

Chapter 12

***‘One Health’* Research Ethics in Emergency, Disaster and Zoonotic Disease Outbreaks: A Case Study from Ethiopia**



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Abstract *‘One Health’* is the concept that human health and well-being are linked to the health of animals and the environment. The goals of One Health include addressing potential or existing global and transnational health risks, which require policies that are systematic, coordinated, collaborative, multidisciplinary and cross-sectoral. One Health is particularly well-suited for zoonotic diseases and emerging and re-emerging infectious diseases (EIDs). Epidemics, emergencies and disasters raise many ethical issues for all involved, including communities, responders, public health specialists and policymakers. Our case study describes ethical dilemmas encountered during an animal disease outbreak investigation in the Somali region of Ethiopia during the 2019 Coronavirus Disease (COVID-19) pandemic with concurrent drought and human conflicts. Outbreak investigations were conducted through systematic collection, analysis and evaluation of pertinent data, and results disseminated to relevant stakeholders. Our observations highlighted the importance

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of addressing community humanitarian needs and potential risks to responders, including researchers, when responding to animal disease outbreaks without compromising ethical principles. Community engagement was crucial in resolving technical and ethical issues. Policy gaps related to ethical issues during animal health emergencies were observed. Our case study supports the formulation of guidelines and policies for One Health research ethics in Africa and elsewhere to strengthen capacity and ethical decision-making.

Keywords COVID-19 · One Health · Zoonosis · Outbreak investigation · Ethical dilemmas · One Health research ethics · Humanitarian issues

Acronyms

AMR	Antimicrobial resistance
CDC	Centers for Disease Control and Prevention
CIOMS	Council for International Organizations of Medical Sciences
EID	Emerging and reemerging infectious disease
MoA	Ministry of Agriculture
NAHDIC*	National Animal Health Diagnostic and Investigation Center, Ethiopia *NAHDIC has now changed to the Animal Health Institute (AHI)
REC	Research ethics committee
SOPs	Standard operating procedures
WHO	World Health Organization

12.1 Introduction

Infectious diseases continue to negatively impact human health and well-being, even before COVID-19 took center stage. In a sub-Saharan country such as Kenya, which has a population of 47.6 million (KNBS 2019), the top three causes of death are infectious diseases; in Ethiopia, with over 110 million people, three of the top five causes of death are infectious diseases (IHME 2019). In the past, public health responses and policies often focused on the human dimensions of infectious diseases and how they could be mitigated. In recent years, a broader approach known as ‘*One Health*’ has received greater attention.

One Health is a multidisciplinary approach to “achieving optimal health outcomes recognizing the interconnection between people, animals, plants, and their shared environment” (CDC 2021). COVID-19 has dramatically demonstrated the global significance of emerging and reemerging infectious diseases (EIDs) and their implications for public health. One Health approaches to public health are well suited

to EIDs, particularly zoonotic diseases, for both those nationally prioritized (Salyer et al. 2017) and neglected tropical diseases (Elelu et al. 2019).

Zoonotic diseases are caused by infectious agents that are present in animals and are also capable of infecting humans, with the potential of causing human illness. At least 60% of today's EIDs are of zoonotic origin, involving domestic and wild animals (Otte and Pica-Ciamarra 2021). Examples include Ebola, rabies, *Salmonella* infections, and emerging coronavirus infections. Other health risks suited to a One Health approach include those related to EIDs (Muzemil et al. 2018), for example mineral poisoning (WHO 2015; CDC 2016), food safety, antimicrobial resistance (AMR), vector-borne infectious diseases, toxicosis and pesticides (Kimani et al. 2019).

Public health initiatives taking a One Health approach have recently increased significantly. One Health has been adopted by the Centers for Disease Control and Prevention (CDC), the World Health Organization (WHO), the United Nation's Food and Agriculture Organization, and the World Organization for Animal Health (O'Mathúna et al. 2020), and the United Nations Environment Programme as of 2022. The approach is particularly well-suited for resource-limited regions of the world where people live in close proximity to animals and natural habitats. In 2018, about 100 One Health networks existed globally (Khan et al. 2018). By 2020, there were 101 One Health initiatives in East Africa alone (Fasina and Fasanmi 2020), an area regarded as one of the world's hotspots for EIDs of zoonotic origins (Kemunto et al. 2018). One Health works very well in sub-Saharan Africa as it can facilitate cross-sectoral, cross-disciplinary engagement and lead to better outcomes more economically (Fasina et al. 2020).

Regardless of where an infectious disease originates, it can quickly spread globally as demonstrated by COVID-19. Disease outbreaks continue to have devastating effects medically, economically and socially at local, regional and global levels. The West Africa Ebola outbreak of 2014–2016 cost an estimated US\$2.8 billion in gross domestic product and resulted in 11,000 deaths, 80% of which could have been averted if appropriate funding and response had been available two months earlier (GPMB 2019). Factors such as climate change, increased ease and speed of cross-border movements, emergence of new pathogens, and re-emergence of endemic pathogens pose increased risks to global health security. Many types of events, including epidemics and pandemics, climate change and natural disasters, industrial accidents and armed conflict, can create emergencies that impact the health of ecosystems, animals and humans. All of these point to the global significance of One Health research, practice and policy, and the importance of coordinated standard operating procedures (SOPs) to address EIDs. Developing such policies is challenging given the variety of disciplines that need to inform these areas.

12.2 One Health Ethics

Public health practice and research, particularly within veterinary medicine, has increasingly adopted One Health approaches. As with any area of public health practice or research, applying One Health approaches may lead to ethical dilemmas and challenges, but they have received little attention from bioethics (Johnson and Degeling 2019). This has been identified as a hindrance to the implementation of One Health policies in East Africa (Destoumieux-Garzón et al. 2018). Even in a country like the Netherlands, known for the strength of its bioethics research into emerging areas of research, the systems for tracking and responding to EIDs were found to be “not well equipped to handle moral dilemmas” and their One Health professionals to “have little ethical knowledge” (van Herten et al. 2020). Because One Health projects involve human, animal and environmental dimensions, different policies from different agencies are commonly applicable, and ethics and regulatory approvals may be required from several committees, sometimes in different countries (Ladbury et al. 2017). Part of the challenge here arises from the very nature of the One Health interdisciplinary approach. Individual researchers and policymakers may be familiar with the ethics of human subject research, or animal research or environmental studies within their own expertise, but not across all areas or with ethics at the points of intersection. There is some irony here, as the term bioethics stems from the work of Fritz Jahr in 1927 when he coined the term *Bio-Ethik* to address ethical obligations to all living beings, humans, animals or plants (Sass 2007). Additional ethical challenges arise when One Health practice and research is initiated due to outbreaks, which require rapid emergency responses. These conditions may overlap with other emergencies and disasters, such as when an outbreak occurs in a refugee camp with people displaced due to war. All of these factors add further complexities to the ethical issues, but heighten the importance of exploring them in order to inform policymaking in this area.

Our research team formed to explore the ethical issues that arise with One Health approaches to public health practice and research. Our team includes One Health researchers and practitioners based in Kenya, Ethiopia and the USA. We have conducted research into the views of researchers, ethics committee members and regulatory bodies about ethics in One Health research in Africa. In this chapter, we present a case study collected by the team during an animal disease outbreak investigation in Ethiopia. The case study demonstrates some of ethical issues that may arise with a One Health approach to public health. From this, combined with preliminary findings from our research, we make some recommendations for One Health policymakers regarding One Health ethics.

12.3 The Case Study

This case study explores ethical dilemmas encountered during investigation into an outbreak of animal disease, hereafter referred to as 'outbreak investigation,' in the Somali region of Ethiopia. The study region at the time was challenged with a triple burden of armed human conflict, the COVID-19 pandemic, and drought due to shortage of rain, and therefore the outbreak investigation took place in the context of concurrent humanitarian crises. The outbreak occurred among pastoralist communities whose livelihoods in Ethiopia depend entirely on their livestock, including sheep, goats and camels. Pastoralists live in areas where crops are difficult to grow due to the arid environment. Some pastoralists are semi-settled and travel during certain seasons to graze their livestock and in search of water, while others are permanently settled with some family members traveling to find grazing pasture and water, while others are constantly moving. The movements can lead to groups crossing regional and/or national boundaries. The close relationship between pastoralists and their animals increases the possibility of contracting zoonotic diseases from animals, mainly through consumption of unpasteurized milk and undercooked animal products (Megersa et al. 2011; Ayim-Akonor et al. 2020). Long-standing community practices related to animals can sometimes be at odds with health promotion or research guidelines, which can lead to challenges that require careful negotiation.

During the first week of February 2021, the Ethiopian Ministry of Agriculture (MoA) Epidemiology Directorate received a disease outbreak alert of an unknown disease affecting sheep and goats, characterized by sudden mortality. A few camel deaths were also reported. This information was immediately communicated to the then national referral laboratory, the National Animal Health Diagnostic and Investigation Centre (NAHDIC), under the Ethiopian MoA. NAHDIC was asked to participate in the investigation of this unknown disease and a team with members from different sectors of the laboratory was established. A multi-disciplinary team composed of epidemiologists, microbiologists, veterinarians and laboratory technicians from NAHDIC and MoA were sent to the outbreak area.

The outbreak investigation was conducted in Liben Zone, which is one of the eleven Zones of the Somali regional state of Ethiopia, as shown in Fig. 12.1. In Ethiopia, the government administration units are named, in decreasing size, Federal, Region, Zone, Woreda, and Kebele. A multi-stage sampling approach was used for the investigation by selecting two districts, Dollo Addo Woreda and Bokolmanyo Woreda. Dollo Addo Woreda sits where three countries have their borders, namely, Kenya, Somalia and Ethiopia. The other site, Bokolmanyo Woreda, hosts one of the largest refugee camps in the Somali regional state, and zoonotic animal diseases are common within the residents. Animals health experts from Dollo Addo Woreda joined the NAHDIC and MoA outbreak investigation team.

The Liben Zone is part of an area frequently affected by drought since it experiences a short rainy season. Vegetation cover is scarce for small ruminants to feed on, with the exception of small patches along the river Dawa. The outbreak investigation took place at a time when the population was facing food shortages due to prevailing

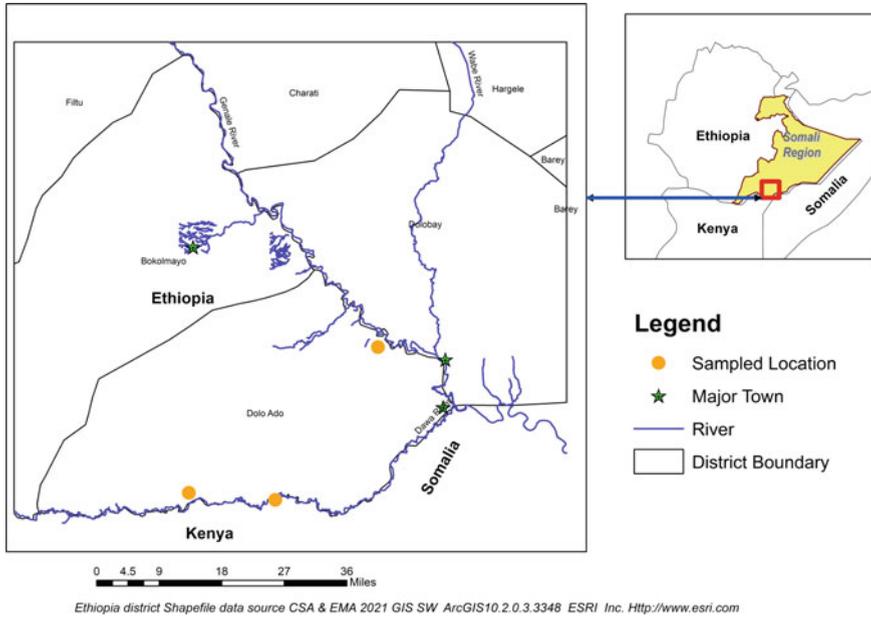


Fig. 12.1 Geospatial Imaging System (GIS) map of the animal disease outbreak investigation area, created using ArcGIS 10 software

drought and the loss of their main source of income because of the massive death of goats and sheep. In the area, practices including poor grazing management, traditional animal husbandry practices, and having livestock present within the household environment increase the potential for the occurrence of zoonotic infectious diseases. In addition, unrestricted movement of livestock across the porous borders and the presence of wild animals within the same ecosystem of farm animals are frequently noticed, again forming ideal conditions for the spread of zoonotic diseases.

The first step in the outbreak investigation was to design an implementable plan for this specific investigation. Upon arrival, the NAHDIC team conducted informational meetings with different regional officers, and zonal livestock and pastoral development officers. Interviews about the situation were conducted at many levels starting with Regional bureau heads and then with Zonal animal health focal personnel. The Zonal-level livestock health focal person arranged an interview session with two Woreda level animal health experts and three Kebele chairpersons, one person from each Kebele where the outbreak occurred. The Kebele chairperson, who knows the local pastoralists, has the responsibility to report to Woreda officials on animal health and public health-related issues and concerns happening in the Kebele. These reports are passed on to both Zonal and Region levels, finally reaching the Federal level.

After discussions with officials, engagement with the community began with local Kebele administrators and religious leaders. Each Kebele chairperson contacted the local pastoralists and arranged a meeting with the religious leader within each

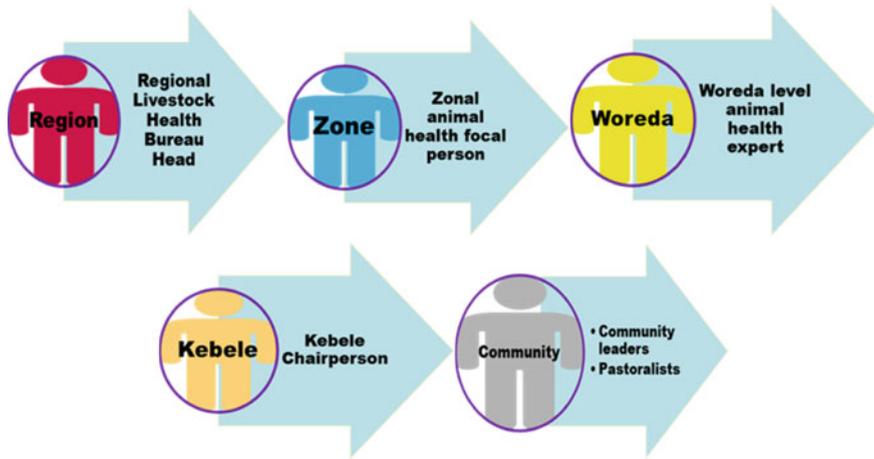


Fig. 12.2 Levels of communication during disease investigation

Kebele. The religious leaders later engaged the rest of the pastoralists and the local community was informed of the investigation's objectives and methods, and later of the investigation outcomes. The channels of communication are shown in Fig. 12.2. The community was consulted and engaged in the outbreak investigation, assisting the investigation team with collection of demographic and epidemiological data and the collection of biological samples.

In each Kebele, during sample collection, the pastoralists were interviewed to collect information about the animal disease and any abrupt climatic or environmental changes that occurred in the recent past. In some situations, the Kebele chairperson served as an interpreter during "question and answer" sessions. The engagement of the community facilitated the collection of sensitive information, such as the number of livestock per household, the number of family members in the household, how animals were used for food, how dead animals were disposed of and the numbers of pregnant animals. Communities were also engaged as they guided the investigation team on which sites to sample or not considering logistical (e.g. accessibility to roads and transportation) and security concerns.

Consent for the outbreak investigation was obtained verbally in culturally appropriate ways involving dialogue between pastoralist community leaders and the investigation team. Verbal consent was also obtained when community members assisted in handling and restraining their animals for purposes of sample collection. The observed clinical signs presented by affected animals included sudden onset of disease, diarrhea, coughing, recumbency, shivering and death. Although clinical symptomatology varied from one Kebele to another, abortion in the mid trimester was a common feature in sheep and goats. Among the twenty two Kebeles in Dollo Addo Woreda, three Kebeles reported severe disease outbreak with massive mortality in sheep and goats. In addition, a similar outbreak was reported in the Bokolmanyo Woreda, which borders Ethiopia and Kenya along river Dawa.

During the outbreak investigation in both areas, a total of 44 sheep (38 males and 6 females), 42 goats (38 males and 4 females) and 10 camels (2 males and 8 females) were examined and samples taken to investigate the cause of the unknown disease. Clinical and laboratory data would help to identify a potential zoonotic disease and samples were collected for this purpose. However, lack of resources (e.g. cold chain maintenance for sample collection and transportation) and lack of financial resources were major challenges for the investigation. In addition, retrospective data from human health care facilities were unavailable due to poor data management systems. The descriptive and interview data which were collected are currently being analyzed with the aim of developing suitable interventions and a mitigation plan for potential future outbreaks. Nevertheless, the investigation identified a number of ethical issues which we report in the next section. While this investigation was not a research project, the ethical issues identified have relevance for One Health research and point to gaps in policy.

12.4 Analysis of the Case Study

The case study notes how community engagement occurred throughout the outbreak investigation and was a key component to addressing ethical issues. Once the community understood the study objectives and its potential benefits, it became easier to navigate several processes, for example interviewing community members to obtain more information about the outbreak. Potential security risks were also minimized; the community was directly involved in identifying trusted guides, coordinating visits to different homesteads, provision of disease history, and identification of affected animals. This facilitated the disease investigation and would be important during deployment of remedial measures to address further loss of animals. The community continued to engage with investigators in designing possible interventions and a mitigation plan that would decrease further animal losses from potential future outbreaks. The plan would entail immediate reporting once disease symptoms are seen in the animals.

Our case study demonstrates the value and importance of community engagement. At the same time, such discussions take time to conduct, particularly when involving various officials, community leaders and pastoralists themselves. The time required may need to be balanced against the need to initiate investigations quickly. This engagement for outbreak investigations typically leads to informal agreements from pastoralists to participate in the investigation. However, some pastoralists did not agree to participate, possibly due to a lack of understanding of scientific approaches to disease investigation (although further work is needed to understand the reasons for non-participation). Interestingly, other pastoralists allowed blood to be drawn from some of their animals, but then stopped allowing more of their flock to be sampled for unknown reasons. Scientifically, this can compromise the thoroughness and consistency of sample collection. Yet, overruling the pastoralists' preferences

would not be ethically acceptable and could have negatively impacted current or future collaboration.

Additional ethical challenges associated with working with pastoralist communities were observed during the disease investigation. The continuous movement of the pastoralists for grazing pasture and water led to difficulties involving the community, especially at the beginning, making it difficult to help all communities facing humanitarian crises.

The investigation into an animal disease outbreak claiming the lives of many animals was further complicated by concurrent crises including drought, conflict, and the COVID-19 pandemic. The potential risks to the investigators needed to be considered since the investigation was being carried out in a region characterized by ongoing conflict. After the decision was made to carry out the investigation, security for the team had to be prioritized and monitored, and became a crucial ethical consideration. Conducting investigations during armed conflict can also put local communities at risk if their engagement with the investigative team is perceived as aligning themselves with one side or another of the conflicting parties.

The outbreak investigation has led to additional ethical dilemmas now that data has been collected. Investigation results are reported to the Federal offices, which then communicate recommendations to local officials who discuss them with the community. Some investigators considered whether some of the data (epidemiological or qualitative interview reports) could be published to inform One Health research and public health practice. At the same time, some investigators could use data to contribute to work they are undertaking towards research degrees. In both situations, the lack of formal research ethics approval prior to undertaking the investigation would likely preclude such uses of this data. Outbreak investigations require an approval letter (support letter) attesting that a team of experts is being officially dispatched to the outbreak area. This can be obtained within days from the MoA and NAHDIC, but no such mechanism exists for research. However, if formal research ethics approval had been sought, it likely would have delayed the investigation for weeks or months during which time the outbreak could have had much more widespread impact. However, the type of in-depth ethical review available for research is not available for outbreak investigations. If it was, it could help ensure that best ethical practice occurs and avoid potential ethical dilemmas and concerns. Such approvals are further complicated with One Health research where animal, human and environmental ethical issues may have required approvals from a number of different committees. Further complexity and delays would have been added if the investigations required following the pastoralists into Kenya or Somalia, the countries bordering the investigation area.

12.5 Lessons Learned from the Case Study for Research Ethics

While the outbreak investigation described in this case study was not a research project, it has implications for research ethics. Many of the activities carried out during an outbreak investigation are also conducted during One Health research and therefore raise similar ethical issues. We identified some of the same ethical issues in another case study involving research in Ethiopia (Yimer et al. 2020). Community engagement was central to how that research project, and this animal outbreak investigation, addressed the ethical issues, and is increasingly advanced as an important aspect of research ethics (CIOMS 2021). We believe that community engagement is also crucial for ethics in human outbreak investigations, public health surveillance, and One Health research in general. Maintaining good relationships with the impacted community is crucial for building trust, promoting respect and ensuring that interventions and mitigation plans are more likely to be adopted and implemented.

Those involved in One Health projects need both to be culturally sensitive to important elements of other cultures and to be flexible enough to adapt to the community's culture while carrying out their investigations. These are important ethical principles that can be applied to a wide variety of One Health practices to help address ethical dilemmas and promote respect for the community (CIOMS 2021). Various strategies have been proposed to promote community engagement, including engaging trusted community members, formation of community advisory boards, and developing formal plans for sustained engagement with the community. Continuous animal movement along the porous land borders between countries also poses a risk for zoonotic and other EIDs. The cross-border situation also complicated the situation with local and regional officials involved from different countries, each with their own approach to investigations and approval systems.

Our case study also highlights one problem with existing approaches to One Health research ethics governance and policies which needs to be avoided if outbreak investigations are to be conducted efficiently. Our case study identified ways that an ethics review and approval mechanism might have helped to avoid some ethical challenges and strengthen ethics features of the investigation. However, existing research ethics procedures would likely have introduced unacceptable delays to initiating the investigation. Similar concerns have been expressed about initiating ethics approval mechanisms for research (Ladbury et al. 2017). Furthermore, the investigation involved animal, human and environmental aspects, which could require approvals from multiple committees or that various experts would need to sit on a multidisciplinary One Health ethics review committee. Additional challenges would arise if the committees were not located in the same place, making ethical approval difficult when the Liben Zone community required urgent assistance. In this particular case study, the cross-border situation added further complexity, with the possibility that ethical approvals could be needed in up to three countries. This points to the importance of SOPs, guidelines and protocols to guide ethical review of One

Health projects during emergencies like disease outbreaks, regardless of whether these are animal or human disease investigations, public health surveillance, or formal research projects. These mechanisms must include ways that reviews can be initiated at short notice and completed quickly without compromising their rigor. This requires that people reviewing such projects are thoroughly familiar with the relevant scientific, ethical and cultural issues involved. Such procedures should also involve ways that cross-border communication and consistency can be achieved, especially for emergency situations. Thus, our findings have important implications for policymakers.

12.6 Implications and Recommendations for Policymakers

One Health research ethics challenges associated with outbreak investigations in pastoral communities were observed during the disease investigation. Although all research, including outbreak investigations should abide by the foundational ethical principles established by relevant research bodies, this was difficult to do while investigating this animal disease outbreak, which generated a number of ethical dilemmas. We realized that the existing ethical guidelines were not adaptable to certain research methods, cultures, and contexts, making it challenging to design and implement studies in pastoral areas, especially at times of zoonoses, disasters, pandemics and animal health emergencies.

To achieve the goals of One Health and address potential or existing global and transnational health risks, policies should be systematic, coordinated, collaborative, multidisciplinary and cross-sectoral (Kimani et al. 2019; Yasobant et al. 2019). The process of systematically collecting, consolidating, analyzing, and evaluating pertinent data, as well as disseminating results to relevant stakeholders during zoonotic disease outbreaks, emergencies and disasters requires a One Health approach to safeguard the health of humans, animals and the environment. Whether such procedures are formally defined as research, public health surveillance or outbreak investigations is not as important as whether they occur effectively, ethically, efficiently and in a timely manner. This implies that ethical conduct of emerging disease investigations requires ethical input and oversight by those familiar with and competent in animal, human and environmental ethics. Community and cultural input is also vital.

These requirements complicate ethical issues since such projects will often involve human, animal and environmental factors that are regulated and overseen by several governmental departments. Given the cross-border nature of emerging infectious and zoonotic diseases, such as rift valley fever, brucellosis, rabies and COVID-19, approvals may be needed from a number of countries. Outbreak investigations such as the one described in this case study would also require ethical approval within a short period of time to limit the potential harm to animals, humans and the environment, and inform potential interventions and mitigation plans as soon as possible. The Ebola outbreak and the COVID-19 pandemic have highlighted the importance of initiating relevant research quickly and at the same time ensuring that ethical review remains

rigorous and thorough (O'Mathúna et al. 2020). Guidelines are needed for when One Health projects would require full review or exemption from review, or some form of pre-review, especially during zoonotic disease outbreaks, emergencies, and disasters. All of these factors require careful consideration by policymakers to ensure that whatever policies and procedures are developed will address each element of these complex scenarios. One of the problems with existing research ethics policies is that most have been designed for non-emergency situations and well-resourced settings (Destoumieux-Garzón et al. 2018).

We also recommend the development of policies and support programs that would:

- enhance the ethical decision-making skills of One Health investigators and researchers, reviewers and regulators;
- strengthen the capacity of One Health practitioners, researchers, reviewers and regulators through training in One Health ethics through various programs ranging from short courses to full degree programs;
- support the formulation of guidelines, policies and SOPs to guide ethical review of One Health projects (of various types) during disease outbreaks, emergencies and pandemics, especially zoonotic ones;
- allow communities to engage in projects from inception, during execution and into final dissemination of results and designing intervention plans;
- lead to the creation of ethical review committees with multidisciplinary expertise to assure critical review of projects at the interface of human, animal and environmental health; and
- promote training of One Health reviewers on ethical issues specific to One Health.

Community engagement and cultural sensitivity must be included as essential elements of One Health practice and research. This should be especially prominent in any ethics-related policies for One Health. Guidelines should include recommendations for practical ways to promote community engagement and develop cultural sensitivity, and data should be collected on the effectiveness and acceptability of various approaches. Community engagement should also be encouraged as a way of resolving ethical dilemmas or concerns that arise during One Health investigations, particularly during disease outbreaks, disasters, and other emergencies when ethical approvals are granted more rapidly than normal. Ethics policies that promote community engagement should be seen as an important way to inform communities about the importance of One Health to their health and empower communities to ensure that their needs and concerns are addressed through outbreak investigations, public health surveillance and research.

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Conflict of Interest The authors declare that the case study was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

- Ayim-Akonor, Matilda, Ralf Krumkamp, Jürgen May, and Eva Mertens. 2020. Understanding attitude, practices and knowledge of zoonotic infectious disease risks among poultry farmers in Ghana. *Veterinary Medicine and Science* 6 (3): 631–638. <https://doi.org/10.1002/vms3.257>.
- CDC. 2016. Lead poisoning investigation in northern Nigeria. <https://www.cdc.gov/onehealth/in-action/lead-poisoning.html>. Accessed 16 Oct 2021.
- CDC. 2021. One Health. <https://www.cdc.gov/onehealth/index.html>. Accessed 16 Oct 2021.
- CIOMS. 2021. Clinical research in resource-limited settings. <https://cioms.ch/publications/product/clinical-research-in-low-resource-settings>. Accessed 16 Oct 2021.
- Destoumieux-Garzón, Delphine, Patrick Mavingui, Gilles Boetsch, Jérôme Boissier, Frédéric Darriet, Priscilla Duboz, et al. 2018. The One Health concept: 10 years old and a long road ahead. *Frontiers in Veterinary Science* 5: 14. <https://doi.org/10.3389/fvets.2018.00014>.
- Elelu, Nusrat, Julius O. Aiyedun, Ibraheem G. Mohammed, Oladapo O. Oludairo, Ismail A. Odetokun, Kaltume M. Mohammed, James O. Bale, and Saka Nuru. 2019. Neglected zoonotic diseases in Nigeria: Role of the public health veterinarian. *Pan African Medical Journal* 32: 36. <https://doi.org/10.11604/pamj.2019.32.36.15659>.
- Fasina, F.O., and O. G. Fasanmi. 2020. The One Health landscape in sub-Saharan African countries. Nairobi, Kenya: International Livestock Research Institute. <https://www.ilri.org/publications/one-health-landscape-sub-saharan-african-countries>. Accessed 16 Oct 2021.
- Fasina, Folorunso O., Niwael Mtui-Malamsha, Gladys R. Mahiti, Raphael Sallu, Moses OleNeselle, Bachana Rubegwa, et al. 2020. Where and when to vaccinate? Interdisciplinary design and evaluation of the 2018 Tanzanian anti-rabies campaign: Biogeography-based vaccination planning. *International Journal of Infectious Diseases* 95: 352–360. <https://doi.org/10.1016/j.ijid.2020.03.037>.
- GPMB-Global Preparedness Monitoring Board. 2019. *A World at risk: Annual report on global preparedness for health emergencies*. Geneva: World Health Organization.
- IHME-Institute for Health Metrics and Evaluation. 2019. Kenya. <http://www.healthdata.org/kenya>
- Johnson, Jane, and Chris Degeling. 2019. Does One Health require a novel ethical framework? *Journal of Medical Ethics* 45: 239–243. <https://doi.org/10.1136/medethics-2018-105043>.
- Kemunto, Naomi, Eddy Mogo, Eric Osoro, Austin Bitek, M. Kariuki Njenga, and S. M. Thumbi. 2018. Zoonotic disease research in East Africa. *BMC Infectious Diseases* 18:545. <https://doi.org/10.1186/s12879-018-3443-8>
- Khan, Mishal S., Peregrine Rothman-Ostrow, Julia Spencer, Nadeem Hasan, Mirzet Sabirovic, Afifah Rahman-Shepherd, et al. 2018. The growth and strategic functioning of One Health networks: A systematic analysis. *Lancet Planetary Health* 2: e264–273. [https://doi.org/10.1016/S2542-5196\(18\)30084-6](https://doi.org/10.1016/S2542-5196(18)30084-6).
- Kimani, T., S. Kiambi, S. Eckford, J. Njuguna, Y. Makonnen, et al. 2019. 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. *Revue Scientifique et Technique* 38 (1): 155–171. <https://doi.org/10.20506/rst.38.1.2950>.
- KNBS-Kenya National Bureau of Statistics. 2019. 2019 Kenya Population and Housing Census. Volume IV: Distribution of Population by Socio-Economic Characteristics. <https://www.knbs.or.ke/?wpdmpromo=2019-kenya-population-and-housing-census-volume-iv-distribution-of-population-by-socio-economic-characteristics>. Accessed 18 Jun 2022.

- Ladbury, Georgia, Kathryn J. Allan, Sarah Cleaveland, Alicia Davis, William A. de Glanville, Taya L. Forde, et al. 2017. One Health research in northern Tanzania—challenges and progress. *East African Health Research Journal* 1 (1): 8–18. <https://pubmed.ncbi.nlm.nih.gov/34308154/>.
- Megersa, Bekele, Demelash Biffa, Fufa Abunna, Alemayehu Regassa, Jacques Godfroid, and Eystein Skjerve. 2011. Seroprevalence of brucellosis and its contribution to abortion in cattle, camel, and goat kept under pastoral management in Borana, Ethiopia. *Tropical Animal Health and Production* 43 (3): 651–656. <https://doi.org/10.1007/s11250-010-9748-2>.
- Muzemil, Abdulazeez, Olubunmi G. Fasanmi, and Folorunso O. Fasina. 2018. African perspectives: Modern complexities of emerging, re-emerging, and endemic zoonoses. *Journal of Global Health* 8 (2): 020310. <https://jogh.org/documents/issue201802/jogh-08-020310.pdf>.
- O’Mathúna, Dónal. P., Andréia G. Arruda, and Getnet Yimer. 2020. One Health research ethics. *Ethiopian Journal of Health Development* 34 (4): 232–234.
- Otte, Joachim, and Ugo Pica-Ciamarra. 2021. Emerging infectious zoonotic diseases: The neglected role of food animals. *One Health* 13: 100323. <https://doi.org/10.1016/j.onehlt.2021.100323>.
- Salyer, Stephanie J., Rachel Silver, Kerri Simone, and Casey B. Behraves. 2017. Prioritizing zoonoses for global health capacity building—Themes from One Health Zoonotic Disease Workshops in 7 countries, 2014–2016. *Emerging Infectious Diseases* 23 (13): S55–S64. <https://doi.org/10.3201/eid2313.170418>.
- Sass, Hans-Martin. 2007. Fritz Jahr’s 1927 concept of bioethics. *Kennedy Institute of Ethics Journal* 17 (4): 279–295. <https://doi.org/10.1353/ken.2008.0006>.
- van Herten, Joost, Suzanne Buikstra, Bernice Bovenkerk, and Elsbeth Stassen. 2020. Ethical decision-making in zoonotic disease control. How do One Health strategies function in the Netherlands? *Journal of Agricultural and Environmental Ethics* 33: 239–259. <https://doi.org/10.1007/s10806-020-09828-x>.
- WHO. 2015. Lead exposure in African children: Contemporary sources and concerns. <https://apps.who.int/iris/handle/10665/200168>. Accessed 30 Aug 2022.
- Yasobant, Sandul, Krupali Patel, and Deepak Saxena. 2019. Hastening One Health collaboration in Gujarat, India: A SWOT analysis. *Journal of Public Health Policy and Planning* 3 (2): 22–24.
- Yimer, Getnet, Wondwossen Gebreyes, Arie Havelaar, Jemal Yousuf, Sarah McKune, Abdulmuen Mohammad, and Dónal O’Mathúna. 2020. Community engagement and building trust to resolve ethical challenges during humanitarian crises: Experience from the CAGED Study. *Conflict and Health* 14: 68. <https://doi.org/10.1186/s13031-020-00313-w>.

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