New approaches to wildlife health

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Summary

Recent environmental change and biodiversity loss have modified ecosystems, altering disease dynamics. For wildlife health, this trend has translated into increased potential for disease transmission and reduced capacity to overcome significant population-level impacts, which may place species at risk of extinction. Thus, current approaches to wildlife health focus not on the absence of disease but rather on the concept of health promotion. That is, wildlife populations will be more resilient to disease if they have the basic requirements for survival, as well as functioning ecosystems, within an enabling socio-economic environment. In this context, animal health programmes must adapt to design and implement wildlife health programmes that bridge knowledge gaps and fully integrate conservation goals. This article proposes new pathways and additions to the animal health management toolbox, including new approaches to surveillance and information management, partnerships and new wildlife health management practices. The traditional approach to disease surveillance in wild animals solely because of risks to domesticated animals and human health has now been replaced by a drive to recognise the intrinsic value of wildlife and the extended benefits of actively pursuing ecosystem health and associated life-sustaining ecosystem services. In this context, it is paramount to transition to holistic health programmes embracing One Health as a pathway to set the health of all on equal footing.

Keywords

Conservation – Ecosystem health – Health promotion – One Health – Paradigm shift – Partnerships – Prevention – Surveillance – Systems thinking.

Introduction

Recent years have been marked by dramatic environmental change, leading to ecosystem changes that are triggering disease emergence with increased frequency. Wildlife loss is occurring at unprecedented speed and scale. Natural barriers between species, such as intact habitat, are being disrupted, enabling pathogen spillover and adaptation to new hosts. Climate change favours pathogen, host and vector expansion, forcing species overlap and enhanced transmission. Industrialised food production systems are facilitating selection of super pathogens at an accelerated pace. Globalisation precipitates disease spread worldwide within days [1].

Underlying this new 'normal' are univocal anthropogenic drivers of biodiversity decline, natural buffer erosion and loss of essential ecosystem services. Moreover, human choices and preferences now also modulate novel and complex trade and value chains that confront existing mechanisms to manage disease risk. This major paradigm shift is reflected in several recent startling events that have challenged the foundations and legitimacy of health and surveillance systems, e.g. the emergence of Covid-19 and the unprecedented expansion of high pathogenicity H5 avian influenza in wildlife. Of unparalleled relevance is evidence of the inadequacy of existing systems to predict, and more importantly prevent, disease emergence and cascading impacts and to assist with population recovery. A major impediment is the underdevelopment of the field of wildlife health, which is in stark contrast to the relatively sophisticated and adaptive mechanisms and structures in equivalent settings for agricultural animal species and public health. Even with major scientific advances, three years after the emergence of SARS-CoV-2 the scientific community still cannot pinpoint a source species or mechanism of emergence of this most recent pandemic [2]. Furthermore, how SARS-CoV-2 spilled over into white-tailed deer (*Odocoileus virginianus*) and then back to humans, and whether these deer now act as competent reservoirs, far from the virus's geographical origin and evolutionary host, is also largely unclear [3].

Diseases are also taking a devastating toll on wildlife populations. The massive die-offs of seabirds and marine mammals in South America since 2022 from high pathogenicity H5 avian influenza are the most catastrophic events ever recorded for wildlife in the

Southern Hemisphere [4-6]. Several such events confirm that diseases no longer threaten only endangered populations. In fact, when combined with synergistic threats (e.g. climate change and overexploitation), they may also push relatively abundant species beyond resilience and recovery. These challenges are likely to accelerate, resulting in urgent calls for action on several fronts, with wildlife health and conservation at the centre. The traditional approach to surveillance in wild animals solely because of risks to livestock and human health has been replaced by a drive to recognise the intrinsic value of wildlife and the extended benefits of actively pursuing ecosystem health and associated life-sustaining ecosystem services. In this context, transition to holistic health programmes embracing One Health as a pathway to set the health of all on equal footing is paramount. Animal health systems will need to balance the requirements for trade with requirements to promote population and ecosystem health and sustainability. This will enable current apparently antagonistic sectors to join in collaborative, win-win efforts that aim for mutual benefits and preserve a positive public image of wildlife. For example, the detection and reporting of high pathogenicity avian influenza in wildlife does not affect livestock trade; rather, it enables countries to activate response strategies aimed at reducing impacts on affected wildlife while stimulating the poultry industry to increase biosecurity or turn to other protective methods such as vaccination.

Overcoming challenges to address wildlife health

Unlike traditional animal health programmes that focus on a limited number of domesticated species and diseases, the design of wildlife health programmes presents major challenges given the vast number of species, transboundary distribution and limited knowledge of the disease threats they must cover. An additional hurdle stems from inadequate governance structures to address the complexities of wildlife health and disease management. At the country level, animal health, public health and wildlife management have generally been managed by different sectors within rigid government compartments. Thus, when faced with the need to manage wildlife disease risks, countries often default to suboptimal wildlife health programme designs, like resorting to the best possible option within a constrained mandate and framework intended for domestic animals and equipped with professionals with limited wildlife-specific skills. Operationalising such programmes within a One Health, cross-sectoral framework is one way to overcome limitations as the systems evolve towards more comprehensive schemes. However, true operationalisation is laborious and difficult within conventional compartmentalised structures. Partnerships, networks and collaborations with external stakeholders may allow for more rapid and fluid enhancement of government capacities.

Alternative models also exist, in which wildlife health surveillance sits primarily outside the government realm yet is embedded in a network of collaborating government agencies and relevant private and public actors. Successful examples are Wildlife Health Australia [7] and the Canadian Wildlife Health Cooperative [8]. Notwithstanding, the prerogative for animal health, including wildlife health management, broadly remains within government bodies that are shaped for responding primarily to the needs of trade and food production. Here, conflicting interests may stall progressive change.

The next phase of wildlife health

While classical veterinary preventive approaches continue to be relevant in some cases, the following are new pathways and additions to the animal health management toolbox that aim to bridge existing gaps and fully integrate conservation goals:

- new approaches to surveillance and information management
- the need for partnerships
- new wildlife health management approaches.

New approaches to surveillance and information management

Many recent publications delve into the practicalities of building wildlife health surveillance programmes [9], provide details on the necessary attributes and purposes of such programmes [10] and offer alternative, locally driven, bottom-up approaches for limited-resource settings [11]. Moreover, some expand on the multi-purpose benefits of wildlife disease monitoring, particularly for the early detection of zoonotic diseases [7]. In addition, innovative data collation and information management systems that incorporate technological advances like machine-learning algorithms provide unconventional low-cost strategies for expanded effectiveness and timeliness of wildlife disease surveillance [12]. The charismatic nature of wildlife species also favours contributions from enthusiastic and concerned citizens [13], which are especially useful for easily identifiable disease traits (e.g. alopecia [14,15]). Invariably, as more countries expand their wildlife surveillance capacities, the wealth of success stories and lessons learned will also expand. Transnational communities of practice can provide forums for consultation and problem-solving and, over time, become solid knowledge and experience brokers.

In the past two decades, several needs and impediments for adequate wildlife disease surveillance, research and diagnostics have been identified [16], and some recommendations to overcome these barriers have been put forward [17]. Yet beyond

technological improvements that facilitate sample preservation and increase the accuracy of diagnosis, solutions for many wildlife-inherent limitations, such as access to quality samples, adequate sample sizes and missing denominator data (e.g. population size), remain elusive. Moreover, a major gap of increasing concern is the disparity in access to specialised diagnostic laboratories, substantially worsened by restrictions to the rapid movement of diagnostic specimens even during emergencies. Such is the case of international conventions originally intended for the protection of wildlife, like the Convention on International Trade in Endangered Species of Wild Fauna and Flora [6], which often delay timely diagnosis and deter relevant research advances. Without diagnosis, early warning and rapid interventions are not possible, severely limiting suitable and timely responses and thus undermining the purpose of having a wildlife surveillance system in the first place. Numerous solutions to this conundrum exclusive to wildlife species (these limitations do not affect domestic animal or human diagnostic specimens) have been proposed, and it is in humans' highest interest as a species heavily impacted by zoonotic pathogens to act on this front. New on-site diagnostic technologies, connected to integrated data and information management systems, hold great promise for improving wildlife health surveillance and preventing pathogen spillover.

Perhaps the most relevant aspect in forward-thinking surveillance is to find practical, cost-effective ways to emphasise and achieve risk reduction and environmental biosecurity. An adequately trained workforce and real-time notification platforms congruent with modern capabilities are increasingly viable aspirations. At a very minimum, wildlife health surveillance must adjust to wildlife health priorities and be capable of eliciting resource mobilisation equal to that for domesticated species.

The need for partnerships

The breadth of proficiencies, means and geographic coverage needed for immediate deployment in response to wildlife health events or for adequate wildlife health surveillance can be daunting. Thus, a simple way to develop a wildlife component within domestic animal health programmes is to collaborate with other government agencies (e.g. environmental ministry) or to establish partnerships outside government regulatory offices, such as with academia or non-governmental organisations. In both cases, but particularly when engaging with the private sector, collaborations must be built on mutually beneficial terms, transparency and equity and based on trust. They must also operate in an enabling and supporting environment. Many countries will need to pass

and enact legislation changes, as well as transform in-house culture, to allow for this shared, pragmatic vision.

In an era when public access to information is not only valued but expected, and when mechanised data processing can streamline performance, a surveillance system that is cost effective and transparent and that aligns sectoral interests can be transformative. In this direction, information-sharing platforms are visible and practical ways to quickly demonstrate value and grow wildlife health surveillance capabilities. Information-sharing systems should be fit for purpose, entice and reward voluntary data sharing and be built so their utility increases exponentially with data input. Importantly, wildlife health data sharing should not inappropriately impact trade of agricultural products to encourage transparency in information sharing.

At the highest levels, multilateral agreements such as the Quadripartite and the One Health High-Level Expert Panel are expected to set the global stage for a more prominent role of the environmental component in reduction of health risks. It is important that these global health and global environmental policies and agreements at the international and national levels have inclusive governance that includes the environmental, veterinary and human health sectors to ensure solutions are optimised for all sectors. Fortunately, there is a growing body of wildlife health experts (e.g. the Wildlife Disease Association) who can advise on and participate in these forums, and new professionals are deeply aware of the pressing needs for wildlife survival and ecosystem health.

New wildlife health management approaches

Diseases in wildlife populations have traditionally been managed using classical veterinary preventive techniques such as vaccination (e.g. rabies [18]), population manipulation, including culling (e.g. chronic wasting disease [19]), and regulatory actions such as movement restrictions and quarantine [20]. However, these techniques have not always been successful in wildlife populations due to challenging logistics, high costs and lack of acceptance by the public. Fundamentally, disease management should not be detrimental to wildlife. Consequently, the limitations of these disease-centric approaches are increasingly recognised [21].

Current concepts on the health of wildlife populations go beyond the mere absence of infectious agents or contaminants to include key concepts related to population sustainability and resilience, which form the main determinant of wildlife health [22]. This

has led to the concept of health promotion: that wildlife populations will be more resilient to disease if they have the basic requirements for survival, including food, water and space (for social interaction, breeding, territory), and functioning ecosystems, within an enabling socio-economic environment. In other words, the fewer ecosystem stressors there are, the more resilient the wildlife populations will be. In addition, local communities that value wildlife and engage in protection of local wildlife will help to increase population resilience. This requires focusing actions on the socio-economic and environmental determinants of health. The One Health Impact Pyramid (Fig. 1) [23] was developed to help design interventions that effectively integrate conservation and environmental needs to create holistic solutions for human, animal and environmental health. At the base of the pyramid are interventions aimed at environmental (e.g. land-use change, climate change and pollution) and socio-economic factors (e.g. poverty, education and access to sanitation) considered to be the underlying determinants of all health. The One Health Impact Pyramid suggests that initiatives addressing the base of the pyramid have the greatest potential to improve all health but are also the most challenging to implement.

For example, studies demonstrated that the increase in Hendra virus spillovers from fruit bats in Eastern Australia was the result of combined habitat loss and climate change [24]. El Niño events result in decreased flowering of the eucalyptus tree, the main food of fruit bats. Further, clearing of the forests has resulted in bats foraging closer to human habitation, increasing the risk of spillovers. This work points to a potential win-win solution in which reforestation of bat habitat will not only allow the bats to thrive, but also reduce the risk of viral spillover.

Systems-thinking approaches include numerous methods for identifying root causes of problems and potential interventions amid complexity and uncertainty [25]. Systems approaches are designed to reveal the root causes of events by identifying the underlying patterns of behaviour, supporting structures and mental models of a system with the goals of gaining new perspectives and identifying leverage points in the system. These methods may assist in identifying interventions at the socio-ecological level. For example, the emergence of Covid-19 may be viewed as a socio-economic and environmental issue, driven by the unregulated trade and marketing of wildlife species, some of which represent important sources of food or are central to cultural practices for many communities. Proactive approaches that seek alternative economic opportunities for these communities and focus on sustainable and responsible wildlife use may help prevent future pandemics and have positive outcomes for wildlife conservation.

Recognising that ecosystems are transforming under climate change and other stressors, with substantial shifts in ecological processes and important ecosystem services occurring at unprecedented rates, decision tools have been created to help prioritise systems in which interventions will be beneficial. These decision tools can also be applied to wildlife health management. For example, the RAD Framework [26] lays out three approaches for making management decisions for systems undergoing ecosystem transformation: i) resist, in which one works to maintain or restore ecosystem composition, structure, processes or function on the basis of historical or acceptable current conditions; ii) accept, in which ecosystem composition, structure, process or function is allowed to change autonomously; and iii) direct, in which managers actively shape change in ecosystem composition, structure, processes or function towards preferred new conditions.

Ultimately, long-term sustainable solutions that optimise outcomes for human, animal and environmental health are required. In this regard, nature-based solutions – defined as actions to protect, sustainably manage and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously benefiting people and nature [27] – should also be considered as strategies to manage wildlife health. Nature-based solutions address societal challenges through the protection, sustainable management and restoration of both natural and modified ecosystems, benefiting both biodiversity and human well-being. They are underpinned by benefits that flow from healthy ecosystems. They target major challenges like climate change, disaster risk reduction, food and water security, biodiversity loss and human health and are critical to sustainable economic development. Such solutions can include diverse, multi-scale opportunities and may include standard practices (e.g. increase the number of protected areas, increase connectivity) [28] but may also include innovative practices (e.g. rewilding).

Finally, when managing population health, it is important to identify relevant health metrics and targets. Beyond detection of pathogens and pathology, few wildlife health metrics exist currently. However, novel metrics can include individual parameters such as fecundity, nutritional status and overall health status; population and metapopulation measures such as reproductive and survival rates; landscape or environmental indicators such as habitat quality and connectivity; and, finally, socio-economic factors [21].

Conclusions

Every crisis presents an opportunity. At this crucial time, there is a need for global guidance on how to better support wildlife and ecosystem health. In the absence of a unique overseeing body with a mandate over the breadth of wildlife health, informal collaborations are imperative. Key elements for advancement are building coordinated strategies for forecasting, planning, responding to and recovering from wildlife disease events; developing multidisciplinary communities of practice with strong representation of environment and wildlife health expertise; enhancing and facilitating access to state-of-the-art wildlife disease diagnostic and investigation capacities; and taking a step back to build and strengthen health-supportive and disease-preventive management approaches that halt diseases at their source.

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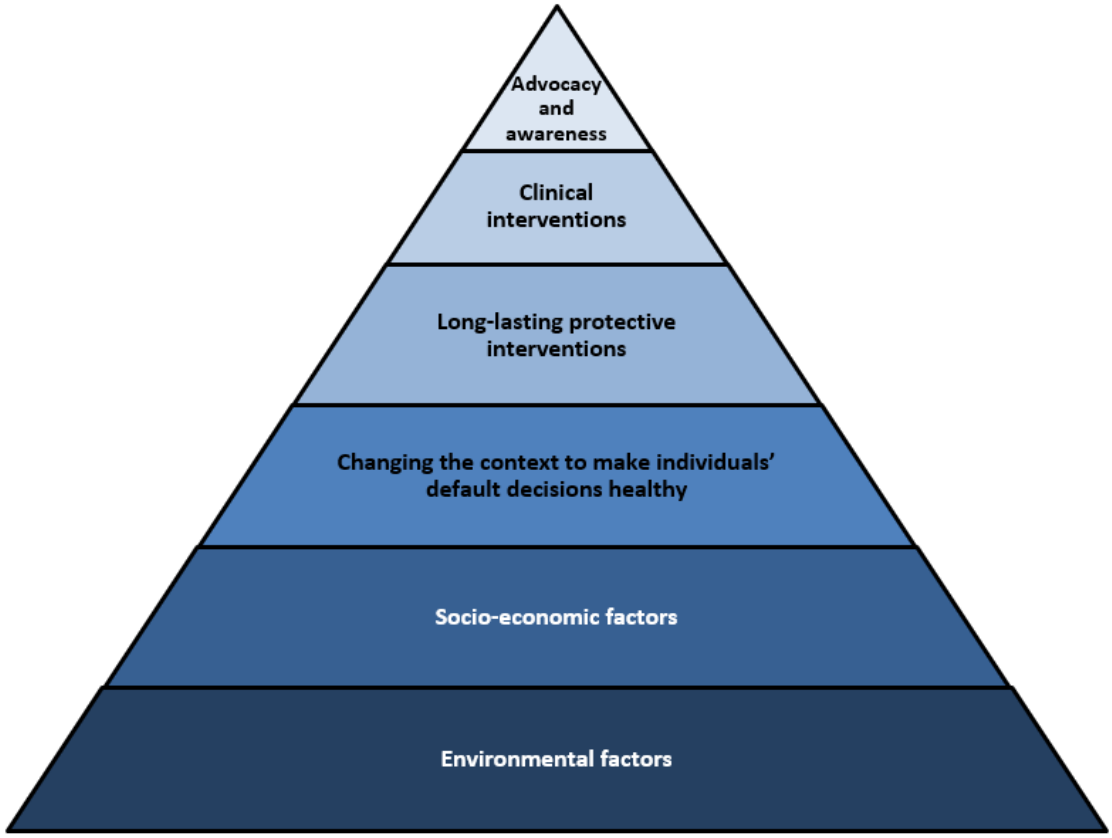

Figure 1

The One Health Impact Pyramid

The One Health Impact Pyramid (reproduced from [23]) illustrates different levels of interventions to improve health. Addressing the socio-economic and environmental determinants of health will have the greatest impact but can also be the most challenging to implement