

REVIEW



Governance principles for the wildlife trade to reduce spillover and pandemic risk

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Abstract

The COVID-19 pandemic and its aftermath are the most significant socio-economic crises in modern history. The pandemic's devastating impacts have prompted urgent policy and regulatory action to reduce the risks of future spillover events and pandemics. Stronger regulatory measures for the trade of wildlife are central to discussions of a policy response. A variety of measures, including broad bans on the trade and sale of wildlife to banning specific species for human consumption are among a suite of discussed options. However, the wildlife trade is diverse, complex, and important for the livelihoods of millions of people globally. We argue that reducing the risk of future pandemics stemming from the wildlife trade must follow established principles of governance which include being equitable, responsive, robust, and effective. We demonstrate how incorporating these principles will support the development of context-specific, culturally sensitive, and inclusive responses that recognize the on-the-ground complexity of disease emergence and the social-ecological systems in which the wildlife trade occurs.

Keywords: COVID-19, global environmental governance, inclusion and equity, public health, virus, wildlife markets, wildlife trade management, zoonotic disease

Introduction

The COVID-19 pandemic has been associated with around 15 million excess deaths in 2021 and 2022 (World Health Organization, 2022), with devastating socio-economic impacts on many aspects of human society and life. These include *inter alia* rising world hunger and food insecurity (Niles *et al.*, 2020; Food and Agriculture Organization of the United Nations *et al.*, 2021a), delayed development in early childhood and missed educational attainment (Egan *et al.*, 2021); disrupted livelihoods, businesses, trade, and economic activity around the world (Rasul *et al.*, 2021), and deepening pre-existing social and economic inequality (Pereira and Oliveira, 2020; Aspachs *et al.*, 2021). Each of these impacts, in turn, can have further direct consequences for public health (McKee and Stuckler, 2020; Aspachs *et al.*, 2021).

The COVID-19 pandemic – stemming from the emergence of the novel pathogen SARS-CoV-2 – has highlighted the importance of minimizing the likelihood of spillover events (Box 1), which occur when a zoonotic pathogen jumps into humans (Bernstein *et al.*, 2022; Vora *et al.*, 2022). Zoonosis is defined by the World Health Organization (WHO) as 'any disease or infection that is naturally transmissible from vertebrate animals to humans' (World Health Organization, 2020). Although the exact role of wildlife trade in the emergence of COVID-19 may never be completely known, current evidence is consistent with zoonotic spillover (Harrison and Sachs, 2022; Worobey *et al.*, 2022; Crits-Christoph *et al.*, 2023), and the wildlife trade has been associated with previous spillover events (Kreuder Johnson *et al.*, 2015; Aguirre *et al.*, 2020; Shivaprakash *et al.*, 2021; Milbank and Vira, 2022). Direct human consumption of wildlife and the associated trade is linked to approximately 10%

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Box 1. Key definitions of terms on the complex dynamics and spread of emerging infectious diseases in the context of the wildlife trade.

Key definitions

Disease – Any disorder in the health or function of an organism.

Emerging infectious diseases – Diseases that have been previously unknown in a species or population, or have existed but are rapidly increasing in incidence or geographic range. Within the context of this manuscript, we have excluded consideration of emerging disease events caused by antimicrobial resistance or those originating from laboratories.

Pandemic – Classically defined as an epidemic occurring worldwide, or over a very wide area, crossing international boundaries and usually affecting many people.

Pathogen – Any organism causing disease to its host.

Pathogen amplification – Used in different contexts to mean either: (a) the replication of a pathogen within a host, resulting in increased pathogen loads within an individual host; or (b) the increase in prevalence along a chain of transmission or within a certain environment, above levels that would normally be expected.

Prevalence of infection – The percentage or proportion of individuals in a population currently infected with a given pathogen at a given point in time.

Reservoir host – A host species that maintains a pathogen within its populations and transmits it to other hosts. Sometimes, a pathogen needs a community of different hosts to enable persistence at a landscape level.

Spillover – The process by which an infectious agent is transmitted from one species to another, with or without ongoing spread through the new host population. If the cross-species transmission (CST) is from an animal to a human, it is called zoonotic transmission or zoonotic spillover.

Vector – A mobile animal, often a blood-feeding arthropod, that transfers pathogens from one host to another.

Wet market – A marketplace selling any fresh meat, where live animals may or may not be present. Markets may vary in their spatial and commercial setting, diversity of products, and customers, ranging from a roadside bushmeat market to a well-managed fish market.

Zoonosis (zoonotic disease) – Any disease or infection that is naturally transmissible from non-human vertebrate animals to humans.

of zoonotic viruses (Kreuder Johnson *et al.*, 2015; Haider *et al.*, 2020; Milbank and Vira, 2022). Along the wildlife trade supply chain, there are multiple phases in which close human-wildlife contact represents potential opportunities for pathogen spillover (Sokolow *et al.*, 2019; Aguirre *et al.*, 2020; Huong *et al.*, 2020; Hilderink and de Winter, 2021), yet organized and consistent surveillance of wildlife trade's disease and public health aspects is currently lacking (Kock and Cáceres-Escobar, 2022). In line with the precautionary principle, stronger measures are needed to manage, regulate, and control wildlife trade to minimize future pandemic risks (IPBES, 2020).

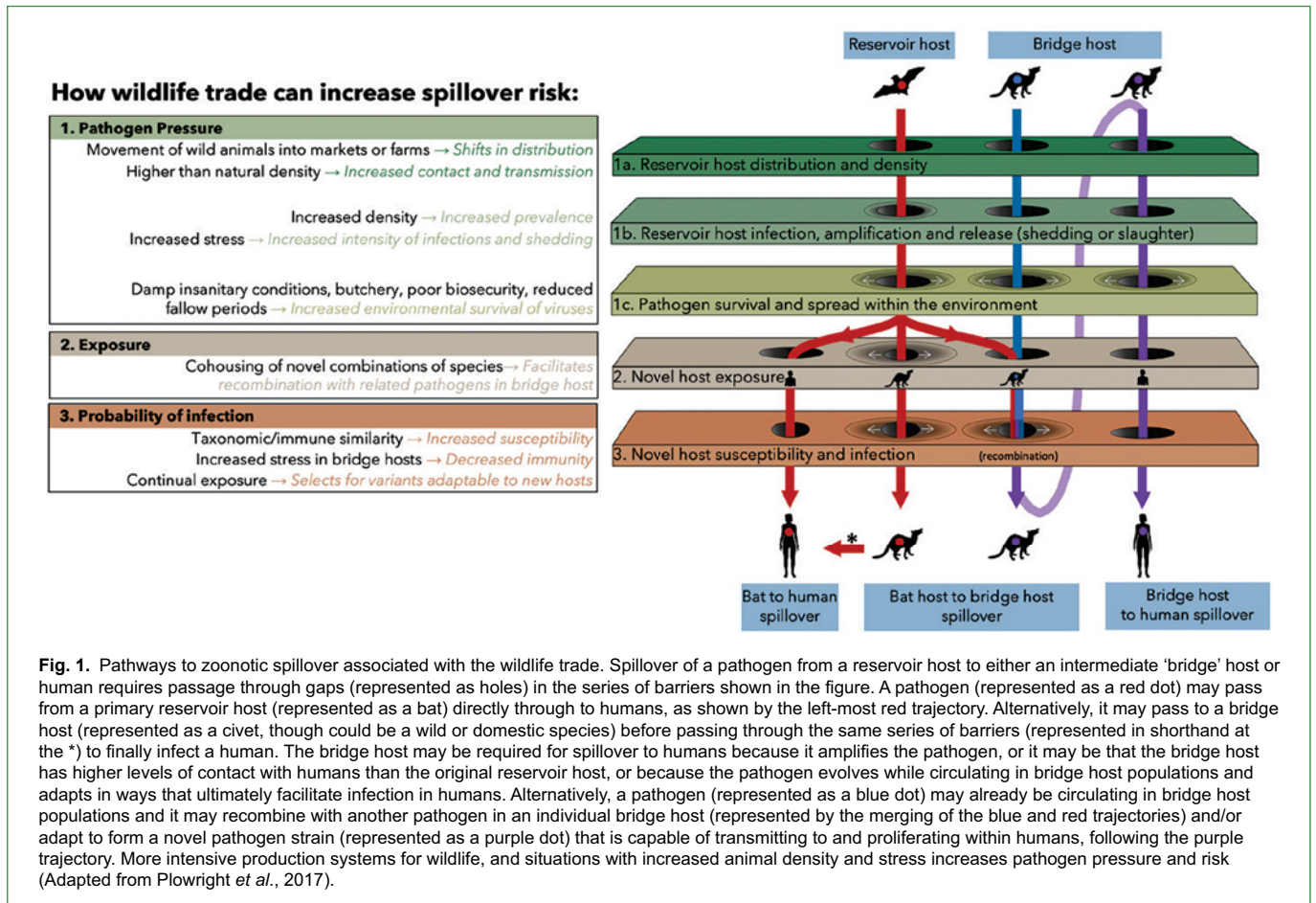
The initial responses to COVID-19 focused on closing markets (in particular wet markets) in which wildlife is sold as food and reopening them only when they met strict food safety and hygiene standards (Briggs, 2020; Forgey, 2020; Greenfield, 2020). The World Health Organization (WHO) and many prominent conservation organizations called on governments to ban the sale and trade of wildlife for human consumption altogether (Coalition to End the Trade, 2020; Walzer, 2020). In addition, there have been mounting calls to reform a range of public health and conservation multi-lateral agreements to ensure improved governance capacity to manage pandemic risk (Díaz *et al.*, 2019; United Nations Environment Programme and International Livestock Research Institute, 2020; Gallo-Cajiao *et al.*, 2022).

The costs of the COVID-19 pandemic have highlighted the importance of minimizing the risks of every avenue of pathogen spillover, and we argue that developing a sustainable response to reduce the spillover risks associated with wildlife trade should incorporate decades of insights from governance practice and scholarship. This includes evidence from across policy domains including environmental management and conservation (Ostrom, 1990; Bennett and Satterfield, 2018; Biggs *et al.*, 2019; Roe *et al.*, 2020; Fukushima *et al.*, 2021), drug policy (Wälti *et al.*, 2004), and public health (Gaygisiz, 2010; Gostin *et al.*, 2020). There is vast diversity and context specificity in wildlife trade (Aguirre *et al.*, 2020)

and in how the emergence of infectious diseases is managed; both are part of complex socio-ecological systems characterized by multiple connections and feedbacks across scales (Wilcox and Gubler, 2005; Adger *et al.*, 2009; Biggs *et al.*, 2011; 't Sas-Rolfes *et al.*, 2019; Schlüter *et al.*, 2019; Fukushima *et al.*, 2021). Solutions lie in context-specific interventions that recognize this global diversity, anticipate complex interlinkages, and account for the voices and concerns of people affected by new policies and regulations (Challender *et al.*, 2015; Biggs *et al.*, 2019; Borzée *et al.*, 2020; Fukushima *et al.*, 2021; Petrovan *et al.*, 2021). Indeed, lessons from environmental governance highlight the limitations of policy solutions that are overly broad and based on speculative albeit popular narratives, such as attempts to ban all commercial wildlife trade and consumption across a wide range of cultural and contextual settings (Bonwitt *et al.*, 2018; Roe *et al.*, 2020). Instead, we advocate for responses that recognize the complexity of disease emergence and the on-the-ground diversity of wildlife trade dynamics globally, and that incorporate four key governance principles: equity, responsiveness, robustness, and effectiveness, that have been established over decades of research and practical experience (Ostrom, 1990, 2009; Bennett and Satterfield, 2018; Biggs *et al.*, 2019).

Governance should recognize the complexity of disease spillover

The environmental governance literature highlights the importance of recognizing and accounting for the complexity of social-ecological systems and the interconnectedness of social and environmental challenges (Biggs *et al.*, 2011; Schlüter *et al.*, 2019; Fukushima *et al.*, 2021). The risk of zoonotic spillover — cross-species vertebrate-to-human pathogen transmission — depends on a complex interplay of ecological, epidemiological, and behavioural factors that connect reservoir and recipient hosts in the three stages of the spillover process (Fig. 1) (Plowright *et al.*, 2017). First, host ecology, distribution, and infection dynamics determine where the pathogen is distributed in wildlife populations



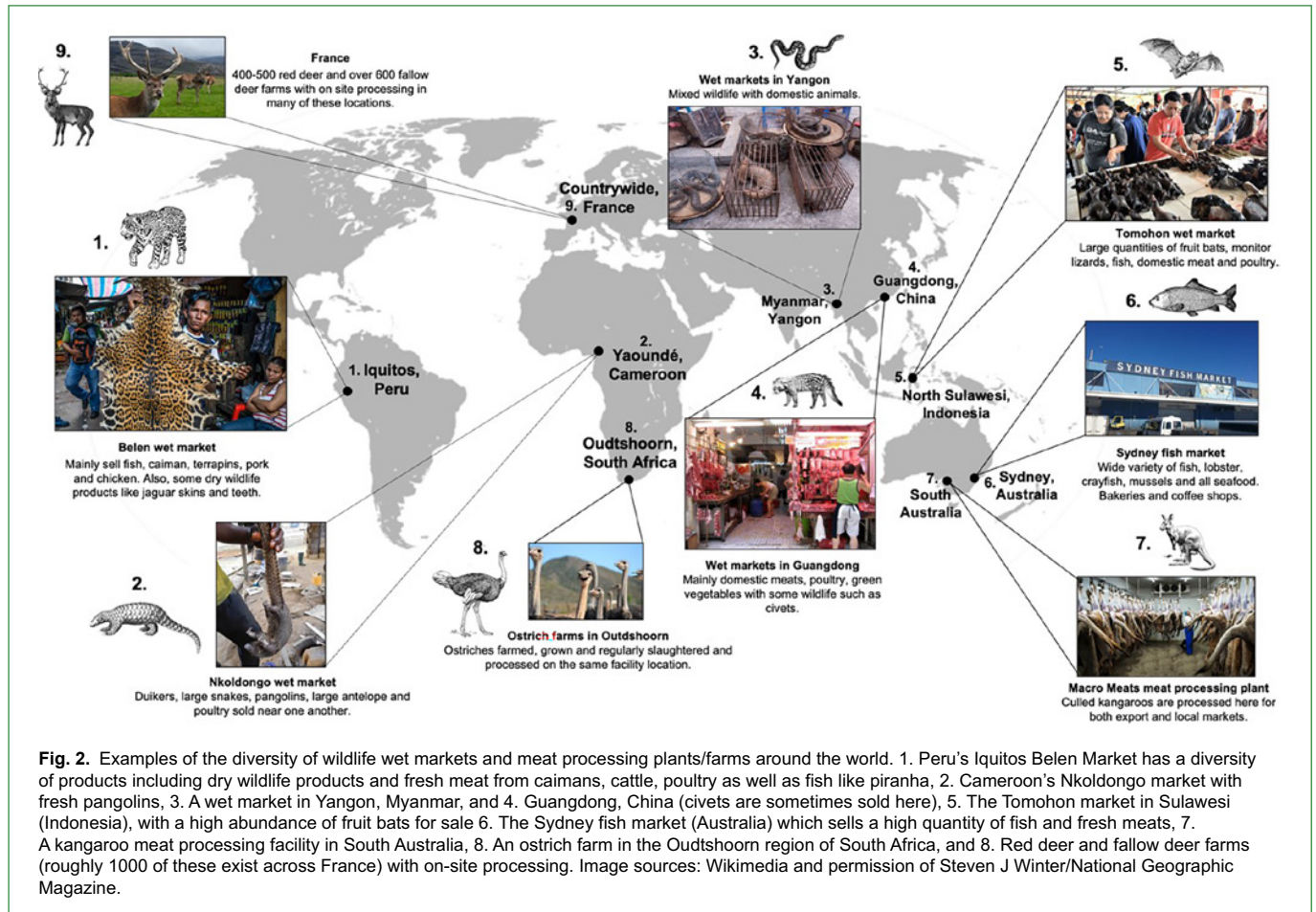
and its intensity within those populations across time and space (Fig. 1, layers 1a and 1b). The pathogen is released from wild animals (via excretion, slaughter, or a vector; layer 1b), and then the environmental conditions determine how much pathogen survives and is available to infect a novel recipient host at any point in space and time (Fig. 1, layer 1c). Second, reservoir host and recipient host behaviour determines the likelihood, method, and dose of pathogen exposure (Fig. 1, layer 2). Third, a range of biological factors determines the likelihood that cross-species pathogen exposure will result in an infection in the recipient host, such as compatibility with the pathogen, stress, and coinfections (Fig. 1, layer 3).

Various factors associated with wildlife trade – or indeed domestic animal trade – have been shown, or are hypothesized to influence the chain of events that align to result in spillover (Fig. 1). The risks of spillover, either directly to humans or to intermediate 'bridge' hosts that can subsequently pass the infection on to humans (Plowright *et al.*, 2017), are particularly high where humans congregate in dense crowds and come into close contact with a diversity of stressed live animals (Loh *et al.*, 2015; Gao *et al.*, 2016; Greatorex *et al.*, 2016; Lin *et al.*, 2021). In markets where wildlife is traded, the handling, butchering, preparation, and consumption of wildlife are all contact points at which humans can be exposed to novel pathogens (Ahl *et al.*, 2002; Monagin *et al.*, 2018; Huong *et al.*, 2020). Moreover, pathogen loads can also be amplified in wildlife markets and along trade chains (Huong *et al.*, 2020), leading to increased spillover risk. Various factors in wildlife markets and along trade chains could contribute to amplified pathogen loads and increased spillover risk; in particular, animals kept at high density in stressful, confined, and unhealthy conditions are more likely to have a higher load of a given pathogen than the same animals in their natural habitat, or under well-managed ranching or zoo conditions (Ashley *et al.*, 2014; Krkošek, 2017; Huong *et al.*, 2020). For example, an animal on a well-managed

wildlife ranch or game farm located within the species' natural habitat and species distribution is likely to be exposed to lower frequencies and intensities of pathogens compared to animals held and transported in unsanitary, crowded, and highly stressful conditions with multiple species assemblages (or in intensive farming systems; Fig. 1). High animal density in itself increases pathogen transmission (McCallum *et al.*, 2001) and chronic stress is well known to suppress immune function (Dhabhar, 2014). As such, the links between emerging zoonoses and the wildlife trade are heavily dependent on the scale of the trade, as well as how trade is governed and practised, including factors like marketplace configurations, welfare and sanitary conditions, and species mixes.

Governance should recognize the diversity of wildlife trade

Infectious diseases from the wildlife trade can emerge via multiple routes and settings (Fig. 1). However, the link between the Wuhan Huanan Seafood Market and the origins of SARS-CoV-2 (Aguirre *et al.*, 2020; Li *et al.*, 2020; Worobey, 2021; Worobey *et al.*, 2022), which was identified very early on in the COVID-19 pandemic, meant that the initial public discourse tended to focus on one specific end-point of the wildlife trade: wet markets, especially in Asia and Africa (and often overlooked similar wet markets across Europe and the Americas; Fig. 2). The term 'wet market', although typically defined as a market that sells fresh meat and produce (Kogan *et al.*, 2019), is often ambiguous (Box 1). Wildlife trade is diverse and heterogeneous (Phelps *et al.*, 2016), and markets vary in their commercial setting and spatial arrangements, the diversity and origin of products sold, their hygienic standards, and their clientele. Some are isolated and very small in size, such as those in rural settings in West or Central Africa selling bushmeat in villages and on roadsides, which often serve as commerce hubs for a cluster of villages (Fig. 2) (Willcox and Nambu, 2007). Other



markets are much larger, with higher quantities and diversity of wild, captive-bred, and domestic animals being sold together, mostly in large urban settings (Cronin *et al.*, 2015; Kurpiers *et al.*, 2016; Fa *et al.*, 2019; Latinne *et al.*, 2020; Zhong *et al.*, 2020). The contextual diversity of wildlife trade (Fig. 2) precludes governance using one-size-fits-all approaches and necessitates nuanced responses (Fukushima *et al.*, 2021).

Wildlife markets also fundamentally differ in their species compositions, and thus zoonotic risks. Certain taxa of mammals, such as rodents (Rodentia), ungulates (Perissodactyla and Artiodactyla), primates (Primates), and bats (Chiroptera), are recognized as potentially higher-risk sources of zoonotic spillover (Johnson *et al.*, 2020; Mollentze and Streicker, 2020). Large wet markets with live wildlife, including these high-risk species, are likely to pose the highest health risk (Fig. 2) (Edderai and Dame, 2006; Cronin *et al.*, 2015; Latinne *et al.*, 2020). Conversely, some wet markets pose fewer risks for public health due to well-managed sanitary conditions and the near absence of trade in live animals, such as in the Tokyo and Sydney fish markets. Interventions to address zoonotic risk must account for these diverse risk contexts.

As with wildlife markets, the wildlife trade itself as a whole is similarly diverse. The value of the legal global trade in wildlife is valued at around US\$300 billion per annum – more than ten times the size of the illegal trade (Harvey, 2020). The illegal trade is diverse and ranges from subsistence use and trade to large commercially oriented criminal operations ('t Sas-Rolfes *et al.*, 2019; Cardoso *et al.*, 2021). These legal and illegal sales include the 'dry' trade of animal products, breeding and selling of animals for zoos, and the pet trade (Broad *et al.*, 2014; Symes *et al.*, 2018; Foster *et al.*, 2019; Wong *et al.*, 2020). Animals may be directly harvested or captured from the wild, brought into captivity and raised to a marketable stage (ranching), or bred in captivity (Damania and

Bulte, 2007). The legal and illegal wildlife trade are sometimes inextricably linked, as wild animals may get mixed with captive bred populations and illegally laundered through licensed ranching or breeding facilities (Phelps *et al.*, 2016). Moreover, whilst the majority of recent emerging novel pathogens affecting humans have ultimately arisen from wildlife, livestock, and domestic animals have frequently been important bridge hosts (Jones *et al.*, 2008; Allen *et al.*, 2017).

International structures governing trade and disease

A range of domestic, regional and international multi-lateral agreements, organizations and initiatives have been established to govern (monitor, regulate, and enforce) human health, animal health, and wildlife trade (Table 1). Internationally, pathogen spillover falls between four sets of international organizational structures: the Convention on the Trade in Endangered Species (CITES – covering conservation and endangered species), World Organisation for Animal Health (WOAH – primarily livestock health), the World Health Organisation (WHO – human health), and the Food and Agriculture Organization (FAO – agri-food systems) (Table 1). The emergence of SARS-CoV-2 and the subsequent COVID-19 pandemic highlights the need for reforming international structures. A range of proposals exists for such reforms, as well as calls to establish an entirely new multi-lateral body (Karesh *et al.*, 2020; Gallo-Cajiao *et al.*, 2022). The One Health concept, which 'is an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals, and ecosystems' (One Health High-Level Expert Panel *et al.*, 2022) and deal with the integrated disease risks from wildlife, livestock, and humans holistically (One Health High-Level Expert Panel, 2022), has been

Table 1. Key multi-lateral organizations and international agreements and initiatives to regulate and manage wildlife trade, and animal and human health risks.

Body/Agreement/Institution	Function and role
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	Aims to ensure that the trade in wild animals and plants does not threaten their survival. The CITES secretariat is administered by the United Nations Environment Programme
Food and Agricultural Organization of the United Nations (FAO)	Aims to defeat hunger and improve nutrition and food security which encompasses wildlife trade and consumption and the impacts of emerging infectious diseases on food security and sustainable development
World Health Organization (WHO)	Specialized agency of the United Nations responsible for International Public Health
World Organization for Animal Health (WOAH, formerly OIE)	Coordinates, supports, and promotes the control of diseases in animals including those transmissible to humans. Provides certification to the World Trade Organization that animal and animal product trade standards to regulate disease risks are adequate

under development for more than a decade (Food and Agriculture Organization of the United Nations *et al.*, 2021b).

The application of One Health principles in addressing societal, animal health, and environmental challenges still face hurdles that hinder their widespread adoption (One Health High-Level Expert Panel, 2022). While the One Health approach has shown immense potential in mitigating the risks associated with wildlife trade, One Health is not legally binding and there is still much work to be done to expand its influence, adoption, and tailor its implementation to the multiple dimensions and actors of wildlife trade. The success of implementing One Health principles hinges on the ability to tackle complex and dynamic challenges by adapting governance systems to heterogeneous sectors by adopting a systematic and collaborative approach that encourages stakeholder engagement, promotes knowledge sharing, and fosters innovation. By doing so, we can harness the potential of One Health to address the challenges of wildlife trade risks and other related issues, while promoting sustainable development and safeguarding the health of people, animals, plants, and the environment.

A range of multi-lateral organizations and international agreements and initiatives to regulate and manage wildlife trade, and animal and human health risks (see Table 1). Of the four structures in Table 1, CITES is the only one explicitly focused on transnational wildlife trade. CITES came into force in 1975, has 184 signatory parties and regulates the trade in over 38,700 species globally, of which around 5950 are animals, with the aim to ensure that international trade in specimens of wild animals and plants does not threaten their survival. The CITES secretariat operates on an annual budget of USD ~\$15–20 million (CITES Secretariat, 2019). CITES has existing collaboration agreements with WOAH, and at the onset of the COVID-19 pandemic, the WHO referred to CITES as the body it defers to on issues of wildlife trade (CITES, 2021). Because the Convention is already well-established and legally binding, there are proposals that the mandate of CITES should be extended to include managing pandemic risk from wildlife trade (Weissgold *et al.*, 2020). Critics of using CITES as a body to manage pandemic risk from wildlife trade argue that any legally binding changes to the CITES mandate would require agreement by a majority of the signatories, which could be challenging (Lieberman, 2020). Critics also argue that CITES only regulates trade in endangered species and only international trade, and this limits its usefulness in reducing the risk of disease spillover (Lieberman, 2020). Moreover, there are broad critiques that CITES governance itself overlooks key lessons from governance research and practice, which would carry over to disease risk management efforts (Challender and MacMillan, 2014).

Governance insights to reduce spillover risk in the future

Initial responses to the pandemic often focused on rules and laws about what is not allowed (e.g. trade bans) (Briggs, 2020;

Coalition to End the Trade, 2020; Forgey, 2020; Greenfield, 2020; Walzer, 2020). However, the structures and processes through which those rules are made, changed, and operationalized are critically important in governance, as evidenced by decades of scholarship on the subject (Ostrom, 1990, 2009; Bennett and Satterfield, 2018; One Health High-Level Expert Panel, 2022). We argue that the international community needs to agree to develop governance principles for wildlife trade and its link to health, which both account for existing known shortcomings (Biggs *et al.*, 2017; Roe *et al.*, 2020) and emerging disease risks. Those agreements and principles can inform international guidelines and standards that need to be incorporated into national and local practices, processes, and laws, with scope for each country and level of government translating them to their context (Thomson *et al.*, 2013b). Innovative initiatives and participatory mechanisms can be developed to improve early disease detection and prompt outbreak control. For example, the Participatory One Health Digital Disease Detection (PODD) smartphone app enables local community members in Chiang Mai, Thailand, to report signs of potential human or animal (domesticated or wild) disease outbreaks, which prompts health experts to conduct further investigation and implement timely public health measures (Yano *et al.*, 2018; Ending Pandemics, 2022).

Relevant principles of 'good' governance are well established through decades of scholarship and practice (Cox *et al.*, 2011; Bennett and Satterfield, 2018; United Nations Environment Programme and International Livestock Research Institute, 2020). Although expectations and practices vary widely across contexts, good governance generally refers to configurations that involve inclusive processes and produce fair outcomes (equitable); enable adaptation to diverse contexts and changing conditions (responsive); ensure that functioning institutions persist and maintain performance amidst perturbations (robust), and support the maintenance of system integrity and functioning (effective) (Bennett and Satterfield, 2018). We draw on these principles to reflect on existing international governance attempts, focused on CITES and WOAH (Table 2). These structures are themselves important to risk reduction; in a globalized world, insufficient risk management in one country or setting can very rapidly affect the entire planet, as COVID-19 has demonstrated.

EQUITABLE: ENABLE PARTICIPATION AND RECOGNIZE DIVERSITY

A key limitation in the governance and management of wildlife trade through CITES is that it relies on external, top-down policy making that has done little to enable the participation of stakeholders who most are affected by the rules governing trade (Table 2) (Challender and MacMillan, 2014; Challender *et al.*, 2019). Indeed, rules developed without the participation of the people most affected by them – and who are key to their effective and sustainable implementation – often fail (Table 2) (Biggs *et al.*, 2019; Roe *et al.*, 2020). Following the COVID-19 pandemic, there has been a renewed appetite for tangible, local-level behavioural change

Table 2. Considerations for strengthening institutions, structures, and processes to strengthen governance of the wildlife trade (One Health High-Level Expert Panel, 2022).

Principle of good governance	Definition	Key considerations, challenges, and solutions
Equitable	Processes are inclusive and produce fair outcomes. Rules and norms require the active consideration and participation of the people that are affected by them. Failure to do so risks implementation success and sustainability (Biggs <i>et al.</i> , 2019; Roe <i>et al.</i> , 2020)	<ul style="list-style-type: none"> – CITES (‘t Sas-Rolfes <i>et al.</i>, 2019; Challender <i>et al.</i>, 2019) and WOA (Thomson <i>et al.</i>, 2013b) receive criticism for lack of equity and participation by those affected in policy and rule development – New formalized processes for participation by those affected by rules are required – Structures and resources, for effectively incorporating inputs from affected communities into new policies and rules are required (Challender and MacMillan, 2014; Challender <i>et al.</i>, 2015)
Responsive	Adaptable to changing conditions and diverse contexts (Bennett and Satterfield, 2018)	<ul style="list-style-type: none"> – CITES (Challender <i>et al.</i>, 2015) and WOA (Thomson <i>et al.</i>, 2013a, 2013b), and the way regulations are implemented, are criticized for limited responsiveness to changing conditions and understanding (e.g. bans, and agricultural health control) – Tripartite agreement between FAO, WHO, and WOA needs to be percolated to the field level where surveillance at the human-animal interface should take place (Bhatia, 2020) – Monitoring and evaluation need strengthening and must include social and governance dimensions (Biggs <i>et al.</i>, 2019) – Structures and processes are required to strengthen feedback systems to policies and rules (Challender and MacMillan, 2014; World Organisation for Animal Health, 2021) – Develop a rapid and internationally coordinated response system to new diseases (World Organisation for Animal Health, 2021)
Robust	The combination of some local autonomy and the interaction with other governing bodies provides opportunities for experimentation and learning across multiple issues, arenas, and required to manage the diversity of contexts in which zoonotic disease emergence may take place (Cox <i>et al.</i> , 2010)	<ul style="list-style-type: none"> – The on-the-ground influence of the existing CITES and WOA structures has been criticized due to insufficient resources and capacity especially in lower-income countries (Dobson <i>et al.</i>, 2020) – New structures and processes for a multi-level governance system that spans the international to local levels with feedback between are required – Resourcing is required to strengthen capacity and implementation, especially in lower-income countries (Thomson <i>et al.</i>, 2013b; Dobson <i>et al.</i>, 2020)
Effective	Governance systems need to be effective in achieving their objectives and maintaining and supporting system integrity (Bennett and Satterfield, 2018)	<ul style="list-style-type: none"> – Monitoring and evaluation and feedback systems need to be strengthened (Challender <i>et al.</i>, 2015; Jolly, 2020) – One Health is criticized for lack of clear definition and agenda, it increases room for collaboration but lacks focus in action (Gibbs, 2014) – Increased resourcing is required to strengthen the effectiveness of the whole system (Dobson <i>et al.</i>, 2020)

(e.g. within markets and more broadly), and this may provide the impetus needed to shift towards more inclusive approaches to wildlife trade regulation, with greater rights devolution, more equitable local funding and the creation of diverse and resilient nature-based economies (Lindsey *et al.*, 2020; Roe *et al.*, 2020).

Moreover, when multiple cultures, value systems, and needs (e.g. livelihoods, food security) are at stake in policy development, as is the case with wildlife trade and wet markets, a process is required to incorporate diverse cultural values and perspectives with scientific evidence, to understand and address risks (Table 2) (Challender and MacMillan, 2014). For example, in the 2014 Ebola crisis in West Africa, initial failures to consider the traditional burial practices of local communities led to unintended outbreak spikes, which were only quelled when safer, yet still culturally acceptable, burial standards were developed (Rodriguez-Dod *et al.*, 2016). Where wildlife markets are important to livelihoods and food security, incorporating local cultural and livelihood concerns is crucial (Roe *et al.*, 2020), and should be managed with the same sensitivity as meat and poultry processing plants that continued to

operate in many countries even after the risk of becoming COVID-19 super-spreading points was recognized (Günther *et al.*, 2020).

Some argue that the devastating cost of the COVID-19 pandemic outweighs the cultural, livelihood, and commercial impacts of a ban on all wildlife trade (Coalition to End the Trade, 2020). Regardless of the perceived importance of cultural values relative to the negative impacts of pandemics (Coalition to End the Trade, 2020), we argue that proposed solutions that overlook core equity and governance dimensions are more likely to fail, especially if there is insufficient information for evidence-based policy making and action. Ensuring that diverse perspectives and cultural values, including those that may be more permissive of trading wildlife from a moral standpoint, are considered as part of new policy development will improve effectiveness and sustainability (Biggs *et al.*, 2019; Thomas-Walters *et al.*, 2020; Cheung *et al.*, 2021; One Health High-Level Expert Panel, 2022). Learnings from the effectiveness of participatory tools like engagement with local communities in Guinea, the PDD smartphone app in Thailand, and the ISIKHNAS participatory system in Indonesia for real-time

livestock disease reporting all point to the importance of solutions that are tailored and appropriate for the relevant stakeholders involved (Yano *et al.*, 2018; United Nations Office for Disaster Risk Reduction, 2021; Ending Pandemics, 2022; Guenin *et al.*, 2022).

We propose an inclusive participatory approach to developing new regulations and measures that strengthens equity and responsiveness in governance. Iterative participatory workshops should be held with participants, including traders and consumers, to account for the livelihood and cultural impacts of stronger regulations or bans, and supported by other processes such as interviews and surveys with relevant stakeholders. Importantly, individuals involved in the regulatory enforcement should also participate. The objective of these participatory processes is to identify ways to reduce health risks, whilst ensuring that stakeholder concerns are accounted for, so as to not undermine the ultimate aims of the policies. Strengthening inclusivity can make wildlife trade governance more adaptable to changing conditions and diverse contexts (Cox *et al.*, 2011; Pooley *et al.*, 2015; Bennett and Satterfield, 2018; Cheung *et al.*, 2021).

Accounting for the challenges of operating in a post-colonial context has been a critical shortcoming of the implementation of CITES and wildlife trade agreements to date (Adams and Mulligan, 2012; van Uhm, 2016). In many countries, wildlife laws and enforcement stem from a formal bureaucratic structure based on the European colonial period (Mkumbukwa, 2008). The structure of enforcement emerged in Europe, and in many cases does not align with the cultural context in which it is implemented (Fukuyama, 2014). This leads to weak enforcement and poor effectiveness. This is particularly concerning as developing nations have the highest risk of emerging infectious diseases due to the intersection between livestock and wildlife, and poor public health capacity (Walsh *et al.*, 2020).

Moreover, the proposal that only indigenous peoples should be permitted to trade in and consume wildlife in the face of commercial trade bans (Coalition to End the Trade, 2020) is problematic in many post-colonial settings. For example, in sub-Saharan Africa, there are ongoing debates as to who qualifies as indigenous (UN Secretariat of the Permanent Forum on Indigenous Issues, 2009). Moreover, the line between traditional and commercial trade and use can be unclear, as the actions, people, and supply chains involved grade into each other, as has been shown in West Africa and Samoa (Phelps *et al.*, 2016).

RESPONSIVE: ENHANCE MONITORING AND EVALUATION

Integrated monitoring, evaluation, and feedback systems should ensure that new governance approaches are adaptable to changing environmental and social conditions. This includes new diseases, novel hosts, and changes in wildlife trade patterns and practices (Phelps *et al.*, 2016) – particularly of high-risk species and trade practices. Monitoring and evaluation should also track the four dimensions of governance, including changing perceptions of equity, aspects of cultural acceptability, and measures taken to adapt rules and enforcement practices to local contexts (Table 2). A mechanism should be established for regular reporting on efforts to monitor and evaluate high-risk wildlife trade practices, including the aspects of cultural acceptability, and on the response measures taken to adapt rules and enforcement practices. This would strengthen the governance principles of responsiveness, effectiveness, and robustness. For example, during the 2014–2016 Ebola outbreak in West Africa, community monitoring of attitudes and practices was critical to more responsive decision making and strategies to manage the outbreak (Gillespie *et al.*, 2016). Similarly, community-centred approaches were introduced to monitor and manage the 2018–2019 Ebola outbreak in the Democratic Republic of Congo, so as to tackle the initial resistance of local communities to health workers. The initial resistance resulted from mistrust in government initiatives following decades of unresolved conflict in the region, and a top-down structure in the outbreak response that

was not adapted to the local context (Masumbuko Claude *et al.*, 2019; Ntumba *et al.*, 2019; Ascuntar, 2020).

Participatory techniques with traders and enforcers can be used to trial and evaluate the likely success and sustainability of proposed changes to wildlife rules. Such an approach can support the effective use of context-specific rules on indigenous and traditional uses in contexts like Australia where there is greater agreement on who qualifies as indigenous, and what qualifies as traditional use, but not in settings like West Africa where such clarity and agreement is lacking. Through a participatory approach, scientific evidence of health risks is combined with local stakeholder knowledge and perspectives to develop solutions that are culturally- and livelihood-sensitive (Gillespie *et al.*, 2016).

Strengthening equity enhances responsiveness. The severity of the COVID-19 pandemic, as well as recent social marketing campaigns, may lead to attitudinal shifts in the trade and consumption of wildlife (Yang *et al.*, 2007; Ascuntar, 2020). A responsive governance system will enable such shifts to be incorporated into new rules and policies for wildlife trade and wet markets. Such new guidance was implemented for meat and poultry processing plants in the USA following the onset of the COVID-19 pandemic (Attwood and Hajat, 2020; US Centers for Disease Control and Prevention, 2020).

ROBUST: STRENGTHENING INSTITUTIONS ACROSS MULTIPLE LEVELS

Policies and laws governing wildlife trade need to be stronger across levels and scales in a nested fashion. There is often a strong focus on international commitments (e.g. Table 2), but these require implementation by regional, national, and sub-national bodies, within other governing bodies at local levels (i.e. city, market, district, provincial, and national levels). Such nested structures and systems are critical to operationalizing rules at the local level, and can also strengthen the legitimacy and responsiveness, so that rules are adapted to changing local conditions (Cox *et al.*, 2011; Bennett and Satterfield, 2018; Biggs *et al.*, 2019). This further provides opportunities for the experimentation and learning across multiple scales (Table 2) (Cox *et al.*, 2011; Biggs *et al.*, 2019). A functional multi-level governance system is required to manage the diversity of contexts and ways in which zoonotic disease emergence may take place (Fig. 1), although such a system is challenging to develop. For example, many parties that joined the CITES convention took decades to adopt the domestic legislation needed to operationalize those commitments (e.g. aligned protected species lists), and in some instances, such legislation has still not been introduced (McOmer, 2001). WOA's Wildlife Health Framework emphasizes the importance of partnerships with INTERPOL and CITES in addressing wildlife trade in an integrated manner (World Organisation for Animal Health, 2021). Additionally, in some cases, countries that have domestic legislation in place often fail to implement those laws, as they are typically externally developed without local participation and lack perceived legitimacy (Biggs *et al.*, 2019). Overlap among international organizations can pose challenges for global governance (Heucher, 2019; Haftel and Lenz, 2022), and with multiple bodies involved in wildlife trade governance (Table 1), affirming the areas in which each institution should have jurisdiction will improve effectiveness. The intensification of wildlife trade requires governance to adapt accordingly, especially given the intersections between wildlife farming, ranching, domestication, and commercial production in diverse animal use systems (Fenollar *et al.*, 2021; Kock and Cáceres-Escobar, 2022). Lessons may further be sought from other governance institutions, such as the World Trade Organization's (WTO) regulatory framework for food safety and animal health standards in the international animal trade (World Trade Organization, n.d.). We propose that formal requirements be developed for the incorporation of the outputs from participatory processes and that evidence of social monitoring and evaluation

is considered under new national or international guidelines and rules on wildlife trade, such as new CITES regulations. This will ensure that cultural and livelihood concerns and the complexities of implementing rules in different cultural and socio-economic settings are accounted for, to strengthen the likely effectiveness and sustainability of implementation.

EFFECTIVE: PROVIDE RESOURCES AND BUILD CAPACITY

Proposed governance reforms are only as good as their on-the-ground implementation, which requires capacity for informed, accountable, and efficient operationalization of policies (Table 2) (Ostrom, 1990). The continued, ineffective implementation of CITES-related and other laws along wildlife trade supply chains and in consumer markets remains a risk for future spillover events (Chaber *et al.*, 2010). Numerous calls point to the need for significant funding increases to reduce the risks of future pandemics. For example, CITES is heavily underfunded, even in the absence of added disease risk monitoring responsibilities (Dobson *et al.*, 2020). Some scholars have called for significant changes to how CITES functions to improve its effectiveness (Cooney *et al.*, 2021). Moreover, incorporating the principles of good governance requires additional resources. Critically, funding should not only be directed to the enforcement of wildlife laws (effective implementation) but equally to strengthening the governance structures and processes we describe above (Gibbs, 2014). Given that potential transboundary differences in policies, governance, and enforcement effort can weaken collaborative efforts, adequate resources are necessary to address transboundary risks for wildlife trade regulations to be effective (Liu *et al.*, 2020).

Effectiveness requires timely responses to emerging risks, such as potentially dangerous new virus strains. Effectiveness also requires that planning and management decisions are informed by the best available knowledge, which includes diverse knowledge types (e.g. natural and social) and sources (e.g. scientific, local communities, indigenous peoples) (Tengö *et al.*, 2014; Bennett and Satterfield, 2018). The inclusion and participation of those affected by new rules take time. Critically, sometimes a high-level risk is identified that requires immediate regulatory action, such as an immediate ban or closing of practices. Examples of such immediate responses are the Chinese nationwide ban on wildlife trade for food consumption (People's Republic of China, 2020a, 2020b) and legislative measures in Vietnam to halt all illegal wildlife trade (Coalition to End the Trade, 2020), following the start of the COVID-19 pandemic in early 2020. However, to increase effectiveness and sustainability, these immediate bans should be implemented simultaneously with more extensive community and stakeholder engagement, including evaluation of (a) impacts of the ban on livelihoods and cultural practices, (b) participatory mechanisms to find ways to address these, and (c) identifying ways to implement bans that align with local cultural contexts and governance systems.

Conclusions and a way forward

Wildlife trade has been recognized as a pathway for pathogen spillover, in addition to substantial risks from domestic animal trade, land-use change, agricultural expansion and intensification, and urbanization (Bogich *et al.*, 2012; IPBES, 2020; Plowright *et al.*, 2021; Kock and Cáceres-Escobar, 2022). Reducing the risk of spillover from wildlife trade requires new efforts to govern harvesting, farming, use, and trading of wildlife. On the international stage, this may involve reform and adaptation of existing bodies like CITES to incorporate disease risk from wildlife trade, intensification of wildlife production and use into their scope, or the creation of a new consortium or body. Such efforts could yield long-term benefits beyond the current need of managing pandemic risk. However, successful risk reduction is likely to involve far more nuanced approaches than one-size-

fits-all policies, blanket bans or simply extending mandates and may require substantial institutional reforms. The weaknesses and failures of prior governance approaches must be addressed and learned from, both internationally and within countries. Examples already exist of approaches to explore to reduce disease risk along trade value chains from decades of efforts on food safety and livestock (Biggs *et al.*, 2021). Addressing risk at critical control points along value chains can be informed on-the-ground realities of disease emergence and trade complexity in different contexts, while complying with the requirement of a strong international framework. Proactive actions are beneficial (Dobson *et al.*, 2020), and urgent reform of the regulation of the wildlife trade is clearly needed. The incorporation of the principles of good governance, and working from examples in other sectors are far more likely to deliver more sustainable gains for human health, animal welfare, and conservation than current approaches.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ETHICS STATEMENT

This work did not require ethics approval.

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AUTHOR CONTRIBUTIONS

D.B., A.J.P., A.R.B., H.C., H.C.-E., J.P., R.K.P., and H.M. led the conception and writing of the manuscript. C.A., C.-Y.C., R.D.O., J.V.R., and J.V.V. contributed to the writing of the manuscript.

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