges in Three African Contexts. *PLoS Negl Trop Dis*. 2014; 8(5): e2884. https://doi.org/10.1371/journal.pntd.0002884
30. Munyua PM, Njenga MK, Osoro EM, *et al*. Successes and challenges of the One Health approach in Kenya over the last decade. *BMC Pub. Hlth.* 2019; 19: 465. https://doi.org/10.1186/s12889-019-6772-7.
31. Mbabu M, Njeru I, File S. Establishing a One Health office in Kenya. *Pan Afr Med J*. 2014; 19:106. doi: 10.11604/pamj.2014.19.106.4588.

32. World Bank. Responses to Avian and Human Influenza Threats (January-June): Progress, Analysis, and Recommendations. Washington, DC: World Bank 2006. http://siteresources.worldbank.org/EXTAVIANFLU/Resources/3124440-1172616490974/UNSIC_Report_Vienna_June2006.pdf
33. Nguku P, Oyemakinde A, Sabitu K, *et al*. Training and service in public health, Nigeria Field Epidemiology and Laboratory Training, 2008 - 2014. *The Pan Afr med J.* 2014; l: 18 Suppl 1(Suppl 1), 2. https://doi.org/10.11694/pamj.supp.2014.18.1.4930.
34. Cleaveland S, Fevre EM, Kaare M, *et al*. Estimating human rabies mortality in the United Republic of Tanzania from dog bite injuries. *Bull World Health Organ*. 2002; 80:304–10. doi:10.1590/S0042-96862002000400009
35. Sambo M, Cleaveland S, Ferguson H, *et al*. The Burden of Rabies in Tanzania and Its Impact on Local Communities. *PLoS Negl Trop Dis*. 2013; 7(11): e2510. https://doi.org/10.1371/journal.pntd.0002510.
36. Lushasi KS, Cleaveland S, Changalucha JJ, *et al*. Progress towards rabies elimination from Pemba Island, Southern Tanzania. Online Journal of Public Health Informatics, 2017.http://ojphi.org, 9(1):e118, 2017
37. Mpolya EA, Lembo T, Lushasi K, *et al*. Toward Elimination of Dog-Mediated Human Rabies: Experiences from Implementing a Large-scale Demonstration Project in Southern Tanzania. *Front. Vet. Sci*. 2017; 4:21. doi: 10.3389/fvets.2017.00021.
38. Sambo M, Johnson PCD, Hotopp K, *et al.* Comparing Methods of Assessing Dog Rabies Vaccination Coverage in Rural and Urban Communities in Tanzania. *Front. Vet. Sci.* 2017; 4:33. doi: 10.3389/fvets.2017.00033.
39. Sambo M, Hampson K, Changalucha J, *et al*. Estimating the Size of Dog Populations in Tanzania to Inform Rabies Control. *Vet. Sci.* 2018; 5(3), 77; https://doi.org/10.3390/vetsci5030077
40. Changalucha J, Steenson R, Grieve E, *et al*. The Need to Improve Access to Rabies Post-Exposure Vaccines: Lessons from Tanzania. *Vaccine*, 2019; 37(Suppl 1):A45-A53. doi: 10.1016/j.vaccine.2018.08.086.
41. Coetzer A, Scott TP, Noor K, *et al*. A Novel Integrated and Labile eHealth System for Monitoring Dog Rabies Vaccination Campaigns. *Vaccines*, 2019; 7:108; doi:10.3390/vaccines7030108
42. Mtui-Malamsha N, Sallu R, Mahiti GR, *et al*. Ecological and Epidemiological Findings Associated with Zoonotic Rabies Outbreaks and Control in Moshi, Tanzania, 2017–2018. *Int. J. Environ. Res. Public Health* 2019, *16*(16), 2816; https://doi.org/10.3390/ijerph16162816.
43. Sallu R, Ponsiano E, Masambu J*, et al* (unpublished). Systematic Assessment of National Public and Private Veterinary Laboratory System in Tanzania using FAO Laboratory Mapping Tool-Core module. Manuscript prepared for journal submission, 2020.
44. Mesfin EA, Taye B, Belay G, *et al*. Factors Affecting Quality of Laboratory Services in Public and Private Health Facilities in Addis Ababa, Ethiopia. EJIFCC, 2017; 28(3): 205–223.
45. Queenan K, Garnier J, Nielsen LR, *et al*. Roadmap to a One Health Agenda 2030. CAB Reviews Perspectives in Agriculture Veterinary Science Nutrition and Natural Resources. 2017; 12, No. 014., https://www.cabi.org/cabreviews/FullTextPDF/2017/20173134856.pdf
46. World Bank (Berthe, FCJ, Bouley, T, Karesh, WB, *et al*.). Operational framework for strengthening human, animal and environmental public health systems at their interface (English). Washington, D.C. World Bank Group, 2018. Available at: http://documents.worldbank.org/curated/en/703711517234402168/Operational-

framework-for-strengthening-human-animal-and-environmental-public-health-systems-at-their-interface. Accessed 01 May 2020.

47. FAO (2020). FAO Progressive Management Pathway for Antimicrobial Resistance (FAO-PMP-AMR). Available at: http://www.fao.org/antimicrobial-resistance/resources/tools/fao-pmp-amr/en/. Accessed 04 May 2020.
48. OIE. The Progressive Management Pathway for Aquaculture Biosecurity (PMP/AB) – A New Initiative, 2019. OIE Global Conference on Aquatic Animal Health, Santiago, Chile, 2-6 April, 2019. Available at: https://www.oie.int/aquatic-conference2019/wp-content/uploads/2019/04/6.ArniMathiesen_presentation_FINAL-_020419.pdf. Accessed 15 July 2020.
49. Conolly C, Keil R, Ali SH. Extended urbanisation and the spatialities of infectious disease: Demographic change, infrastructure and governance. *Urban Studies*. 2020. https://journals.sagepub.com/doi/pdf/10.1177/0042098020910873
50. Jones KE, Patel N, Levy M, *et al*. Global trends in emerging infectious diseases. *Nature*. 2008; 451: 990–94.
51. Morse SS, Mazet JAK, Woolhouse M, *et al*. Prediction and prevention of the next pandemic zoonosis. *Lancet*. 2012; 380: 1956-1965.
52. Moore M, Gelfield B, Okuogbe A, *et al*. Identifying future disease hot spots: Infectious disease vulnerability index, 2016. Rand Corporation. Available at: https://www.rand.org/pubs/research_reports/RR1605.html. Accessed 03 May 2020.
53. Allen T, Murray KA, Zambrana-Torrelio C, *et al*. Global hotspots and correlates of emerging zoonotic diseases. *Nature Comm.* 2017; 8:1124, |DOI: 10.1038/s41467-017-00923-8.
54. African Forestry and Wildlife Commission. Forests and Wildlife: Africa's diversity for shared prosperity and security. Report On FAO Activities In Response To The Recommendations of The 21st Session of The African Forestry And Wildlife Commission, Skukuza, South Africa, 9-13 March, 2020.
55. Southern African Centre for Infectious Disease Surveillance (SACIDS). Value of One health approach, 2020. Available at: http://www.sacids.org/how-we-work/value-one-health-approaches/. Accessed 03 May 2020.
56. Tukamushaba E, Musinguzi D. Evaluation of Problem Based Learning as a Teaching and Learning Method in Social Sciences, 2016 (Chapter 13). In: Leaning Inquisitiveness (Blom, H., Ed). Stenden University of Applied Sciences, Qatar.
57. World Health Organization (WHO). Zoonoses: Managing public health risks at the human-Animal-environment interface, 2020a. Available at: https://www.who.int/zoonoses/en/. Accessed 26 April 2020.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 19 September 2020 doi:10.20944/preprints202009.0453.v1

Table 1. Chronological transition and major One Health initiatives*

S No.	Contributor(s)/ Organization(s)/Event(s) & timeline(s)	Contributions to One Health advancement
1.	Hippocrates (460 – 370 BCE)	Recognized the role of environmental factors and impact on human health [a.]
2.	Rudolf Virchow & William Osler (1821 – 1902)	Recognized the link between animal and human medicine, and coined the name 'zoonosis' [b.]
3.	James Steele (1947)	Veterinarian who was trained in public health who founded the Veterinary Public Health Division at the Centers for Disease Control and Prevention (CDC), in Atlanta, in 1947. His works contributed significantly to the understanding of the epidemiology of zoonotic diseases [b.]
4.	Calvin Schwabe (1927 – 2006)	A veterinarian trained in public health, coined the term One Medicine in a veterinary medical textbook in 1964 [b.]
5.	Wildlife Conservation Society (2004)	The twelve Manhattan Principles were created in Rockefeller University, New York. They showed the links between humans, animals, and the environment. Also showed how these integrate understanding disease dynamics, and the importance of interdisciplinary approaches to prevention, education, investment, and policy development [c.]
6.	American Veterinary Medical Association (2006)	Established One Health Initiative Task Force [d.]
7.	American Medical Association (2007)	Passed a One Health resolution to promote partnering between veterinary and human medical organizations. Recommended One Health approach for responses to global disease outbreaks [e.]
8.	International Ministerial Conference on Avian and Pandemic Influenza (2007)	Developed the One Health concept and strengthened linkages between the human and animal health systems especially for the pandemic preparedness and human security, New Delhi [e.]
9.	International Ministerial Conference on Avian and Pandemic Influenza in Egypt (2008)	Development of a framework titled 'Contributing to One World, One Health-A Strategic Framework for Reducing Risks of Infectious Diseases at the Animal-Human-Ecosystems Interface', with key recommendations for One Health approach to global health [e, f.]
10.	International Ministerial Conference on Avian and Pandemic Influenza (2008)	Adoption of the developed framework on 'Contributing to One World, One Health-A Strategic Framework for Reducing Risks of Infectious Diseases at the Animal-Human-Ecosystems Interface' at Sharm El Sheik [g.]
11.	FAO/OIE/WHO/UNSIC/ UNICEF/WB (2008)	Development of the implementable policies on One Health finalized in 2010 at the Stone Mountain, Georgia [e.]
12.	Centers for Disease Prevention and CDC (2009)	Establishment of a One Health Office to serve as a point of contact for external animal health organizations which would aim at procuring external funding. The office has since expanded its role to support public health, facilitate data exchange, implement zoonotic disease prioritization and enhance cross-disciplinary research across sectors
13.	USAID (2009)	Launching of the Emerging Pandemic Threats (EPT) program to ensure a coordinated comprehensive international effort to prevent, detect and respond to emergence of animal-origin diseases that could threaten human health.
14.	Public Health Agency of Canada (2009)	Held One World, One Health Expert Consultation meeting, Winnipeg, Canada
15.	International Ministerial Conference on Avian and Pandemic Influenza (2010)	Expansion of the above jointly-developed framework the organizations involved also developed implementable policies on One Health and the development of six workshops
16.	International Ministerial Conference on Avian and Pandemic Influenza (2010)	Adoption of the Hanoi Declaration (focused attention at the animal-human-ecosystem interface), Hanoi, Vietnam
17.	WB and UN (2010)	Joint release of the 'Fifth Global Progress Report on Animal and Pandemic Influenza'

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 19 September 2020 doi:10.20944/preprints202009.0453.v1

18.	EU (2011)	Published a report on 'Outcome and Impact Assessment of the Global Response to the Avian Influenza Crises: 2005 – 2010 ' [h.]
19.	1st international One Health Congress (2011)	Meeting was held in Melbourne, Australia [e, i.]
20.	The International Congress on Pathogens at the Human-Animal Interface (ICOPHAI) (2011, 2013, 2015, 2017, 2019)	To address important challenges and needs for capacity building in the field of One Health, an inaugural ICOPHAI congress was held at the United Nations Conference Center (UNCC) in Addis Ababa, Ethiopia, in 2011, followed by the 2nd in Porto de Galinhas, Brazil (2013), 3rd in Chiang-Mai, Thailand (2015) and 4th in Doha, Qatar (2017) and the 5th conference was held in Quebec, Canada.
21.	1st One Health Conference in Africa (2011)	Meeting was held in Johannesburg, South Africa [e, i.]
22.	High-Level Tripartite Technical meeting (2011)	Considered the Tripartite Concept Note and addressed health risks that occurred in the different geographic regions using three selected diseases and issue (rabies, influenza and antimicrobial resistance) as points of departure to build political will and engage Health Ministers on issues of One Health
23.	Global Risk Forum - One Health Summit (2012)	A policy and economic forum to advocate for One Health – One Planet – One Future [j.]
24.	Zoobiquity publication and Conferences (2012)	Published a book on the connection between human and animal health and, later, in reference to many interdisciplinary issues on humans and animals, followed by conferences held globally [k.]
25.	2nd International One Health Conference in collaboration with WHO/FAO/OIE (2013)	Meeting was held in Bangkok, Thailand [g.]
26.	International Conference on One Health (Africa)	Funded by USAID, OHCEA organized three meetings in Addis Ababa, Ethiopia (1st) and Kampala in Uganda (2nd and 3rd) from 2013 – 2019.
27.	International One Health Day	Set up in 2016 and held every November 3rd [l.]
28.	3rd international One Health Congress (2015)	Meeting was held in Amsterdam, The Netherlands.
29.	4th international One Health Congress (2016)	Meeting was held in Melbourne, Australia
30.	5th international One Health Congress (2018)	Meeting was held in Saskatoon, Canada
31.	6th World One Health Congress (2020)	Meeting will be held in Edinburgh, UK [m.]

**Note that the list is not exclusive as many One Health-related events are happening that may not have been formally captured.*

[a] Bresalier et al., 2015; [b] CDC, 2016b; [c] 29 September 2004 Symposium. www.oneworldonehealth.org; [d] AVMA, 2018; [e] Gibbs, 2014; [f] FAO/OIE/WHO/UNSIC/UNICEF/WB, 2008; [g] Killewo, 2019; [h] European Union, 2011; [i] Mackenzie & Jeggo, 2011; [j] GRF, 2020; [k] Natterson-Horowitz & Bowers, 2012; [l] OHC, 2020; [m] Osterhaus et al., 2020; https://icophai.org/about-icophai.

 doi:10.20944/preprints202009.0453.v1

Table 2. List of identified organizations and groupings, likely impact, Mean interest, Mean Influence and Policy power scores of One Health Initiatives& Policies.

Serial Number	Organizations & groupings	Likely impact on One Health initiatives (Low - Moderate - High)	Mean influence score (0 - 10)	Standard Deviation	Mean interest score (0 - 10)	Standard Deviation	One Health Policy Power Score (0 – 10)
1	National Livestock Marketing Councils	Moderate	6.3	1.7	6.6	2.5	6.4
2	National Livestock Producers Associations	Moderate	6.9	1.1	7.2	3.1	6.7
3	National Associations of Traders and Processors	Moderate	6.3	2.2	5.9	2.3	6.5
4	National Research Support Systems like NRF, ETF, COSTECH, ARC, others	Moderate	7.1	2.4	6.5	2.4	7.1
5	Veterinary, environmental and other field officers working in clinics, holding grounds, livestock markets and quarantine stations	High	7.5	1.8	7.3	1.7	6.9
6	Medical health care staff (clinics, hospitals)	High	8.1	1.9	7.7	2.0	2.0
7	General public	Moderate	6.2	2.7	6.2	2.8	6.0
8	Ministry responsible for Agriculture and Forestry	High	6.8	2.0	6.8	1.7	6.7
9	Ministry responsible for Livestock and Fisheries	High	9.3	1.7	7.8	1.7	8.0
10	Ministry responsible for Natural Resources and Tourism	High	7.3	2.1	7.8	1.8	6.9
11	Ministry responsible for Environment	High	7.4	1.7	7.3	1.8	7.2
12	National Environment Management Authority	High	7.0	1.9	7.6	2.1	7.2
13	Ministry responsible for Lands and Physical Planning	Moderate	8.0	2.2	7.0	2.0	7.0
14	Ministry responsible for Public Health	High	8.9	2.0	8.1	1.6	7.4
15	Agricultural & Veterinary Universities /Faculties/Colleges	Moderate	7.4	1.5	7.9	1.4	6.9
16	Medical & allied health Universities/Faculties/Colleges	Moderate	7.3	2.1	8.1	2.0	7.1
17	Agency/Directorate responsible for medicine control	High	7.3	1.6	7.7	1.6	7.0

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 19 September 2020 doi:10.20944/preprints202009.0453.v1

18	Development partners, funders & financial institutions (USAID, EU, UKAid, World Bank, others)	High	8.0	1.5	8.6	1.5	7.4
19	Public & private financial Institutions	Low	5.2	1.5	5.1	1.5	1.5
20	National Medical Research Institute	High	6.9	2.7	6.6	1.9	6.9
21	National Plant Health Inspectorate Service	Moderate	7.6	2.5	7.5	2.3	6.5
22	National Poultry Farmers & Breeders Association	Moderate	7.3	2.5	7.8	2.5	7.1
23	National Association of animal Feed Manufacturers	Moderate	8.1	1.6	8.0	1.1	7.1
24	African Union-IBAR	Moderate	7.5	2.4	7.9	1.9	7.4
25	Regional Livestock Development Agencies/Organization and Regional Economic Communities	High	8.0	1.6	7.3	1.5	6.8
26	Africa Centers for Diseases Control and Prevention	Moderate	7.6	2.3	8.2	1.6	7.4
27	National Medical Board	High	8.1	1.6	8.0	1.6	7.5
28	National Veterinary Board	High	7.3	2.4	7.8	1.8	7.2
29	Ministry responsible for Policy and Planning	High	7.8	1.7	7.5	1.9	6.6
30	National Bureau of Standards	Moderate	7.4	2.0	7.5	1.6	7.2
31	National Agricultural and Livestock Research Institute	High	8.0	1.5	7.6	1.6	7.7
32	Dairy Board	High	7.8	1.4	8.3	1.4	7.5
33	Livestock Meat & Food Board	High	8.4	1.0	8.0	1.6	7.3
34	Pharmacy Board	Moderate	7.8	1.8	8.5	1.3	7.7
35	Field Epidemiology & Laboratory Training Program (FELTP)/ In-Service Applied Veterinary Epidemiology	High	7.7	2.0	7.9	2.1	7.3
36	State/Province/County Authorities	High	7.5	2.2	7.6	2.0	7.9
37	Local Government/District Authorities	Moderate	8.3	1.5	8.5	1.3	7.8
38	World Organization for Animal Health	Moderate	7.5	2.0	8.3	1.2	7.5
39	International Livestock Research Institute	Moderate	7.7	2.2	8.2	1.5	7.2

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 19 September 2020 doi:10.20944/preprints202009.0453.v1

40	Wildlife Management & Research Institutions and Services	High	8.4	2.1	8.9	0.9	7.8
41	Food and Agriculture organization of the UN	Moderate	8.3	1.2	8.7	1.0	7.8
42	National Centers for Diseases Control and Prevention	High	8.5	1.3	8.7	0.9	7.8
43	Africa One Health University Network	Moderate	8.5	1.4	8.7	0.8	7.9
44	World Health Organization	High	8.5	1.5	8.9	0.7	7.9
45	Local NGO, CBO and FBOs	Moderate	5.7	1.8	5.7	1.4	6.3
46	Public and Private public and veterinary laboratories	High	8.2	1.1	8.0	1.7	6.5
47	US CDC	Moderate	8.5	1.3	8.7	0.9	7.8
48	Government Boards	Moderate-high	6.5	2.1	6.8	2.1	7.2
49	Law enforcers (police, military, customs)	Low-moderate	6.0	2.1	6.1	1.3	5.2
50	Input providers (Veterinary, medical, pharmaceuticals, chemicals, biologicals, feed & equipment	High	7.2	1.6	6.9	1.7	5.5
51	Meat inspectors	High	8.4	1.6	7.9	2.2	2.2
52	Media (print, electronic & social)	Moderate	7.3	1.8	7.7	1.8	1.8
53	Politicians/Policy makers	High	7.5	2.1	9.0	1.7	1.7
54	Environmental health officers & researchers	High	6.0	NA	6.0	NA	NA
55	Climate office & experts	High	6.0	NA	8.0	NA	NA

Correlation analysis of One Health Interest, Influence and Power-policy

S/no.	**Variable**	**Interest**	**Influence**	**Power-Policy**	
1.	**Interest**	1.0000			**Significant at < 0.0001*
2.	**Influence**	0.7138*	1.0000		
3.	**Power-Policy**	0.1725	0.1809	1.0000	

A total of 57 experts from the following fields responded to the questionnaire: global one health leaders, veterinarians, physicians, animal scientists, public health professionals/epidemiologists, butcher, infectious disease expert, aquaculture expert and animal health technician. Responses were provided through feedbacks online or in hard copies on paper. No physical meeting was engaged in view of the risk of COVID-19 infection.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 19 September 2020 doi:10.20944/preprints202009.0453.v1

Table 3. Common themes originating from selected One Health stakeholders on important questions on One Health initiatives.

S. No.	Observed weakest link in the Sub-Saharan African countries that have prevented or limit the successful implementation of One Health at local, national or regional level	Suggested area of best invest towards improving One Health implementation in the African countries
1.	Weak collaborations between the various sectors that should implement One Health. Unhealthy rivalry and competition amongst the various sectors of one health sometimes hamper developments in One Health. One Health integration among the various sectors of One Health is still somewhat weak. Reductionism.	Strengthening collaboration between the various sectors at national and subnational levels (see appendix 4 for example). This may also have regional ramifications.
2.	Inadequate human, material and financial resources from the government. There is oftentimes Inter-sectoral discrimination in funding and budget provisions among key disciplines hence the lack of funds to finance projects. The government could facilitate a Theory of Change process for different (One) Health problems and engage all sectors and disciplines in developing their roles and contribution in the big puzzle	Capacity building of the staff at central (national) and subnational level – on management, coordination, communication and resource mobilization. Such example include but is not limited to the HEAL curriculum.
3.	Decentralization of One Health activities to subnational level for implementation should be prioritized.	Invest in research and software development for easy reporting and collation of data in the field of One Health.
4.	Low level of One Health awareness among policy makers and the public on burden of zoonoses and benefits of One Health.	Developing strategies and guidelines for zoonoses and relevant One Health issues like antimicrobial resistance, toxins, environmental issues etc.
5.	There are limited data on burden of zoonoses and other One Health challenges to influence policy. Even where data from vital research outputs exist, sharing among the various One Health stakeholders and end users/beneficiaries may be problematic.	Mapping of One Health stakeholders/actors and activities implemented in the country.
6.	Relatively weaker wildlife sector compared to public and animal health.	Joint (inter-ministerial and intersectoral) field activities e.g. outbreak investigations.
7.	Cross-border implementation of One Health initiatives is always challenging in view of different policies, legislations, and uneven finance/sponsorship among countries that share borders. Ineffective cross-border One Health implementation.	Support advocacy on One Health approach and associated activities (including good practices documented so far) to ensure enhanced understanding among policy makers and actors. Promote One Health education among reputable political leaders.
8.	Coordination mechanism at both national and subnational levels is still weak and often non-committal. This is as a result of not having adequate staff fully committed to implementation of One Health activities.	Lobby for adequate number of qualified staff (experts in public health, animal health and environment health/metrological, GIS/data and information management specialist and risk communication expert) at the central coordination office to ensure implementation of the agreed work plan.
9.	Wildlife health is currently not well captured in the principles of One Health. The human medical and veterinary practitioners are sometimes at loggerheads for supremacy of disciplines	Utilize fund for human resource development and capacity building, especially for the professionals left behind in previous One health training so that they will be better positioned to perform optimally in the One Health initiatives.
10.	Poor representation of other fields like the animal scientists, biologist, other relevant biomedical and natural sciences, and social sciences and policy related fields in the One Health teams. Wildlife health and ecohealth are also still very deficient and left behind in One Health initiatives	Equipping the coordination office to facilitate data collection, processing and timely information sharing
11.	The career civil servants often want to take the forefront role in new initiatives like One Health without consideration for professional fits, hence the lack of competence and administrative lapses to lead the One Health team	The payment of ad-hoc staff to support substantive staff in ramping up capacity for One Health.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 19 September 2020 doi:10.20944/preprints202009.0453.v1

12.	Foreign partnership on One Health joint activities is dwindling and insufficient external funding is available.	Training on One Health through various means and innovations like online platforms, remotely accessed training, localised training initiatives, and nationally institutionalised training on resource mobilization and establishing global collaborations.
13.	Inferiority – superiority complexes among the various professionals and institutions. In some high-profile organizations and institutions, some persons see their role as more important than that of others. This mindset and insular attitude generate resistance to collaborate and refusal to give due credit to other productive groups/organizations with counterproductive consequences for noble One Health concept/approach	Assembling a team comprising various professional bodies and stakeholders like veterinarians, animal health technologists, epidemiologists, public health specialists, print and electronic media practitioners etc. to propagate the concept and importance of One Health in the representative local government areas in all the regions of the country. During this exercise data will be obtained simultaneously to ascertain the level of awareness of One Health concept in the country for future use.
14.	Concealment and denial of information and data among the various One Health stakeholders, hence the obvious inter-sectoral communication gap. Information and data sharing among sectors may also be met with some level of resistance or officially barred.	Form a team of different professionals across disciplines to start a large One Health national team, with subnational formats replicated at the secondary and tertiary levels of administration. The team will be expected to develop proposals and jointly implement different activities together including research, awareness creation, training and field implementation for different stakeholders.
15.	Misconceptions of One Health approach. Prevailing uni-disciplinary research and weak understanding of the essence of One Health. For example, public health clinicians still think largely of clinical approach, the veterinarians think of population medicine approach and the environmentalists and ecologists think of the environment and wildlife/habitat/ecosystem health primarily.	Carry out gap assessments to determine the core areas with obstacle for the development of One health initiatives in the country. This will be followed by the presentation of the positive impact of one health to the stakeholders in the country. The outcome will be presented to higher officials, policy makers and influencers for purpose of advocacy.
16.	Administrative challenges and inter-sectoral bureaucratic bottlenecks may sometimes make One Health impracticable. For example, some line ministries cannot pull funds together inter-ministerially to jointly implement activities	To finance researches that are related to public health, food-borne diseases, meat contamination, food preservation, food security, livestock genetic improvements, and evidence-based research.
17.	Undefined or not clearly defined roles, responsibilities and functions of the various stakeholders hence encroachments and duplication of functions and activities. Lack of policy framework and system that will enable the effective coordination of relevant stakeholder institutions.	To sponsor projects related to AMR and resistance gene transfer amongst human, animal and their environment.
18.	There is no unified database on One Health as the different sectors prefer their independence.	Construction of a good slaughterhouse, and proper remuneration of meat inspectors to showcase proof of concept.
19.	Poor advocacy to policy makers hence lack of One Health approaches at subnational levels.	Injection of fund into areas and projects starved of funds.
20.	Poor knowledge of relevant One Health initiatives among relevant stakeholders (the general public) as well as inadequate/archaic knowledge of concept roles, importance and contributions of One Health.	To attend workshops and relevant seminars that clearly put into perspectives enlightenment and acquisition of knowledge on One Health programs, initiatives and activities, as well as the establishment of Community of Practice (CoP)
21.	Prioritization of other emergency issues e.g. the ongoing COVID-19, Ebola, natural disasters etc.	Money will be used to prepare the MOU or legislation for partnership which clearly define the roles of every professional partaking in One Health activities. Such investment should focus on preventive rather than responsive outbreak response.
22.	The non-existent of relevant One Health policies and robust understanding of the topic by legislators and regulators.	Establishment of One Health administrative offices at subnational level for proper organization
23.	Poor monitoring and evaluation of One Health activities and initiatives.	Boosting capacities of different constituents of One Health and setting up necessary M & E to closely monitor progress.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 19 September 2020 doi:10.20944/preprints202009.0453.v1

24.	Endemic poverty prevents making informed One Health decisions	Investment into One Health Education and Curricula at University/College levels. Promote One Health approaches among undergraduate medical and veterinary students, in diploma colleges and or fund MSc projects utilizing One Health approaches. Such is also important at primary education level (e.g. teaching the concepts of good hygienic practices, how health of animals and humans and environment are interconnected) including the supportive training to teachers.
25.	Access to direct local funding to support research/implementation of One Health approaches are inconsistent. Most of the present One Health activities are donor-driven.	Establish undergraduate and post-graduate training and research in the One Health approach with practical and applicable field attachments for all cadres of practitioners using modern ICT techniques. This should be tied to local, subnational and national resource mobilizations.
26.	The lack of formal education of stakeholders. For instance, the farmers, herders, butchers, smallholder farmers, roadside drug shop owners, food vendors and other artisans may be important stakeholders but are not formally educated in hygiene, biosafety and biosecurity, one health, antimicrobial resistance and such one health issues, hence they will continually serve to limit milestones and achievements in One Health.	To support the implementation of a policy framework that mandates One Health collaboration and integration at all relevant stakeholder institutions. Integration of One Health into relevant stakeholder institutions through the establishment of One Health Desks in every institution that will cater to issues or projects that require multi-disciplinary and transdisciplinary actions/contributions.
27.		To strengthen coordination and empower subnational One Health actions (implementation)
28.		Conduct community sensitization using established front like the political and religious leaders.
29.		Conduct Community sensitization at one of the hot spots and interfaces for diseases e.g. point of entry (POE)
30.		Strengthen preparedness planning and improve the ability to respond to zoonotic diseases, AMR and other public health events outbreak at all levels.
31.		Strengthens animal and public health reporting systems and their interoperability
32.		Initiate the collaboration of different professionals to research into climate-smart agriculture for increased food production, ecofriendly utilities and vibrant blue economy due to the fact that humans now encroach into the natural forests and their rich and diverse fauna which expose humans and domestic animals to new pathogens
33.		Initiate transdisciplinary research where veterinarian, public health, social science, laboratory and environment health experts and local community opinion leaders could work together on shared objectives
34.		To support centralization of tools for reporting of zoonotic infectious disease and related One health issues once it is detected and ensuring that this platform is available to all key parastatals and stakeholders involved in One health
35.		Promotion of biosecurity amongst veterinarians, rangers, health workers and others
36.		Start a project that would incorporate transdisciplinary approaches with contributions from a wide range of professionals. Such project would target the integration of One Health approach and target the vulnerable (unemployed youth and women) in the

		society. These individuals make the larger part of the population. The projects objectives will include: 1. Improvement of livelihoods of the target populations through the creation of awareness on one health approach. 2. Empowerment of the vulnerable by creating sustainability 3. Use the target subset of the population to disseminate the acquired information and benefit as proof of concept to the rest of the community.
37.		Establish a national one health task force or network multiple professionals
38.		I would then recruit community leaders and members and train them on this approach and use them as ambassadors and One Health champions to preach the one health approach at the community level.
39.		Establishment of or strengthening of One Health administrative offices at subnational levels for proper organization of national-subnational integration and future funding
40.		Such money will be invested to promote wildlife health involvement in One Health
41.		The money will be used to augment budget deficit wherever there is genuine interest in One Health administration
42.		To address poorly coordinated One Health activities by running an office
43.		To sponsor bills for legislations and policies on One Health initiatives

Responses were obtained from individuals and groups of professionals from various fields and disciplines including public health, animal health, environmental health, fisheries, and other stakeholders, cutting across multiple African countries and from experts who have worked in the field of One Health in Africa but reside within or outside the continent. Snowballing method was utilized to gather this information until the saturation point was reached when no new theme was mention.