# The role of laboratories in animal-related disasters and emergencies

D. Eagles [(1)*] & R.B. Gurung [(2)]

(1) Commonwealth Scientific and Industrial Research Organisation (CSIRO) Australian Animal Health Laboratory, 5 Portarlington Road, East Geelong, Australia
(2) National Centre for Animal Health, Serbithang, Department of Livestock, Ministry of Agriculture and Forests, Bhutan
*Corresponding author: debbie.eagles@csiro.au

**Summary**
This paper outlines the role of laboratories in animal-health-related disasters and emergencies, with a particular focus on biological threats – intentional, accidental and natural. Whilst multisectoral coordination is increasingly recognised as necessary for effective preparedness and response to all kinds of disasters, the role of the laboratory is often overlooked. The laboratories' involvement, not just in the response, but across all phases of disaster management – mitigation, planning, response and recovery – is essential, not only for improved animal health but for preservation of livelihoods and for food security, social cohesion and economic stability.

**Keywords**
Animal health – Diagnostic testing – Disaster – Emergency – Laboratory – Preparedness – Surveillance.

## Introduction

The Centre for Research on the Epidemiology of Disasters defines a disaster as a 'situation or event that overwhelms local capacity, necessitating a request at the national or international level for external assistance; an unforeseen and often sudden event that causes great damage, destruction and human suffering' (1). Some disasters or emergencies, such as outbreaks of animal disease, may have direct impacts on animal health, while others, such as cyclones or hurricanes, may indirectly impact animals by, for example, reducing access to food, water and shelter. With the effects of global warming, the number of disasters caused by extreme meteorological events – such as cyclones/typhoons, floods, droughts, tsunamis, glacial lake outburst floods (GLOFs) and wildfires – is increasing globally. Similarly, disease threats of both emerging and re-emerging pathogens are also growing, due to increased urbanisation and human/wildlife/domestic animal interactions, and to the interconnectedness enabled through global trade and travel. Global political instability, the interest of state and non-state actors in weapons of mass destruction, alongside rapid advances in biotechnology (2), have all increased the risk of intentional biothreats. Combined, all of these factors have also raised concerns around what are now termed 'global catastrophic biological events' (3).

Disasters that impact animal health may have subsequent effects on public health, food security, economic sustainability, social stability, and cultural values. Humanitarian responses to emergencies are not just about saving lives, but about sustaining livelihoods (4). As noted by Rushton and Upton (5), the ability of government and private industries to respond to and control an outbreak of disease determines whether or not it becomes a disaster.

It is well recognised that cross-sector engagement is essential for effective disaster management. A multisectoral approach to disaster management is now routinely advocated in guidelines such as the *Tripartite Guide to Addressing Zoonotic Diseases in Countries* (6), and in assessments such as the Global Health Security Index (7). The veterinary profession, particularly through the World Organisation for Animal Health (OIE) (8, 9) and the Food and Agriculture Organization of the United Nations (4), has developed specific guidelines in relation to the management of animal health during emergencies. In 2016, the OIE adopted guidelines on disaster management and risk reduction in relation to animal health and welfare and veterinary public health, and more specific guidelines were adopted in 2018 for the investigation of suspicious biological events (9). This paper will specifically look at the role of veterinary laboratories in the prevention of, preparedness for, response to and recovery of animal health in disasters.

http://dx.doi.org/10.20506/rst.39.2.3090

# Mitigation/prevention

Knowledge remains one of the essential elements of disaster prevention. For pathogens, this includes an understanding of their pathogenesis, transmission and epidemiology, all areas to which laboratories provide key inputs. Such knowledge can inform control and eradication measures, with laboratories further contributing to preventative measures through research on host–pathogen interactions, development of cell lines, and direct vaccine development and evaluation. African swine fever is an example of a virus for which there remain significant knowledge gaps, which presents challenges related to the complexity of the virus and its host–pathogen interactions. The rapid spread of the disease within Asia after its original detection in the People's Republic of China in August 2018 has been widely recognised as an economic and social disaster.

Laboratories may also be custodians of agents that have the potential to pose a severe threat to public and animal health. The 'select agent' list, managed by the Department of Health and Human Services and the Department of Agriculture in the United States of America, comprises pathogens and toxins that have the potential to pose a severe threat to public health and safety, to animal or plant health, or to animal or plant products. This list includes, amongst others, both zoonotic pathogens and pathogens that affect animals only. Twenty-seven of the currently listed pathogens are also on the OIE list of notifiable diseases (10), indicating their potential for transboundary spread and to have severe socio-economic consequences and a significant impact on animal and public health. The select agent list has been adopted by a number of other countries around the world and forms the basis for regulations on the possession, use and transfer of the agents. Laboratories have a key role in mitigating the risks associated with select agents, through an improved understanding of the disease agents and also through the implementation of appropriate biosafety, biocontainment and security measures to ensure that they are not intentionally or unintentionally released from the facilities in which they are held.

Biothreat mitigation also includes awareness around biotechnological advances, which are inherently dual use. Investing in science to reduce biological risks associated with new technologies, and supporting laboratories in developing and evaluating new platforms for diagnostics and surveillance, has the potential to protect against biological emergencies (3). Innovative technologies and data-sharing platforms, informed by clinical, epidemiological and laboratory information and novel data sources, such as social media and Internet search logs, can also increase the speed of detection of a biothreat, disaster or pandemic and assist in rapid response (3).

# Preparedness

Global insecurity, extreme weather events and changed land usage have increased the frequency and impact of disease events, with increasing concerns about the possibility of a 'global catastrophic biological event'. Preparedness for such events, alongside that for other disasters, is more important than ever. This has been recognised in a series of recent exercises and reviews on global preparedness (2, 11) and in the assessments that form the OIE Performance of Veterinary Services (PVS) Pathway (12). Similarly, the heightened importance of disaster preparedness is reflected in the World Health Organization's (WHO) Joint External Evaluation (JEE) for assessing countries' capacity to detect, report, assess and respond to public health emergencies of international concern (13).

The JEE forms part of the WHO Monitoring and Evaluation Framework for assessing countries, compliance with the International Health Regulations (IHR) (14), and this framework also includes a self-assessment component for which WHO has developed the State Party Self-Assessment Annual Reporting (SPAR) Tool (15). This tool helps countries to fulfil their obligation to provide an annual report on their compliance with the IHR and it assists countries to evaluate their performance in 13 different technical areas, including laboratory preparedness. Preparedness is assessed through the progress made in three main areas: 'specimen referral and transport system'; 'implementation of biosafety and biosecurity regime'; and 'access to laboratory testing capacity for priority diseases' (15). All WHO Member States are required to maintain mechanisms that ensure: 'shipment of specimens to appropriate reference laboratories; reliable and timely laboratory testing; characterisation of infectious agents and other hazards likely to cause public health emergencies of national and international concern; and sharing of results on time' (15). The OIE PVS Pathway, which assesses the capacities of national Veterinary Services and their ability to comply with the reporting requirements for OIE-listed diseases, evaluates these same requirements for animal health laboratories.

Laboratory preparedness includes two major interlinked components: ensuring that capability, training and quality are developed and maintained during 'peacetime', and, in parallel, ensuring that there is surge capacity to respond to outbreaks and other high-volume events. To facilitate an effective outbreak response, laboratories should have their own outbreak response plans. These plans should facilitate the full and proper mobilisation of resources to meet the demands of the emergency and enable the laboratory to fulfil its function within the national response. Plans should also ensure that quality systems and microbiological security are maintained. Exercising such plans, as well as conducting 'after action' reviews, is essential for identifying

inconsistencies, bottlenecks, resource constraints and other areas for improvement. Laboratory-specific plans should be developed in conjunction with, and be included in, relevant country-level planning for disease response. For example, Australia's Veterinary Emergency Plan (AUSVETPLAN) incorporates diagnostic testing in disease-specific response plans and has a laboratory-specific manual outlining national planning.

Laboratories can also improve their preparedness by being integrated into national and international laboratory networks, which should include laboratories from both the animal and human health sectors. Such networks can ensure that samples are collected appropriately, transported correctly and handled properly in field situations and that paperwork (such as material transfer agreements and import and export permits for sample transport) is prepared in advance. In addition, they can ensure that reporting protocols are clearly defined and that laboratories have the required diagnostic testing capabilities. The latter can be supported through international reference laboratories as well as through a national, networked approach to outbreak response diagnostics.

Quality assurance, including assay validation and in-house verification, and involvement in proficiency testing and external quality assurance schemes are essential for national authority confidence in diagnostic testing. To this end, laboratories should ensure that they conform to the relevant international standard of the International Organization for Standardization (ISO), namely *ISO 17025: General Requirements for the Competence of Testing and Calibration Laboratories*. Inadequate quality assurance will inevitably lead to inaccurate results, which may impede disease control, lead to the implementation of unnecessary control measures, result in the ineffective use of resources and cause delays in return to trade or restocking.

Point-of-care or field-based diagnostics will become increasingly important in future outbreak responses. Laboratory evaluation of this diverse range of diagnostics, including everything from nanopore sequencing to lateral flow assays, is essential for understanding test characteristics and informing their fitness for purpose. This is essential for ensuring assays are used appropriately, and their results interpreted correctly, to ensure rapid pathogen detection, disease response and threat mitigation.

# Response

The response phase of a disaster is probably the one for which laboratory engagement – at least in disease outbreaks – is best recognised. Diagnostic testing is important for identification or confirmation of the causative agent, for further agent characterisation, for identification of infected cases during an outbreak and for confirmation of the absence of disease through post-outbreak surveillance.

Confidence in diagnostic test results is essential, and this again is dependent on laboratory preparedness. National authorities must have confidence in the laboratory's quality management systems, in its emergency response capability, and in its turnaround times for testing. A shortfall in laboratory capability at any point can have significant implications for the management of an outbreak. For example, a failure to detect an index case through false-negative results can lead to a significant increase in the size of the outbreak and in the overall costs (economic and social). Bottlenecks within outbreak testing can again lead to delays in control, whilst false-positive results can lead to the culling of animals or imposition of other unnecessary control measures. Poorly designed post-outbreak surveillance, or inaccurate interpretation of diagnostic results, can delay return to trade.

In the future, with increasing point-of-care or in-field diagnostic capability, there will likely be less reliance on centralised laboratories for all aspects of response diagnostics, at least for known diseases. However, laboratories will remain fundamental for confirmatory diagnosis as well as for diagnosis of 'unknowns' through the broader capabilities of pathology, microscopy, next-generation sequencing, and the combination of all of these disciplines with epidemiological and clinical assessment. Additionally, laboratories – particularly those that hold significant reference materials (including clinical samples, in addition to isolates) – will be responsible for evaluating the characteristics of in-field diagnostics and, particularly, in providing guidance on their fitness for purpose for given situations.

Deployment of mobile laboratories, including high-containment laboratories, to the site of outbreaks is also increasing, with the recent deployment of such laboratories during outbreaks of Ebola in West Africa serving as an excellent example (16, 17). The benefits of well-constructed mobile laboratories include quicker turnaround times on test results, fewer biosafety concerns associated with long-distance sample transport, a reduction in the cost of testing, and involvement of local staff in diagnostic testing.

With respect to zoonotic disease events, cross-sector communication – between not just the animal health and public health agencies, but also their respective laboratories – is essential for effective response.

# Recovery

The recovery phase of a major disease outbreak encompasses the post-outbreak period during which there are efforts to

return to normal societal and economic functioning. This includes 'proof of freedom' surveillance and testing for a return to trade, as well as efforts made to return to pre-outbreak livestock practices, or alternatives that provide similar economic and cultural benefit. Proof-of-freedom testing, in particular, can stretch already exhausted laboratory resources and it is essential that this phase is considered in planning for outbreak response. Again, a networked approach involving multiple laboratories can assist during this phase.

After extreme weather events and other natural disasters, the impact on livestock can be felt long into the recovery phase. This is because *i)* extreme weather can create conditions that favour the spread of vector-borne diseases, *ii)* exposure of livestock to extremes of conditions can make them more susceptible to infectious diseases, and *iii)* disasters can cause a scarcity of resources that forces closer interaction between livestock and wildlife, thus increasing the risk of disease transmission. Such indirect impacts of natural disasters are well documented, for example, in India (18) and Italy (19). Monitoring of animals after a natural disaster is likely to be limited by difficulty in accessing animals and/or by financial constraints, and welfare decisions may be made based on clinical assessment rather than on laboratory results.

All of the above factors can also contribute to zoonotic disease outbreaks, and cross-sector engagement between public and veterinary health laboratories – as well as their overarching agencies – should extend into the recovery phase.

Finally, during the recovery phase, post-action reviews of the laboratory response should be carried out, as should an assessment of additional mitigations that may be needed. These may include adjustments to diagnostic assays, additional research on a disease agent, changes to biosafety/biocontainment measures, in addition to amendments to laboratory response plans.

# Conclusions

Laboratories have key roles across all phases of disaster management: mitigation, prevention, response and recovery. Appropriate funding of laboratories, as well as their inclusion in cross-sector engagement for disaster management, is essential to ensure animal health is maintained. This is vital not just for disasters in which there is a direct impact on animal health – such as disease outbreaks – but also for those in which animal health may be indirectly impacted, such as extreme weather events. These events can themselves result in the spread of diseases amongst impacted animals, as well as contribute to the spread of zoonotic diseases. Consequently, veterinary laboratories play a role in reducing the impact of disasters on both animal and human health, as well as in assisting the return to economic and social stability post disaster. ■

# Le rôle des laboratoires dans les catastrophes et les urgences affectant les animaux

D. Eagles & R.B. Gurung

**Résumé**

Les auteurs examinent le rôle des laboratoires dans les catastrophes et les urgences affectant les animaux, en se centrant particulièrement sur les menaces biologiques (qu'elles soient intentionnelles, accidentelles ou naturelles). Si la nécessité d'une coordination multisectorielle pour une préparation et une intervention efficaces face aux catastrophes de toute nature est désormais mieux perçue, le rôle des laboratoires est souvent négligé. La participation des laboratoires est essentielle, non seulement dans les interventions mais aussi dans chacune des phases de la gestion des catastrophes, à savoir l'atténuation, la planification, l'intervention et le redressement et ce, non seulement pour améliorer la santé animale, mais aussi pour préserver les moyens de subsistance et la sécurité alimentaire, la cohésion sociale et la stabilité économique.

**Mots-clés**

Catastrophe – Laboratoire – Préparation – Santé animale – Surveillance – Test de diagnostic – Urgence.

■

# Función de los laboratorios en desastres y emergencias relacionados con los animales

D. Eagles & R.B. Gurung

**Resumen**
Los autores exponen a grandes líneas la función que cumplen los laboratorios frente a desastres o emergencias que guardan relación con el mundo animal, prestando especial atención a las amenazas biológicas, ya sean de origen natural, accidental o intencionado. Mientras que por un lado se asienta cada vez más la idea de que la coordinación multisectorial es indispensable para una eficaz labor de preparación y respuesta ante todo tipo de desastres, a menudo se pasa por alto la función que en la materia incumbe a los laboratorios. Es esencial que estos participen no solo en las labores de respuesta, sino en todas las fases del proceso de gestión de desastres (mitigación, planificación, respuesta y recuperación), y ello no solo para mejorar la situación zoosanitaria, sino también para preservar los medios de sustento y proteger la seguridad alimentaria, la cohesión social y la estabilidad económica.

**Palabras clave**
Desastre – Emergencia – Laboratorio – Preparación – Pruebas de diagnóstico – Sanidad animal – Vigilancia.

# References

1. Centre for Research on the Epidemiology of Disasters (CRED) (2019). – Natural disasters, 2018. CRED, Brussels, Belgium, 8 pp. Available at: www.cred.be/sites/default/files/CREDNaturalDisaster2018.pdf (accessed on 28 November 2019).

2. Cameron E., Katz R., Konyndyk J. & Nalabandian M. (2019). – A spreading plague: lessons and recommendations for responding to a deliberate biological event. Nuclear Threat Initiative, Washington, DC, United States of America, 24 pp. Available at: https://media.nti.org/documents/NTI_Paper_A_Spreading_Plague_FINAL_061119.pdf (accessed on 28 November 2019).

3. Watson C., Sell T.K., Watson M., Rivers C., Hurtado C., Shearer M.P., Geleta A. & Inglesby T. (2018). – Technologies to address global catastrophic biological risks. Center for Health Security, Johns Hopkins University School of Public Health, Baltimore, United States of America, 71 pp. Available at: www.centerforhealthsecurity.org/our-work/pubs_archive/pubs-pdfs/2018/181009-gcbr-tech-report.pdf (accessed on 28 November 2019).

4. Livestock Emergency Guidelines and Standards (LEGS) Project (2014). – Livestock Emergency Guidelines and Standards, 2nd Ed. Practical Action Publishing, Rugby, United Kingdom, 16 pp. doi:10.3362/9781780448602.

5. Rushton J. & Upton M. (2006). – Investment in preventing and preparing for biological emergencies and disasters: social and economic costs of disasters versus costs of surveillance and response preparedness. *In* Biological disasters of animal origin. The role and preparedness of veterinary and public health services (M. Hugh-Jones, ed.). *Rev. Sci. Tech. Off. Int. Epiz.*, **25** (1), 375–388. doi:10.20506/rst.25.1.1671.

6. World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO) & World Organisation for Animal Health (OIE) (2019). – Taking a multisectoral, One Health approach: a Tripartite guide to addressing zoonotic diseases in countries. WHO, Geneva, Switzerland; FAO, Rome, Italy; & OIE, Paris, France, 166 pp. Available at: www.oie.int/fileadmin/Home/eng/Media_Center/docs/EN_TripartiteZoonosesGuide_webversion.pdf (accessed on 28 November 2019).

7. Nuclear Threat Initiative (2019). – Global Health Security Index: building collective action and accountability. Nuclear Threat Initiative, Washington, DC, United States of America; & Center for Health Security, Johns Hopkins University School of Public Health, Baltimore, United States of America, 324 pp. Available at: www.ghsindex.org/wp-content/uploads/2019/10/2019-Global-Health-Security-Index.pdf (accessed on 28 November 2019).

8. World Organisation for Animal Health (OIE) (2018). – Guidelines for investigation of suspicious biological events. OIE, Paris, France, 8 pp. Available at: www.oie.int/fileadmin/Home/eng/Our_scientific_expertise/docs/pdf/Guidelines_Investigation_Suspicious_Biological_Events.pdf (accessed on 28 November 2019).

9. World Organisation for Animal Health (OIE) (2016). – Guidelines on disaster management and risk reduction in relation to animal health and welfare and veterinary public health. OIE, Paris, France, 8 pp. Available at: www.oie.int/fileadmin/Home/eng/Animal_Welfare/docs/pdf/Others/Disastermanagement-ANG.pdf (accessed on 28 November 2019).

10. McElwain T.F. & Thumbi S.M. (2017). – Animal pathogens and their impact on animal health, the economy, food security, food safety and public health. *In* Biological threat reduction (T. Beckham, ed.). *Rev. Sci. Tech. Off. Int. Epiz.*, **36** (2), 423–433. doi:10.20506/rst.36.2.2663.

11. Global Preparedness Monitoring Board (2019). – A world at risk: annual report on global preparedness for health emergencies. World Health Organization, Geneva, Switzerland, 48 pp. Available at: https://apps.who.int/gpmb/assets/annual_report/GPMB_annualreport_2019.pdf (accessed on 28 November 2019).

12. World Organisation for Animal Health (OIE) (2020). – OIE PVS Pathway. Available at: www.oie.int/solidarity/pvs-pathway (accessed on 6 January 2020).

13. World Health Organization (WHO) (2018). – Joint External Evaluation Tool: International Health Regulations (2005), 2nd Ed. WHO, Geneva, Switzerland, 122 pp. Available at: www.who.int/ihr/publications/WHO_HSE_GCR_2018_2/en/ (accessed on 21 July 2020).

14. World Health Organization (WHO) (2018). – International Health Regulations (2005) Monitoring and Evaluation Framework. WHO/WHE/CPI/2018.51. WHO, Geneva, Switzerland, 20 pp. Available at: www.who.int/ihr/publications/WHO-WHE-CPI-2018.51/en/ (accessed on 21 July 2020).

15. World Health Organization (WHO) (2018). – State Party Self-Assessment Annual Reporting Tool. WHO/WHE/CPI/2018.16. WHO, Geneva, Switzerland, 34 pp. Available at: www.who.int/ihr/publications/WHO-WHE-CPI-2018.16/en/ (accessed on 21 July 2020).

16. Broadhurst M.J., Brooks T.J.G. & Pollock N.R. (2016). – Diagnosis of Ebola virus disease: past, present, and future. *Clin. Microbiol. Rev.*, **29** (4), 773–793. doi:10.1128/cmr.00003-16.

17. Weidmann M., Faye O., Faye O., El Wahed A.A., Patel P., Batejat C., Manugerra J.C., Adjami A., Niedrig M., Hufert F.T. & Sall A.A. (2018). – Development of mobile laboratory for viral hemorrhagic fever detection in Africa. *J. Infect. Dis.*, **218** (10), 1622–1630. doi:10.1093/infdis/jiy362.

18. Sen A. & Chander M. (2003). – Disaster management in India: the case of livestock and poultry. *Rev. Sci. Tech. Off. Int. Epiz.*, **22** (3), 915–930. doi:10.20506/rst.22.3.1453.

19. Migliaccio P., Nardoia M., Possenti L. & Dalla Villa P. (2018). – Veterinary public health activities and management of the livestock sector during earthquakes and snowstorms in the Abruzzo region – Italy, January 2017. *Animals*, **8** (11), Article No. 218. doi:10.3390/ani8110218.