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One Health early warning and response system for zoonotic diseases outbreaks: Emphasis on the involvement of grassroots actors

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Abstract

Background: Emerging and reemerging zoonotic diseases have become a global concern due to their frequent occurrence. Large delays between onset of emerging zoonotic disease outbreaks and their reporting and control are indicative of weak animal and human health systems.

Objectives: The objective of this paper is to tackle the time delay by suggesting a One Health Early Warning and Response System (OH-EWRS) aiming at improving the surveillance and notification of zoonotic diseases by strengthening 'bottom-up' approaches and systems for early detection, especially in hot spot areas where they emerge.

Methods: In this conceptual paper, we searched online database including PubMed, Google and Google Scholar to explore the scientific landscape for zoonotic diseases and One Health Early Warning and Response Systems published in English up to December, 2020. In addition, the authors made use of their own expertise and critically reviewed the retrieved papers that were found to be of relevance as the three authors are experts in their own fields, coming from different backgrounds, but are all working to improve the prevention and control of zoonotic disease outbreak.

Results: The OH-EWRS advocates for collaboration between relevant stakeholders including nongovernmental organisations, country offices of international and intergovernmental technical organisations, governmental bodies, research institutes, the private sector and local communities with the aim of an integrated One Health prevention and control system. The OH-EWRS considers various priorities and objectives of the different stakeholders, taking into account possible conflict of interests and considering the need for trust, transparency and mutual benefits.

Conclusions: Although the operationalisation, governance and institutionalisation of the OH-EWRS should be the responsibility of government bodies, inputs from and feedback to relevant stakeholders through a bottom-up and top-down approach

are essential elements for the application of the successful operationalisation of a OH-EWRS.

KEYWORDS
community engagement, early warning and response system, emerging zoonotic diseases, multistakeholders, One Health, surveillance

1 | BACKGROUND

Emerging diseases are those that are detected for the first time or expand their geographical distribution while remerging disease are those that were controlled, eliminated or eradicated in a specific geographical area but reappear (Morse, 1995). Emerging and reemerging diseases considered as a global threat due to their potential for cross-border spread (Nii-Trebi, 2017) threatening the security of people and populations. The majority of these infectious diseases are zoonotic, transmitting from animals to humans via direct contact, contaminated products, inhalation of aerosolised particles and vectors (Rahman et al., 2020). With a world population expected to increase to 9.6 billion by 2050, livestock production is expected to increasingly intensify (Yamada et al., 2014). This increase in population will require vast land to secure food, for both livestock and humans (Yamada et al., 2014). Encroachment of livestock and humans into previously uninhabited ecological systems exposes humans to unfamiliar or new pathogens (King, 2014). Emerging transboundary animal and zoonotic diseases, particularly those that are vector-borne, have a potential to spread globally due to globalisation (Marano et al., 2007) and climate change (Gould & Higgs, 2009). They can lead to significant human and livestock morbidity and mortality, resulting in severe socioeconomic impacts. This may include livestock trade ban and disruption of food security leaving especially small-scale farmers in the poverty trap.

Due to the seriousness of emerging zoonotic diseases and their potential geographic spread (Allen et al., 2017), international organisations responsible for human and animal health, ecosystems as well as agriculture have developed a strategic global framework to reduce the risk of emerging infectious diseases at the animal–human ecosystems interface including the Global Early Warning and Response System for major animal diseases, including zoonoses (GLEWS) and the Early Warning, Alert, and Response System (EWARS) (OIE, 2008; WHO, 2010). Newly emerging zoonoses often start in remote areas which are characterised by weak human health systems and veterinary services, including lack of disease surveillance and timely response. The vital interconnectedness between animal, human and environmental health is called 'One Health', which needs inter and transdisciplinary collaboration and communication to control zoonoses (Zinsstag et al., 2011).

Therefore, it is essential to strengthen a global strategy for disease surveillance through a country-level One Health Early Warning and Response System (OH-EWRS) that encompasses all relevant stakeholders, particularly private sector and communities, and focuses on controlling diseases at the source where they emerge. The purpose of an OH-EWRS is to improve the reporting and surveillance of zoonotic diseases from a bottom-up approach by including various sectors in an interdisciplinary manner to participate in zoonotic diseases prevention and control by sharing responsibility and commitment. Such an integrated OH-EWRS aligns with the global call to adopt an OH approach in order to combat emerging zoonotic diseases (Table 1) by engaging different stakeholders to act and to communicate together with the common aim of assuring the health for humans, animals and the ecosystem (Bordier et al., 2018; Zinsstag et al., 2012; Zinsstag et al., 2011).

According to studies conducted in countries where recent outbreaks have occurred, the importance of engaging communities at risk as a way to improve the surveillance of emerging zoonoses has been recognised, particularly in Africa, the Mediterranean and Middle East Regions (Hassan et al., 2017; Mazet et al., 2009; Seimenis, 2010). However, the engagement and role of at risk communities towards the prevention and control of these diseases has been rarely discussed or included in communicable disease policy discussions. Target zoonotic diseases would need to be agreed with the communities to ensure community participation in timely detecting, reporting and addressing emerging diseases. Such policy should represent a joint collaboration between communities, private sector, nongovernmental organisations (NGOs) and governmental authority. However, so far this is not happening in a concerted way. We propose that the suggested OH-EWRS could fill this obvious gap.

2 | INTRODUCTION

The global strategic framework for reducing risks of infectious diseases at the human-animal ecosystems interface developed by the World Organization for Animal Health (OIE), the Food and Agricultural Organization of the United Nations (FAO) and the World Health Organization (WHO) has called for strengthening the global support and funding for countries under threat of emerging zoonotic diseases (OIE, 2008). The World Bank has focused on multidisciplinary efforts to control zoonotic diseases cost-effectively and to foster healthy humans and animals (Berthe et al., 2018; World Bank, 2010. Therefore, the focus of this conceptual paper is at the country level, reaching municipalities, districts and rural areas where diseases emerge and spread. The main idea of the suggested OH-EWRS (Figure 1) is the engagement and integration of communities of rural and remote areas and the private sector into the surveillance systems to reduce the delay between onset of emerging zoonotic

TABLE 1 Examples of emerging and reemerging zoonotic diseases where the suggested Integrated One Health Early Warning and Response System is applicable.

Viral diseases
Zoonotic influenza (different subtypes)
Crimean-congo haemorrhagic fever (CCHF)
Dengue fever
Ebola haemorrhagic fever
Hanta Virus Syndromes
Henipa virus syndromes
Human monkeypox
Lassa haemorrhagic fever
Marburg haemorrhagic fever
Middle East respiratory syndrome (MERS)
Nipah virus syndromes
Severe acute respiratory syndrome (SARS-CoV)
Swine flu
Rabies
Rift Valley fever (RVF)
Zika virus disease
Yellow fever disease
West Nile Virus disease
Bacterial diseases
Anthrax
Brucellosis
Campylobacteriosis
Escherichia coli diseases
Helicobacter pylori diseases
Lyme disease
Listeriosis
Mycobacterium diseases
Plague
Salmonellosis
Tularaemia
Q-fever
Parasitic diseases
Cryptosporidiosis
Echinococcosis
Taenia solium (neuro)cysticercosis
Trypanosomiasis

disease outbreaks and the actual reporting and response to these cases. The late detection and response to emerging zoonotic diseases has led to considerable negative impacts on human health and socioeconomic growth (Hassan et al., 2011).

The ultimate goal of the suggested OH-EWRS is to create awareness about the importance of shifting the focus from crisis management of emerging zoonosis outbreaks to a sustainable system of early detection of and response to emerging diseases within the hotspot areas they emerge. Thus, the OH-EWSR aims at enhancing the national surveillance system for zoonotic diseases at country and specifically community level (Figure 1).

The main stakeholders that need to be engaged are communities, the private sector, NGOs, governments, and international organisations as well as their respective country offices (e.g. WHO for public health and FAO and OIE for food, agriculture and animal health) (Figure 1). Governmental authorities need to embrace multidisciplinary approaches to better address new emerging zoonotic diseases in the future, taking into consideration the priorities and objectives of the different stakeholders (Lee & Brumme, 2013).

Interdisciplinarity comes with many opportunities but also a few challenges, one of them being difficulties in communication, not only in terms of frequency but also quality. In order to overcome the communication challenges between governments authorities, communities, NGOs, private sector and international organisations, transparency, trust and mutual benefits need to be in place. While most times communication has been established between governments, NGOs and international organisations, communities and the private sector all too often are not included. We therefore suggest bringing in particularly local communities and the private sector into the communication of strengthening surveillance systems (Figure 1). Stakeholders need to agree on shared goals of more cost-effective surveillance systems that have the potential to decrease morbidity and mortality of humans and animals related to emerging zoonotic diseases.

3 | MATERIALS AND METHODS

The frequent outbreaks of zoonotic diseases that occur at the human, animal and environmental interface show that there is a definite need for a well thought-through and locally adapted OH-EWRS. Therefore, we searched online database including PubMed, Google, and Google Scholar in a nonsystematic way in order to explore the scientific landscape for zoonotic diseases and One Health Early Warning and Response Systems published in English up to December, 2020. In addition, the authors made use of their own expertise and critically reviewed the retrieved papers that were found to be of relevance as the three authors are experts in their own fields, coming from different backgrounds, but are all working to improve the prevention and control of zoonotic disease outbreak.

4 | RESULTS AND DISCUSSION

4.1 | Role of stakeholders and mechanism of integration

The International Health Regulations (IHR) (http://www.who.int/topics/international_health_regulations/en/) are the international legal instrument that streamline efforts towards prevention and response to serious public health risks (including emerging infectious

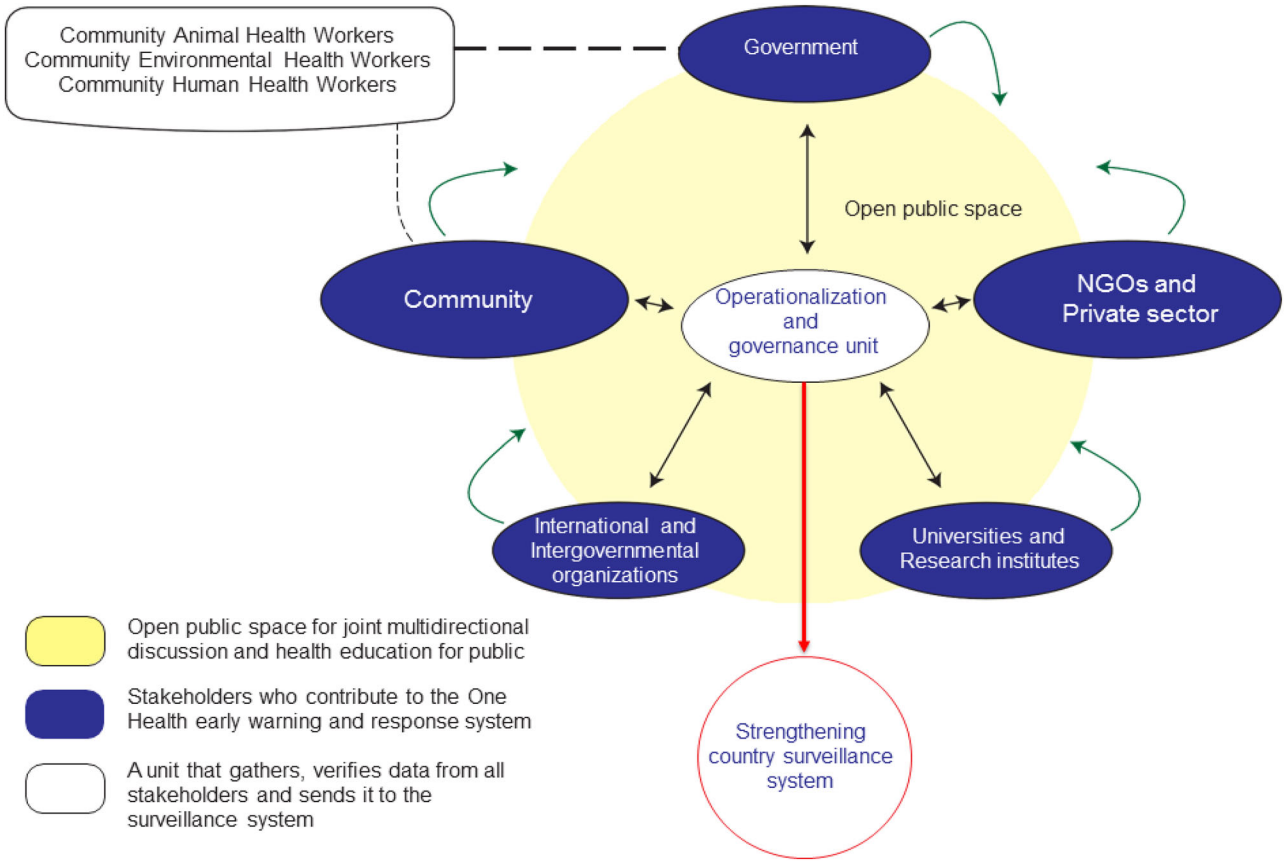

FIGURE 1 Integrated One Health Early Warning and Response System to disrupt emerging zoonotic diseases in hot spot areas.

diseases). The IHR's aim is to prevent geographical spread of such health risks within a country or across the globe (Fidler & Gostin, 2006). The below suggested roles of the communities, private sector and other stakeholders should be further aligned with the IHR guidelines.

4.1.1 | The shared and reciprocal role of communities and governmental authorities

Build multidisciplinary teams and approach at the local level

Government are encouraged to take a more integrated and multidisciplinary approach when engaging Ministries responsible for livestock/animal production, Ministries of Health, Ministries of Environment and others as well as private sector and local communities. Awareness creation, communication and information sharing on emerging zoonoses and their vectors among communities at risk can be challenging but is crucial for early detection (Falzon et al., 2019) (Figure 1). To enhance such intersectoral collaboration, agreed objectives of mutual benefits and joint training among the different sectors could act as an incentive to facilitate collaboration.

Collaboration between local veterinary clinics and health care centres is often less challenging compared to national level. To implement work through interidisciplinary teams requires leadership and a new way of thinking as well as managing the different interests of the stakeholders (Anholt et al., 2012b).

Improve the capacity and avail access to veterinary service in rural areas

Enhancing the capacity of veterinary services including public and private sectors at the local level in rural areas is the first step to strengthen the ongoing surveillance system for zoonoses. The veterinarians are very close to the farmers and they know and respect the value of animals for communities as a crucial part of their lives. However, veterinarians might not able be to cover remote areas of pastoralists in big countries. In such situation, community animal health workers or community animal health supporting team can be established and trained in order to help in providing basic animal health service and contribute to the surveillance by notifying animal diseases including zoonoses (Figure 1).

In case of an animal showing signs of a disease, there needs to be a trusted relationship between the community and the animal health provider as for the farmer to report the disease. Investing in veterinary infrastructure, for example, basic field diagnostic tests to be used in rural areas that do not have ready access to laboratories as well as in mobile clinics or trained community animal health workers for remote areas enables the access of communities to animal health service and

consequently can improve zoonotic diseases surveillance system and decrease pressure on animals health system. The detection of zoonoses circulating among animals in rural areas can serve as sentinel for human diseases in the area when this information is communicated to the human health authorities or local clinics in the communities on a routine basis. Well-established animal health services can also help monitor animal movement and markets through which emerging diseases may circulate and spread to animal and human. New technologies represent new opportunities. A digital surveillance system transmitting information about the occurrence or suspicion of zoonotic diseases from communities for example using mobile phones can contribute to early warning, diagnosis and timely treatment of human cases at the health centres. When this information is shared between animal and human health systems in a timely manner, it can prevent the spread locally and enhance preparedness nationally. A good example is the integrated bite case management (IBCM) where the human bite incidents by dogs are communicated to the animal health services that will investigate the possible occurrence of rabies in the community tracing back and forward possible rabies cases in animals as well as potentially exposed humans. This can largely contribute to the prevention of human rabies cases by assuring timely provision of rabies postexposure prophylaxis to persons bitten by suspected rabid animals (Anholt et al., 2012a; Falzon et al., 2019).

Ensure compensation system for culled or dead animals

To encourage the transparency of early notification of notifiable diseases that eventually can lead to the culling or slaughter of animals, a fair compensation system needs to be available. Normally compensation is established at national level as financial resources need to be earmarked in advance of any outbreak so that they can be mobilised rapidly (emergency fund). Starting the discussions when a disease is already occurring can lead to long delays. Therefore, the determination of compensation level needs to be done in a transparent way. For those diseases that spread cross-border, a regional emergency funding system where affected countries contribute with clear guidelines as to who and how to compensate should be developed. This will incentivise early reporting of animal diseases, preventing the zoonotic disease from further spread.

Introduce affordable vaccination system for important zoonoses

Rural communities need to have access to effective and affordable vaccination for their animals. A number of zoonotic diseases can be easily prevented and controlled through vaccination (e.g. anthrax, brucellosis, rabies, Rift Valley fever, etc.). Through vaccination zoonotic diseases can be prevented not only in animals but also their spread to humans (Bird & Nichol, 2012). Investments in the animal health field can lead to savings of human lives as has been clearly documented for diseases as rabies and brucellosis (Zinsstag et al., 2007). If this will be only left to farmers, they tend to prefer curative compared to preventive approaches. However, developing a list of priority zoonotic diseases at a national and regional level would increase disease awareness and importance of vaccination against such targeted zoonoses.

Discuss and apply an animal quarantine system

Discussing animal movement and biosecurity with local communities practicing communal grazing in the context of disease prevention and control requires dialogue within communities as well as with the local and national authorities. Understanding cultural practices that have been passed down from various generations is crucial and needs to be carefully considered when introducing new policies that will impact these traditional practices. Without reaching mutual understanding with local communities, top-down solutions, coordinated and implemented only from ministerial levels might not be culturally appropriate and may not match the interests of livestock keepers. Compliance with animal movement restrictions such as isolation of sick animals or quarantine of animals suspected to be infected whenever this is necessary to avoid further spread of transboundary and/or zoonotic diseases will require careful consideration regarding the provision of alternative sources of grazing and water for animals when their movements are restricted.

Expand the human health system access in rural areas

On the human health side, strengthening health care systems and making them more accessible in remote areas also potentially improves surveillance systems. In primary health care settings, the information about circulating zoonotic diseases can be shared with the veterinary authorities to trace back the source in case of outbreaks. A simple digital system including zoonoses in animals and humans and detected by either veterinary or health care systems at the local level can be adapted to monitor zoonotic diseases at the human and animal interface. For instance, mobile communication can be used by the community to notify possible zoonoses in both animals and humans to the veterinary and health authorities respectively. If there is no internet or mobile service in some remote areas, a weekly paper-based report can be exchanged and serves the same purpose as the digital system.

Introduce and apply integrated monitoring and control management system for vectors and potential reservoirs at local community level

As most of the emerging zoonotic diseases are triggered by environmental factors (Ostfeld & Keesing, 2000; Patz et al., 2000) and agricultural practices (Jones et al., 2013), disrupting disease transmission at the interface with the environment is crucial. For instance integrated vector control can be applied with the full engagement of the local community to identify and eventually control breeding sites of disease vectors. The community can also notify when mosquitoes are abundant or when new mosquitoes are spotted in the area through a suggestion of environmental health workers volunteers (Figure 1). Protective measures such as the use of impregnated bed-nets to avoid mosquito bites can also be discussed with the community as part of vector control management. These measures are applicable in rural, semiurban and urban settings; an example is vector control of sleeping sickness (Welburn et al., 2009).

Many of the zoonotic diseases have reservoirs where the pathogens naturally exist and reproduce. For example bats, rats, mice, ticks, monkeys and birds are reservoir hosts for zoonotic pathogens such as Ebola haemorrhagic fever virus, *Trypanosoma cruzi*, Hanta virus,

Crimean-Congo haemorrhagic fever virus, yellow fever virus and avian influenza virus, respectively (Balfour, 1914; CDC-a, 2021; CDC-b, 2021; Morens et al., 2004; Rosal et al., 2018; Stallknecht & Brown, 2007). The community may get in contact with such reservoirs during their routine activities and this might lead to spillover of such zoonotic pathogens to the community and may cause disease outbreaks. Hence, there is a need for targeted knowledge sharing within the community to avoid unintended transmission and integration of a community participatory approach within reservoir surveillance programs to identify and control the risk of such spillover transmission.

Monitoring animal markets and animal slaughterhouses

Animal markets are an important place where people sell and buy their livestock. Disruption of these markets due to outbreaks of animal or emerging zoonoses can have negative effects on rural and national economies (Cartín-Rojas, 2012; Pfeffer & Dobler, 2010). Animal owners are interested to be a part of an animal market that serves them in a safe way. Monitoring animals that come into the market not only prevents the spread of diseases, but also enables treatment of sick animals or their safe slaughter. SARS-CoV-2, which spread in live animals market in Wuhan, China, in December 2019 and was linked to animal sources, is a remarkable example of the importance of monitoring animal markets (Petrikova et al., 2020; Zhou et al., 2020). Moreover, active sampling of blood of healthy animals that come to the market can give insights into circulating pathogens in the areas where animals come from. So far, in most low- and middle-income countries (LMICs) animal markets are a source of income for the local governmental authorities' through taxes without providing the required veterinary services at the market against such taxations. The lack of mutual benefits jeopardises collaboration between animal market authorities and animals' owners as well as traders. Sharing benefits could also improve the surveillance systems for zoonotic and other relevant diseases at local and national levels (Van Metre et al., 2009).

In addition, slaughterhouses provide an excellent opportunity for screening against zoonoses, what could predict the occurrence of zoonoses in the area (Dupuy et al., 2013). However, this opportunity is largely missed. If at least the information of critical zoonoses, that is agreed with slaughterhouses and farmers, would be shared with veterinary and health authorities, it could add great value to the monitoring of zoonoses.

Community empowerment and participation in prevention and control of zoonoses

An empowered community entails effective community participation. There are various areas for developing community capacities as part of an emerging zoonosis control strategy. First, awareness needs to be raised and knowledge provided about circulating diseases in terms of notification or preventive/control actions at the community level through health education. This could be facilitated through a multidisciplinary team at the rural, district or the municipality level.

Another area of empowerment is to select community animal health workers, human health workers as well as environmental health workers and train them with respect to the zoonotic disease spectrum that they may encounter (Figure 1). The latter could participate in the early notification of mosquito swarms in the area and be part of an integrated vector management.

The community in collaboration with community leaders can select the voluntary health workers. The voluntary workers could facilitate the dialogue between the authorities and the community. At this level, it is useful to let human health, animal health and environmental health community workers communicate with each other and share their observations. This initiative might be connected to incentives given to the community to encourage them to participate in the surveillance of emerging diseases. It has to be emphasised that the communication (either through mobile phones, emails or face-to-face) needs to be established between the various community workers as to share information in a timely manner about emerging zoonotic disease and possible risk factors within the community.

4.1.2 | The role of nongovernmental organisations (NGOs) and the private sector in animal and human health systems

In many resource limited countries the public veterinary services might not be present in rural areas. This gap at times is filled by NGOs and eventual private animal health service providers. Often these stakeholders have different priorities compared to the authorities and therefore they do not feed information into the regular surveillance system (Hassan, 2007). However, without them the picture of zoonoses circulating in those remote parts would remain unclear. It may be that the profit orientation of the private sector, which decides the prices of the provided veterinary service such as diagnosis, treatment and vaccination sometimes, makes it difficult to comply with the governmental regulations and particularly the surveillance system. Incorporating information collected by private clinical services into the national surveillance system might encounter difficulties due to extra workload and bureaucratic procedures. A simple easy-to-use digital platform that enables the incorporation of information and reports from NGOs and private veterinary clinics would be beneficial to strengthen the coverage of the national surveillance system.

There are many cases that are only detected by private health care systems in remote areas where NGOs, mission hospitals and private clinics are the main providers of diagnosis, treatment and vaccination. These cases are not routinely reported to the Ministry of Health and consequently are missed within the national surveillance system (Khan et al., 2006). Again finding ways how this information could be streamlined potentially with the above mentioned private animal health services is worth exploring.

A digital active surveillance system at district level at both animal and human health services may be able to integrate data in a One Health manner, save time and report directly to regional and national surveillance system. An important aspect for the establishment of successful integrated digital information systems is to create feedback mechanism that update communities about the information provided

and responsive actions undertaken. Such an approach could contribute to retain community motivation.

4.1.3 | The role of the universities and research institutes

Globally, universities and research institutes are established to produce knowledge for the benefit of society and to provide the evidence for policy makers with the ultimate goal to contribute to the development and overall health (Mosha, 1986; Trippl et al., 2015). In many LMICs, expansion of higher education is among the priorities of community needs. However, these universities and institutes face many challenges (Sawyerr, 2004), among others a lack of convergence between human, animal and environmental health education and practice. By adopting an institutional One Health approach in education and practice, value will be added through linking education to the realities in the field where the health of humans, animals and environment are interconnected. Such integrated approaches are needed to effectively combat zoonoses after developing prioritisation exercise at community level in order to contribute to the development of rural as well as national economies and overall health and well-being (Salihu et al., 2015).

4.1.4 | The role of international or intergovernmental organisations

International organisations which are responsible for human, animal, agriculture and environmental health such as WHO, OIE, FAO and UN Environmental program which have representations in many LMICs and provide technical assistance at national and field level. These organisations demonstrate leadership on intersectoral collaboration and can facilitate One Health collaboration at country level achieving health for animals, humans and the environment (Brückner, 2009; FAO, 2019). Such convergence to implement projects also should be adopted between ministries and institutions at country level (WHO, 2012).

4.2 | Operationalisation, governance and institutionalisation of the OH-EWRS

To implement an OH-EWRS, it is essential to set an initial list of priority zoonotic diseases at country level. Accordingly, the OH-EWRS could be adopted to confront the listed zoonoses, thereby proving that it is beneficial. Later, the OH-EWRS can be expanded to include other zoonotic diseases of interest in the country.

An especially joint technical unit composed of the relevant ministries and connected with other external stakeholders should be developed to run such integrated OH-EWRS (Figure 1). It is the aim that data from different sectors are gathered, analysed and interpreted within a joint system that can consist of a common database where the data are inputted or separate databases that are compatible and that enable the analysis of information from various sectors (Figure 1). If a pathogen exceeds a predefined threshold either in humans, animals or the environment, a previously agreed response plan should be put into actions with clearly defined roles and responsibilities. Timely access to human and financial resources is key and therefore the establishment of an emergency fund is highly recommended as well as the creation of capacity and the development of a response plan during 'peace time' as to enable the rapid response in case of disease emergence and outbreaks.

An integrated EWRS requires relevant sectors to work together in a multidisciplinary way across sectors to strengthen One Health surveillance by clearly defining the key role of communities (Figure 1). To establish a One Health culture, professional curricula need to be developed where students from different disciplines such as human and veterinary medicine, environmental science, social science and biomedicines come together to discuss health issue and risk factors. This will build the capacity and enhance the culture of multidisciplinary among the students who will become the professionals of the future. Policy makers also need to embrace One Health to become part of the new integrated approach for early warning and response system for zoonotic diseases and other health threat that benefit from an integrative and multidisciplinary One Health approach. This would change the traditional way of looking at health in a fragmented and compartmentalised way. An open and constructive dialogue across sectors and levels, including various relevant stakeholders is needed to advance One Health thinking.

For One Health to receive high-level political commitment to cross-sectoral collaboration clear joint objectives and benefits need to be defined. In addition, leadership building trust between professionals and communities would be key to sustain a One Health approach. Also, there need to be clear financial gains, for example, the implementation of an efficient OH-EWRS is less costly compared to the pandemic consequences. In order to measure such efficiency we can compare the disability-adjusted life year (DALY) for morbidity and mortality of the outbreak and the resources allocated to its control with the resources allocated for the OH-EWRS as a preventive measure.

5 | CONCLUSIONS AND RECOMMENDATIONS

We suggest the development of an OH-EWRS (Figure 1) to be an integral part of animals and humans health systems for curbing emerging zoonotic diseases, which are on the rise at the human, animal and ecosystems interface, generally located at community level.

The conventional disease surveillance systems in many countries require adaptation to the changing ecology of emerging zoonosis and the determinants that interact where humans, animals and the environment come together. This needs structural changes to enable different sectors to work together and improve mechanism of multisource data collection and simultaneous analysis, interpretation and communication (Figure 1). In addition, bringing about change also requires an open dialogue with local communities, understanding their needs and

practices, facilitating the creation of the One Health culture, empowering and involving communities in addressing health threats by adapting practices and enhancing a bottom-up–top-down approach to the prevention and control of zoonotic diseases. There is a clear role for social sciences to lead this behavioural and sociocultural change (Lapinski et al., 2015), which has to be incorporated within the agendas of ministries dealing with public health, animal health and agriculture as well as the environment. Alongside community roles, we also need to explore how private sector service providers can be integrated into such OH-EWRS.

It is time for the community, the private sector, NGOs, the various involved ministries, international and intergovernmental organisations and academia to converge their capacities and to build strong OH-EWRS (Figure 1) that serves the people, animals and the ecosystems of our planet.

AUTHOR CONTRIBUTIONS

Osama Ahmed Hassan: conceptualisation; data curation; formal analysis; methodology; visualisation; writing – original draft; writing – review & editing. Katinka de Balogh: data curation; validation; writing – review & editing. Andrea Sylvia Winkler: data curation; methodology; validation; visualisation; writing – review & editing.

CONFLICT OF INTEREST STATEMENT

The authors have no conflict of interest to declare.

DATA AVAILABILITY STATEMENT

Data sharing not applicable—the article describes entirely theoretical research.

ETHICS STATEMENT

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to. No ethical approval was required as the article describes entirely theoretical research.

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REFERENCES

Allen, T., Murray, K. A., Zambrana-Torrelio, C., Morse, S. S., Rondinini, C., Di Marco, M., Breit, N., Olival, K. J., & Daszak, P. (2017). Global hotspots and correlates of emerging zoonotic diseases. *Nature Communications*, *8*(1), 1124.

Anholt, R.-M., Stephen, C., & Copes, R. (2012a). Strategies for collaboration in the interdisciplinary field of emerging zoonotic diseases. *Zoonoses and Public Health*, *59*(4), 229–240.

Anholt, R., Stephen, C., & Copes, R. (2012b). Strategies for collaboration in the interdisciplinary field of emerging zoonotic diseases. *Zoonoses and Public Health*, *59*(4), 229–240.

Balfour, A. (1914). The wild monkey as a reservoir for the virus of yellow fever. *The Lancet*, *183*(4730), 1176–1178.

Berthe, F. C. J., Bouley, T., Karesh, W. B., Le Gall, F. G., Machalaba, C. C., Plante, C. A., & Seifman, R. M. (2018) *Operational framework for strengthening human, animal and environmental public health systems at their interface (English)*. Washington, D.C.: World Bank Group.

Bird, B. H., & Nichol, S. T. (2012). Breaking the chain: Rift Valley fever virus control via livestock vaccination. *Current Opinion in Virology*, *2*(3), 315–323.

Bordier, M., Uea-Anuwong, T., Binot, A., Hendrikx, P., & Goutard, F. L. (2018). Characteristics of One Health surveillance systems: A systematic literature review. *Preventive Veterinary Medicine*, *181*, 104560.

Brückner, G. (2009). The role of the World Organisation for Animal Health (OIE) to facilitate the international trade in animals and animal products. *Onderstepoort Journal of Veterinary Research*, *76*(1), 141–146.

Cartín-Rojas, A. (2012). *Transboundary animal diseases and international trade*. International Trade from Economic and Policy Perspective: InTech.

CDC-a. (2021). Hanta Virus: reservoir and reservoir distributions: United States. doi: https://www.cdc.gov/hantavirus/technical/hps/ecology.html

CDC-b. (2021). Crimean-Congo hemorrhagic fever (CCHF). doi: https://www.cdc.gov/vhf/crimean-congo/transmission/index.html

Dupuy, C., Morignat, E., Maugey, X., Vinard, J.-L., Hendrikx, P., Ducrot, C., Calavas, D., & Gay, E. (2013). Defining syndromes using cattle meat inspection data for syndromic surveillance purposes: A statistical approach with the 2005–2010 data from ten French slaughterhouses. *BMC Veterinary Research*, *9*(1), 88.

Falzon, L. C., Alumasa, L., Amanya, F., Kangethe, E. K., Kariuki, S., Momanyi, K., Muinde, P., Murungi, M. K., Njoroge, S. M., Ogendo, A., Ogola, J., Rushton, J., Woolhouse, M. E. J., & Fèvre, E. M. (2019). One Health in action: Operational aspects of an integrated surveillance system for zoonoses in western Kenya. *Frontiers in Veterinary Science*, *6*, 252.

FAO. (2019). Our priorities – The strategic objectives of FAO. Rome: FAO.

Fidler, D. P., & Gostin, L. O. (2006). The new International Health Regulations: An historic development for international law and public health. *The Journal of Law, Medicine & Ethics*, *34*(1), 85–94.

Gould, E. A., & Higgs, S. (2009). Impact of climate change and other factors on emerging arbovirus diseases. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, *103*(2), 109–121.

Hassan, A. (2007). A strategy for strengthening the national epidemiological surveillance systems in Africa. Paper presented at the OIE Conference.

Hassan, O. A., Affognon, H., Rocklöv, J., Mburu, P., Sang, R., Ahlm, C., & Evander, M. (2017). The One Health approach to identify knowledge, attitudes and practices that affect community involvement in the control of Rift Valley fever outbreaks. *PLoS Neglected Tropical Diseases*, *11*(2), e0005383.

Hassan, O. A., Ahlm, C., Sang, R., & Evander, M. (2011). The 2007 rift valley fever outbreak in Sudan. *PLOS Neglected Tropical Diseases*, *5*(9), e1229.

Jones, B. A., Grace, D., Kock, R., Alonso, S., Rushton, J., Said, M. Y., McKeever, D., Mutua, F., Young, J., McDermott, J., & Pfeiffer, D. U. (2013). Zoonosis emergence linked to agricultural intensification and environmental change. *Proceedings of the National Academy of Sciences*, *110*(21), 8399–8404.

Khan, M. I., Sahito, S. M., Khan, M. J., Wassan, S. M., Shaikh, A. W., Maheshwari, A. K., Acosta, C. J., Galindo, C. M., Ochiai, R. L., Rasool, S., Peerwani, S., Puri, M. K., Ali, M., Zafar, A., Hassan, R., von Seidlein, L., Clemens, J. D., Nizami, S. Q., Bhutta, Z. A., & Rasool, S. (2006). Enhanced disease surveillance through private health care sector cooperation in Karachi, Pakistan: Experience from a vaccine trial. *Bulletin of the World Health Organization*, *84*, 72–77.

King, L. J. (2014). *Combating the triple threat: The need for a One Health approach* (pp. 3–15). American Society of Microbiology.

Lapinski, M. K., Funk, J. A., & Moccia, L. T. (2015). Recommendations for the role of social science research in one health. *Social Science & Medicine*, *129*, 51–60.

Lee, K., & Brumme, Z. L. (2013). Operationalizing the One Health approach: The global governance challenges. *Health Policy and Planning*, *28*(7), 778–785.

Marano, N., Arguin, P. M., & Pappaioanou, M. (2007). Impact of globalization and animal trade on infectious disease ecology. *Emerging Infectious Diseases*, *13*(12), 1807.

Mazet, J. A., Clifford, D. L., Coppolillo, P. B., Deolalikar, A. B., Erickson, J. D., & Kazwala, R. R. (2009). A "one health" approach to address emerging zoonoses: The HALI project in Tanzania. *PLoS Medicine*, *6*(12), e1000190.

Morens, D. M., Folkers, G. K., & Fauci, A. S. (2004). The challenge of emerging and re-emerging infectious diseases. *Nature*, *430*(6996), 242–249.

Morse, S. S. (1995). Factors in the emergence of infectious diseases. *Emerging Infectious Diseases Journal*, *1*(1), 10.3201/eid0101.950102

Mosha, H. (1986). The role of African universities in national developments. *Higher Education*, *15*(1–2), 113–134.

Nii-Trebi, N. I. (2017). Emerging and neglected infectious diseases: Insights, advances, and challenges. *BioMed Research International*, *2017*, 1–15.

OIE. (2008). Contributing to One World, One Health: A strategic framework for reducing risk of infectious diseases at the animal-human-ecosystem interface. FAO/OIE/WHO/UNICEF/UNSIC/World Bank.

Ostfeld, R. S., & Keesing, F. (2000). Biodiversity series: The function of biodiversity in the ecology of vector-borne zoonotic diseases. *Canadian Journal of Zoology*, *78*(12), 2061–2078.

Patz, J. A., Graczyk, T. K., Geller, N., & Vittor, A. Y. (2000). Effects of environmental change on emerging parasitic diseases. *International Journal for Parasitology*, *30*(12–13), 1395–1405.

Petrikova, I., Cole, J., & Farlow, A. (2020). COVID-19, wet markets, and planetary health. *The Lancet Planetary Health*, *4*(6), e213–e214.

Pfeffer, M., & Dobler, G. (2010). Emergence of zoonotic arboviruses by animal trade and migration. *Parasites & Vectors*, *3*(1), 35.

Rahman, M., Sobur, M., Islam, M., Ievy, S., Hossain, M., El Zowalaty, M. E., Rahman, A. T., & Ashour, H. M. (2020). Zoonotic diseases: Etiology, impact, and control. *Microorganisms*, *8*(9), 1405.

Rosal, G. G., Nogueda-Torres, B., Villagrán, M. E., José, A., Montañez-Valdez, O. D., & Martínez-Ibarra, J. A. (2018). Chagas disease: Importance of rats as reservoir hosts of *Trypanosoma cruzi* (Chagas, 1909) in western Mexico. *Journal of Infection and Public Health*, *11*(2), 230–233.

Salihu, H. M., Salinas-Miranda, A. A., Paothong, A., Wang, W., & King, L. M. (2015). Community-based decision making and priority setting using the R software: The community priority index. *Computational and Mathematical Methods in Medicine*, *2015*, 1–8.

Sawyerr, A. (2004). African universities and the challenge of research capacity development. *Journal of Higher Education in Africa/Revue de l'enseignement supérieur en Afrique*, *2*, 213–242.

Seimenis, A. (2010). Capacity building for zoonotic and foodborne diseases in the Mediterranean and Middle East regions (an intersectoral WHO/MZCP proposed strategy). *International journal of antimicrobial agents*, *36*, S75–S79.

Stallknecht, D. E., & Brown, J. D. (2007). Wild birds and the epidemiology of avian influenza. *Journal of wildlife diseases*, *43*(SUPPL 3), S15–S20.

Trippl, M., Sinozic, T., & Lawton Smith, H. (2015). The role of universities in regional development: conceptual models and policy institutions in the UK, Sweden and Austria. *European Planning Studies*, *23*(9), 1722–1740.

Van Metre, D. C., Barkey, D. Q., Salman, M., & Morley, P. S. (2009). Development of a syndromic surveillance system for detection of disease among livestock entering an auction market. *Journal of the American Veterinary Medical Association*, *234*(5), 658–664.

Welburn, S., Maudlin, I., & Simarro, P. (2009). Controlling sleeping sickness–A review. *Parasitology*, *136*(14), 1943–1949.

WHO. (2010). Sharing responsibilities and coordinating global activities to address health risks at the animal human-ecosystems interfaces. The FAO-OIE-WHO Collaboration.

WHO. (2012). World Health Organization. High-level technical meeting to address health risks at the human-animal ecosystems interfaces: Mexico city, Mexico 15–17 November 2011.

World Bank. (2010). *People, pathogens and our planet, volume 1: Towards a One Health approach for controlling zoonotic diseases*. Washington, DC: World Bank Group.

Yamada, A., Kahn, L. H., Kaplan, B., Monath, T. P., Woodall, J., & Conti, L. (2014). *Confronting emerging zoonoses: The one health paradigm*. Springer.

Zhou, P., Yang, X.-L., Wang, X.-G., Hu, B., Zhang, L., Zhang, W., Si, H.-R., Zhu, Y., Li, B., Huang, C.-L., Chen, H.-D., Chen, J., Luo, Y., Guo, H., Jiang, R.-D., Liu, M.-Q., Chen, Y., Shen, X.-R., Wang, X., … Shi, Z.-L. (2020). A pneumonia outbreak associated with a new coronavirus of probable bat origin. *Nature*, *579*(7798), 270–273.

Zinsstag, J., Mackenzie, J. S., Jeggo, M., Heymann, D. L., Patz, J. A., & Daszak, P. (2012). Mainstreaming one health. *EcoHealth*, *9*(2), 107–110.

Zinsstag, J., Schelling, E., Roth, F., Bonfoh, B., De Savigny, D., & Tanner, M. (2007). Human benefits of animal interventions for zoonosis control. *Emerging Infectious Diseases*, *13*(4), 527.

Zinsstag, J., Schelling, E., Waltner-Toews, D., & Tanner, M. (2011). From "one medicine" to "one health" and systemic approaches to health and well-being. *Preventive Veterinary Medicine*, *101*(3-4), 148–156.

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