Convention on the Conservation of Migratory Species of Wild Animals

CMS

ONE HEALTH CASE STUDIES: A RESOURCE FOR PARTIES TO THE CONVENTION ON MIGRATORY SPECIES

In partnership with

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One Health Case Studies: A Resource for Parties to the Convention on Migratory Species

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COVER IMAGE

Eurasian griffon vultures (*Gyps fulvus*) are at risk from non-steroidal anti-inflammatory drugs © Pierre Dalous/Wikimedia

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Executive summary

Context

One Health is now a widely used term and is defined by the One Health High-Level Expert Panel (OHHLEP) – an advisory group for the Quadripartite organisations (the Food and Agriculture Organization of the United Nations (FAO), the United Nations Environment Programme (UNEP), the World Health Organization (WHO) and the World Organization for Animal Health (WOAH)) – as '*an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems. One Health recognizes the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and inter-dependent*' (WHOa).

One Health is of great relevance to the Convention on the Conservation of Migratory Species of Wild Animals (CMS), not least as One Health approaches are recommended in CMS Resolution 12.6 (Rev. COP14) Wildlife Health and Migratory Species (UNEP/CMS, 2024a). The purpose of this report is to explore tangible One Health case studies to help demonstrate to CMS Parties how a One Health approach can be used to meet shared objectives, while highlighting key principles for its practical implementation.

The case studies were chosen, in part, to illustrate some of the key recommendations (with minor modifications) from the CMS Migratory Species and Health Review (Migratory Species and Health: A Review of Migration and Wildlife Disease Dynamics, and the Health of Migratory Species, within the Context of One Health) (Kipperman *et al.*, 2024). These recommendations are as follows and are highlighted throughout the selected case studies:

1. Tackle drivers of disease
2. Enable transdisciplinary health frameworks
3. Reduce the risks at interfaces between livestock/humans and wildlife
4. Tackle non-infectious health problems
5. Improve preparedness, planning and response
6. Improve reporting and information sharing
7. Fill knowledge gaps
8. Use and provide information sources for wildlife health
9. Encourage international/regional cooperation
10. Address funding needs.

The case studies

One Health is increasingly advocating for prevention of, and early intervention in, health problems. However, most attention and investment in One Health is currently directed towards known single health issues particularly those of anthropocentric concern. Therefore, these selected case studies reflect One Health as it is currently most commonly practiced, but not necessarily what it could be.

Notwithstanding, this arguably narrow view, the case studies involve a range of migratory species from different regions of the world and illustrate many aspects of wildlife health management that promote One Health outcomes. They include zoonotic risks reduction arising from wildlife protection, control of globally threatening and regionally important infectious diseases affecting wildlife, addressing (at source) pollutants that impact wildlife and their environments, and developing and maintaining regional surveillance networks.

Lessons learned from the case studies can help to identify practices and pathways to a more comprehensive approach to One Health that prevents, responds to and helps species recover from health problems.

Despite our collective understanding of the impacts of a recent global pandemic, there remains a persistent problem of limited action before impacts occur – a problem which has plagued public health for generations. There is, however, growing evidence and acceptance that biodiversity protection is a cornerstone of pandemic prevention as well as instrumental to sustainable development and community health. Therefore, there are growing expectations and opportunities for conservation instruments, such as the CMS, to achieve their goals while providing the co-benefits of public health protection and sustainability. Governments, international forums, multilateral agreements and civil society are increasingly advocating for health, environmental issues, and socio-economic drivers to be managed holistically across sectors and at multiple scales in a more coordinated and integrated fashion.

The case studies provide real-world examples of both preventative and reactive approaches to managing health from which several cross-cutting themes emerge,[1] namely:

Conservation and health are connected

Protecting and restoring biodiversity and ecosystems is a prerequisite to the health of people, animals, plants and ecosystems and underpins conservation and sustainable development. The case studies provided in the report illustrate that health and conservation can represent two sides of the same coin. A One Health approach does not require health nor conservation bodies to assume responsibilities of the other. Rather it asks that health and conservation policies and actions are undertaken in appreciation of each others' obligations and goals, seeking ways to more efficiently and effectively deliver these by working together. Multiple cross-cutting and specific actions mandated under CMS already relate directly to health both in supporting the root causes of good health for migratory species and in acting preventatively to reduce the conditions which lead to poor health and unfavourable conservation status (Kipperman *et al.,* 2024). In doing so, benefits for public health and sustainable development can accrue.

Preventative and reactive One Health approaches are connected parts of a health programme

The report contains examples of both preventative and reactive One Health approaches. CMS Resolution 12.6 (Rev. COP14) (UNEP/CMS, 2024a) specifically calls for action to tackle the drivers of disease. This represents identifying and promoting the underlying factors that contribute to good health through good conservation practices (working 'upstream') while also thinking proactively about prevention of ill-health downstream to maximise cross-sectoral co-benefits for health and conservation with cost-effective approaches. Despite the preference for prevention, responses to disease issues and threats must still occur. Several of

1 See also Annex 3 of UNEP/CMS/COP15/Doc.28.5 for summary of key messages taken from this report XXX

the One Health case studies show how a coordinated response maximises the potential for benefits across sectors.

International cooperation

Conservation and protection of health of migratory species requires cooperation across jurisdictional boundaries. This may take many forms but includes, for example, sharing of surveillance data to inform broader regional risk assessments (*e.g.* for highly pathogenic avian influenza (HPAI)) or regulatory approaches to restrict pollutants or toxic veterinary pharmaceuticals at source (*e.g.* lead ammunition or non-steroidal anti-inflammatory drugs (NSAIDs)). However, to realise the aspirations of international agreements, their goals and objectives also need to be adapted to a local context, and there need to be 'on-the-ground' skills, knowledge and capacity to act.

Financial benefits

Despite a potential perception that thinking more equitably about health across sectors may be costly, there are instead economic efficiencies to be made. A review of the economic value of One Health initiatives has indicated that they tend to result in a positive economic outcome (Auplish *et al.,* 2024). In 2022 the World Bank estimated that One Health approaches could have a $37 billion annual benefit to the global community and the expenditure needed would be less than 10% of these benefits (WHOb). In times of limited budgets and increasing urgency to act to conserve biodiversity, solutions that simultaneously lead to gains in human, wildlife and domestic animal health, while promoting conservation goals, offer compelling opportunities.

Enabling effective collaboration is key

A key feature of successful One Health implementation is effective collaboration between sectors. This is essential as individual sectors or stakeholders are unlikely to have the authority, responsibility, expertise and resources to undertake effective approaches in isolation.

HPAI has become an unprecedented health and conservation challenge. Addressing this challenge needs cross- governmental and -organisational working. A shared goal of minimising risks to animal production, human health and environmental sectors has forced an understanding of the interconnectedness of the issue and the needs for interconnected responses. Such cross-sectoral collaborations lead to more robust decision making and better forecasting and mitigation of unintended consequences. Lessons learned from the global response to COVID-19 and HPAI are driving innovations in collaboration for more integrated responses to a wider suite of health threats.

Address multiple health issues in conjunction

There are multiple drivers of health problems in migratory species. Many of these overlap with the drivers of species decline and extinction. Effective One Health approaches are guided by the principle that actions should strive to promote the health of all species and people sharing a setting. This principle is often put into practice through 'multisolving' when people work together across sectors to address multiple problems through integrated policy or intervention. The case studies highlight how a focus on preventative action such as prevention of release of pollutants, reducing opportunities for pathogen transmission between livestock/humans and wildlife through changes in farming practices or good protected area management, acts preventatively and is beneficial for health across all sectors.

Global and local focus

The case studies in the report illustrate the differing scales of One Health approaches. Some may be regional and highly tailored to local settings, *e.g.* working closely with local stakeholders to vaccinate domestic dogs to prevent spillover of canine rabies to wildlife in those environments. Others may require measures on a larger scale such as regulatory frameworks for pollutants to protect migratory species across their range. One Health is not a 'one-size-fits-all' approach. Rather, it provides a conceptual framework and generalisable tools that can be modified to meet different needs and context.

The need for greater equity in One Health

Accepting that healthy wildlife in resilient ecosystems contributes positively to health across sectors, there is a persistent sense that wildlife health exists as something of a 'poor relation' in the current framing of health. It was notable during the selection of the case studies that the term "One Health" is now often used to describe various aspects of human health and its relationship with the environment, or as a term to replace older existing areas of expertise such as ecotoxicology. The case studies demonstrated an over-representation of anthropocentric examples where positive outcomes for human health were the key focus and success indicator. Outcomes for other sectors were either not evaluated or were not considered relevant, falling short of a true One Health approach as defined above. An understandable but persistent focus on zoonoses in wildlife serves to reinforce this. A model that moves from the (albeit important) surveillance of wildlife for zoonotic pathogens, into a model of ensuring good protection of resilient ecosystems with fewer opportunities for spillover at anthropogenic or livestock interfaces represents a more balanced and equitable One Health approach.

The literature also contains examples of good recommendations for One Health approaches for specific issues but examples of operationalisation of these actions were lacking. It is clear that implementing, evaluating and documenting true One Health case studies where there are benefits to health across the board, has great value for informing others and, along with better global representation, is to be encouraged.

Greater equity in One Health remains hindered by knowledge gaps in relation to the epidemiology and impact of many diseases in wildlife, compounded by inadequacies in wildlife health reporting. While addressing these deficiencies is essential, preventative One Health approaches, working upstream to tackling known root causes of ill-health, offers a cost-effective means of addressing problems at source and promoting health across the board – a clear win-win.

Contents

Background

Protecting and restoring biodiversity and ecosystems are a prerequisite to the health of people, animals, plants and ecosystems which in turn underpin conservation and sustainable development. Modern descriptions of wildlife health in terms of resilience have become more prominent in the past two decades. This represents a shift in thinking wherein conservation promotes health and health promotes conservation. Governments, international forums, multilateral agreements and civil society are increasingly advocating for health, conservation and socio-economic concerns to be managed holistically across sectors and at multiple scales in a more coordinated and integrated manner. As an example, the 2022 United Nations General Assembly recognised the human right to a clean, healthy and sustainable environment (UN General Assembly, 2022).

Many of the drivers of threats to biodiversity and health are found outside of the legislated scope of conservation agencies (*e.g.* agriculture, pollution regulation, energy production, infrastructure and land use planning may be beyond their jurisdictions). Multi-sectoral and cross-silo coordination, collaboration, and engagement are critical, therefore, to finding shared paths forward to protect the social and ecological value of healthy wildlife. This approach and working upstream to tackle the root cause of threats are where the greatest cross-sectoral co-benefits are most likely to be found.

Multiple cross-cutting and specific actions mandated under the Convention on the Conservation of Migratory Species of Wild Animals (CMS) already relate directly to health both in supporting the determinants of health for migratory species and in acting preventatively to reduce the conditions which lead to poor health and unfavourable conservation status. There is a valuable challenge in supporting Parties to recognise the double win of acting to conserve migratory species and the benefits to health that this brings across the board.

One Health emerged in the early 2000s to promote intersectoral action between human, animal, and ecosystem health sectors (WCS, n.d.). It is one in a line of fields that strive to more comprehensively understand and manage the interconnections between conservation, health and sustainable development.

One Health is defined by the One Health High-Level Expert Panel (OHHLEP) – advisory group for the Quadripartite organisations (the Food and Agriculture Organization of the United Nations (FAO), the United Nations Environment Programme (UNEP), the World Health Organization (WHO) and the World Organization for Animal Health (WOAH)) – as "*an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems. It recognizes the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and inter-dependent*" (WHOa). The importance of One Health was highlighted by the COVID-19 pandemic and its far-reaching and ongoing consequences, as well as the current HPAI H5N1 panzootic. This has subsequently led to a greater interest in wildlife health and its role in zoonotic disease epidemiology (UNEP ILRI, 2022).

Wildlife health can be defined as "*the physical, physiological, behavioural, and social wellbeing of wild-living animals measured at an individual, population and wider ecosystem level, and their resilience to change*" (Meredith *et al.,* 2022). For the health of migratory species, this is additionally dependent on inter-sectoral and transboundary collaborations. However, within One Health, wildlife health has tended to be seen as the 'poor relation.' It is often inadequately understood and undervalued, having not yet fully benefitted from One Health interventions despite its relationships with, and potential to impact, human and livestock health (Kipperman *et al.,* 2024).

One in five species listed on Appendices to the Convention on Conservation of Migratory Species of Wild Animals (CMS) are threatened with extinction, and a substantial proportion (44%) are undergoing population declines (UNEP-WCMC, 2024). The drivers of population decline are also drivers of ill-health; so exacerbating declines in some situations and overall reducing ecosystem resilience. The interconnected and interdependent nature of health means poor health of wildlife typically has implications for livestock and human health.

CMS Resolution 12.6(Rev. COP14) on Wildlife Health and Migratory Species states that "*the dynamics of diseases relating to migration are complex and migration can have both positive and potentially negative effects on the health of the hosts and subsequent risks to domestic animals and people*" (UNEP/CMS, 2024a). The complexity of the relationship between migration and wildlife health, and the potential impacts on both human and domestic animal health, highlight the need for a better understanding of the One Health implications of migration. The CMS Migratory Species and Health Review (Kipperman *et al.,* 2024) has assessed the current state of knowledge on the role of migratory species in a One Health context and recommends some key principles to guide One Health interventions.

Despite the increasing calls for taking One Health approaches, including from CMS Resolution 12.6(Rev.COP14)(UNEP/CMS, 2024a), a barrier to implementation is caused by poor understanding of what this looks like in reality. Building on the CMS Migratory Species and Health Review (Kipperman *et al.,* 2024), and the valuable One Health resources on the Panorama Solutions website (Panorama, n.d.), this series of case studies provides Parties to CMS and others with examples of One Health interventions involving migratory species.

The aim of this report is to illustrate One Health approaches in practice, highlight the benefits of taking a One Health approach to wildlife health, demonstrate key principles that may make a successful intervention (again drawing on the key messages from the *CMS Migratory Species and Health Review* (Kipperman *et al.,* 2024)), as well as lessons learned. The stakeholders involved are highlighted in the case studies to illustrate the importance of their involvement.

Key Principles

Figure 1 illustrates One Health problems and their drivers, as well as recommending principles to guide and enable pragmatic solutions (Kipperman *et al.,* 2024). It highlights the need to appreciate health as interconnected and embedded in the environment. A key goal of these cases studies is to illustrate and highlight the importance of the principles that help improve wildlife health and contribute to the aims of CMS and thus increase the success of One Health approaches. A list of these principles is outlined in Figure 2. They are taken, with some small amendments, from the recommendations shown in Figure 1 and are illustrated by the appropriate icons and within the text throughout the case studies.

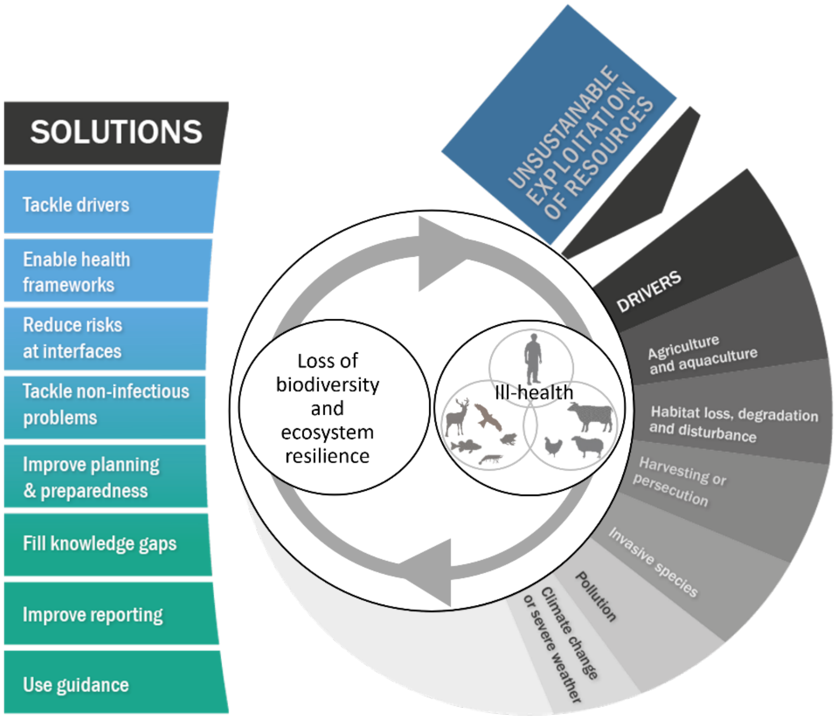


Figure 1. An overview of interconnected health issues, their causes and recommended solutions from the CMS Migratory Species and Health Review (Kipperman et al., 2024).

Figure 2. The key principles that should be considered in One Health interventions involving migratory species

One Health Case Studies:

WILDHEALTHNET: WILDLIFE HEALTH SURVEILLANCE

Tackle drivers of disease	Enable health frameworks	Reduce the risks at interfaces	Preparedness, planning, and response	Improve reporting and information sharing	Information sources for	Internation al cooperatio n	Address funding needs

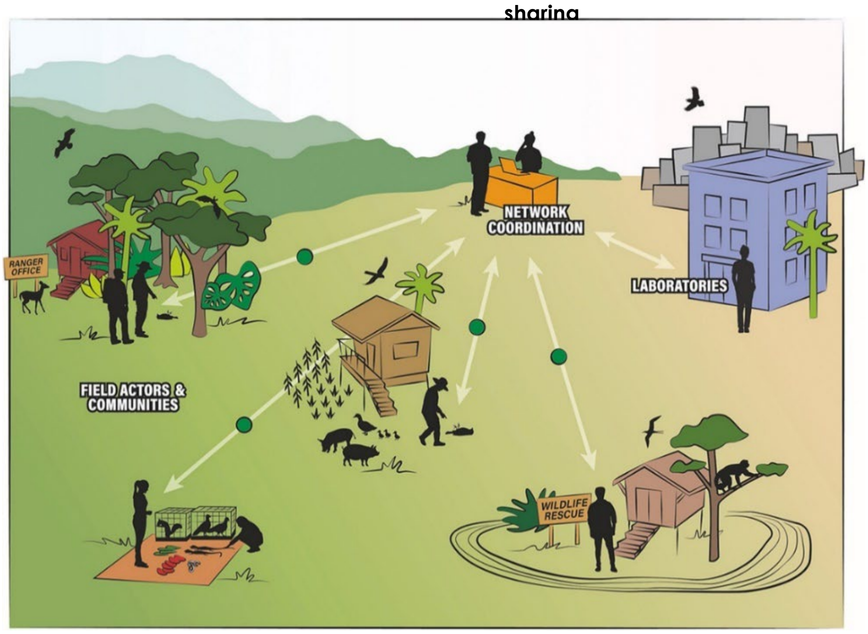


Figure 3. WildHealthNet aims to enable collaboration between various sectors in the monitoring of wildlife health. Image credit: Pruvot et al., (2023).

KEY STAKEHOLDERS

1. Local communities
2. Rangers
3. Public health sector
4. Livestock farmers
5. Local and national governments
6. International conservation organisations providing funding

KEY POINTS

1. Wildlife health monitoring can identify infectious disease outbreaks and enable a quick response to reduce further negative impacts across sectors. However, regionally and globally there is often a lack of effective surveillance and reporting of wildlife health data which hinders planning and preparedness.

2. WildHealthNet was an initiative deployed in Southeast Asia to create national wildlife health surveillance networks in Lao PDR, Cambodia and Vietnam. Developing and operationalising these networks has enabled the detection of, and response to, wildlife disease outbreaks. These responses have potentially prevented cascading impacts

such as spillover of pathogens to livestock or humans, worsening impacts on wildlife populations, and costly economic consequences.

3. The monitoring system successfully demonstrated a standardised approach to wildlife health surveillance, integrating both local and international sectors and building on existing networks and capacities. These networks enabled the first detections of high-consequence pathogens in free-ranging wildlife, including the first documented cases of African swine fever in wild boar (*Sus scrofa*) in Southeast Asia (Denstedt *et al.,* 2021) and the first cases of lumpy skin disease detected in Cambodia's banteng (*Bos javanicus*)(Porco *et al.,* 2023).

4. Similar approaches would support CMS Parties in early detection of risks to health across the board and would respond to obligations under CMS Resolution 12.6 (Rev.COP14)(UNEP/CMS, 2024a).

ISSUE

Infectious diseases can have global economic, social and environmental impacts, as illustrated by the COVID-19 pandemic. The likelihood of disease outbreaks is increasing due to drivers such as human encroachment on wildlife habitat, climate change, illegal wildlife trade and globalisation (Baker *et al.,* 2022). Effective multinational responses to disease emergence are required to mitigate the potential impacts. However, disease emergence in wildlife is often under-monitored and wildlife health is frequently overlooked in health security priorities. A review found that 58% of countries with major health security reports did not provide evidence of a functional wildlife health surveillance programme (Machalaba *et al.,* 2021). Additionally, in contexts where wildlife disease surveillance does exist, there are often failures to produce harmonised and centralised information (Cardoso *et al.,* 2022).

IMPACTS

The potential impacts of infectious diseases of migratory species are widespread, multiple and severe. Migratory species' pathogens can significantly impact wildlife health (*e.g.* HPAI), terrestrial and aquatic ecosystems health (*e.g.* sea turtle fibropapillomatosis (Saladin and Freggi, 2024)), human health due to a pathogen's zoonotic potential (*e.g.* Ebola and HPAI H5N1 (OHHLEP, 2023)), and livestock health (*e.g.* tuberculosis). The impacts of infectious diseases on migratory species are highlighted in the *CMS Migratory Species and Health Review* (Kipperman *et al.,* 2024). The relationships between infectious agents and migratory species are situation-dependent and can have both positive and negative health outcomes for populations of migratory species and health more broadly (Altizer *et al.,* 2011; Kipperman *et al.,* 2024). In some cases, migratory species have the potential to transmit infectious agents over large distances. For example, migratory birds have been found to spread West Nile virus across Africa and Europe (García-Carrasco *et al.,* 2023). In other situations, migration enables pathogen avoidance through migratory escape, or infected individuals are 'weeded out' through migratory culling (Hall *et al.,* 2022; Kipperman *et al.,* 2024). Due to the potential role of migratory species in pathogen transmission, these species can be subject to negative public perception and inappropriate control measures (Kipperman *et al.,* 2024). For example, during the COVID-19 pandemic bats were subject to culling in some regions due to the false belief that they were spreading the virus (CMS, 2020a).

ONE HEALTH APPROACH

WildHealthNet was an initiative funded by the USA's Defense Threat Reduction Agency and conducted in Cambodia, the Lao People's Democratic Republic (Lao PDR), and Vietnam that supported the creation of national **wildlife health surveillance networks**. It has embedded a One Health approach in the surveillance of wildlife health (Keatts, 2025). It has enabled these countries to identify, **monitor and report** priority wildlife pathogens, as well as rapidly respond to emerging issues. These networks have been successful in detecting the first instance of African swine fever in wildlife in Southeast Asia, identifying a transnational outbreak of HPAI, and identifying the first cases of lumpy skin disease in Cambodia's endangered banteng (Pruvot *et al.,*2023). In all these instances, the networks were **prepared** to make a **quick response** to the issue, which may have reduced the threat to other free-ranging wildlife. The detection of lumpy skin disease, for example, activated a collaborative multisector vaccination campaign to vaccinate domestic livestock in and around priority protected areas which host banteng and gaur (*Bos gaurus*). Lumpy skin disease has not been detected in banteng or gaur in Cambodia since the livestock vaccination campaign began following the initial wildlife case detection. Also in Cambodia, early detection of wild waterbird mortalities by protected area rangers due to HPAI H5N1 has allowed for rapid sampling, carcass clean-up, and communication with communities surrounding the outbreak sites (WCS, 2024a). While not all the examples of pathogen identification listed above involve migratory species, these examples show how migratory species surveillance can feature as part of a larger wildlife health surveillance programme. This One Health approach was implemented through several steps (Pruvot *et al.,* 2023):

- Surveillance – focused on wildlife mortality and morbidity events, enabled by a range of stakeholders who directly engage with wildlife such as rangers, local communities, wildlife rescue centres, and other governmental and non-governmental entities.
- Policy development – Standard Operating Procedures and mechanisms to support the institutionalisation of wildlife health surveillance networks and enable mandates and protocols to be adopted into national policy (WHO, 2024).
- Capacity building – **training material and guidance** was developed for stakeholders to safely carry out surveillance tasks, for example training rangers in bio-secure wildlife sampling.
- Data collection and management – wildlife health data collection and management tools were piloted, customised for the local context and continue to be utilised and improved in several protected areas in Southeast Asia and beyond (Montecino-Latorre *et al.,* 2025).
- One Health coordination and response – One Health working groups were formed in each country to coordinate the response to disease events. Additionally, the surveillance network was embedded in One Health planning and policy processes.

The success of this One Health approach was due to several key features:

- It is locally driven with a focus on 'boots on the ground' and local knowledge. WildHealthNet empowered local institutions to take ownership of the project which allowed the initiative to be tailored to local circumstances.

- While the project was locally tailored, some aspects were standardised across the three countries, for example the training offered and the storage of data, which enabled effective collaboration.
- The initiative built on existing networks and local capacity.
- The initiative responded to a need identified by the countries to integrate the environmnetal sector into One Health responses given the immediate and ongoing disease threats present at wildlife-domestic animal-human interfaces (*e.g.* the introduction of African swine fever to the region; the repeated outbreaks of HPAI H5N1 in poultry and wild birds in Cambodia with spillover events to humans)
- It provided valued outputs for public health and economic interests in terms of domestic animal production.

WIDER APPLICABILITY

The mechanisms and structures of the WildHealthNet approach implemented in Southeast Asia are relevant and adaptable at a broader geographical scale and in a range of situations. The project has, in effect, provided proof of concept for a broader wildlife health surveillance initiative. Such networks may be integrated into already existing One Health tools (WHO, 2023) helping to support WOAH objectives of well-established universal reporting and surveillance mechanisms of terrestrial and aquatic animal pathogens across range states.

As the project coordinators have commented, "*the WildHealthNet approach offers locally-driven solutions to meet global objectives*" (Pruvot *et al.,* 2023). This local focus on global issues is particularly important for the health of migratory species as surveillance and reporting needs to be adopted across range states for health issues to be understood and addressed.

In the context of increased risks of emergence and spread of wildlife diseases due to climate change and other environmental stressors, a migratory wildlife pathogens surveillance network may:

- help to mitigate the risks caused by known wild migratory species' pathogens of conservation concern
- include a cross-silo approach to disease management, aiming at bridging data gaps between local stakeholders and international bodies;
- be based on the existing network of animal pathogens surveillance of WOAH, that may be adapted or reinforced as relevant, for example, expanding to surveillance for pathogens of specific conservation concern such as sea turtle fibropapillomatosis, viral disease considered a panzootic in green turtles (*Chelonia mydas*)(Saladin and Freggi, 2024).

LESSONS LEARNT

This case study illustrates the benefits of taking a preventative One Health approach to limit the impacts of wildlife health issues. As CMS Resolution 12.6 (Rev.COP14) acknowledges, preventative approaches to managing health are much more cost-effective than addressing health problems once they emerge (UNEP/CMS, 2024a). WildHealthNet was enabled by **long-term financial support** for technical expertise and implementation (Keatts, 2025). This should be recognised as a key requirement of efforts to scale up, particularly in contexts where financial resources are scarce and international cooperation will be required across range states.

INFECTIOUS DISEASE IN APES

Tackle drivers of disease | Enable health frameworks | Reduce the risks at interfaces | Improve preparedness , planning, and response | Improve reporting and information sharing | Information sources for wildlife health | International cooperation

Figure 4: The health of gorillas (Gorilla spp.) is threatened by, among other issues, respiratory illnesses from human sources. Image credit: Rod Waddington/ Wikimedia

KEY STAKEHOLDERS

1. Local communities
2. Tourism sector
3. Ape conservationists
4. Public health sector

KEY POINTS

- The close evolutionary relationship between humans and apes means that infectious diseases have strong potential to pass relatively easily between species.
- In the COVID-19 pandemic existing One Health frameworks prevented heath impacts on gorillas. This was achieved by a quick response involving human and non-human health surveillance, the cessation of tourism and sanitation measures.
- In some instances, the cross-border nature of gorilla habitats meant that collaboration between range states was a key requirement of One Health success.

- This case study shows the clear benefits to ape populations by following this preventive One Health approach – an example of a double win for conservation and health.

ISSUE

The close evolutionary relationship between humans and apes means that many pathogens may be relatively easily transmitted between species. The health of apes is at risk from diseases passed from humans to apes (termed zooanthroponoses or reverse zoonoses), in particular, respiratory viruses. During the COVID-19 pandemic this risk became prominent as endangered apes such as western lowland gorillas (*Gorilla gorilla gorilla*) were found to be susceptible to the disease (Gibbons, 2021). Zoonotic diseases can also pass from apes to humans. For example, apes have been identified as a likely intermediary in the transmission of Ebola virus from its reservoir in bats to humans (Ayouba *et al.,* 2019). These issues are compounded by the increased risk at the wildlife-human interface caused by human encroachment on ape habitats. In particular, there is a high risk of disease transmission in instances where habituated apes come into regular close contact with humans including in uncontrolled tourism situations.

IMPACTS

Diseases that pass between apes and humans can have significant and far-reaching health impacts. For example, the repeated emergence of Ebola virus in Gabon and Congo in 2002 and 2003 killed around 5000 western gorillas (*Gorilla gorilla*) (Bermejo *et al.,* 2006). Outbreaks of Ebola in apes often occur concurrently with outbreaks in humans, with apes being a likely source of human infection (Ayouba *et al.,* 2019; Hayman, 2019). In humans, some strains of Ebola virus have an average fatality rate of 50% (WHOc, n.d.). The 2014-2015 outbreak of Ebola in West Africa resulted in over 11,000 human deaths and the near collapse of health systems (Elston *et al.,* 2017; Kyobe Bosa *et al.,* 2024). It is important to note that the rural poor are often most severely affected, as they are at the forefront of the human encroachment on wildlife habitat and the corresponding increase in risk of zoonotic disease (Azevedo *et al.,* 2021).

Transmission of disease from humans to apes is a health issue across Africa, particularly respiratory diseases. Human-origin respiratory diseases have become a significant cause of death in chimpanzees (*Pan troglodytes*)(Negrey *et al.,* 2019) and are responsible for a large proportion of mountain gorilla (*Gorilla beringei beringei*) mortalities (Mazet *et al.,*2020). Research in Rwanda found that gorillas habituated to humans are repeatedly exposed to respiratory pathogens through interactions such as close contact (ibid). This zooanthroponotic disease transmission became an issue during the COVID-19 pandemic as captive western lowland gorillas tested positive for COVID-19 and exhibited clinical signs of the disease (Gibbons, 2021).

ONE HEALTH APPROACH

In the Congo basin, at Dzanga-Sangha and Campo Ma'an ecotourism sites, a One Health **surveillance and early warning reporting system** for zoonotic diseases such as Ebola, monkeypox and anthrax has been in place since 2012 (Heral, 2025). Supported by the Worldwide Fund for Nature (WWF), an integrated system involving field laboratories monitors the health of both humans and apes that regularly come into contact with each other, while also conducting health checks in local communities. Additionally, an outreach programme increases the availability of **information sources about wildlife health** and **increases preparedness** through training for outbreak scenarios. These measures proved successful in the local response to the COVID-19 pandemic. The collaborative **health frameworks** already in place enabled a **quick response** to suspected human cases and the regular testing of employees and the local population. Additionally, measures were adopted to **reduce the risk of disease transmission at interfaces** and protect the health of habituated gorillas. Dzanga-Sanga already had risk mitigation measures for gorilla visitors such as mask-wearing, disinfecting hands and shoes, and some mandatory vaccinations (DSPA, 2020). During the COVID-19 pandemic more stringent measures were adopted, including 15 metre distancing between gorillas and humans and limiting the number of visitors (ibid).

Measures were also taken to protect the remaining population of around 1000 mountain gorillas that live across Rwanda, Uganda and Democratic Republic of the Congo, Approximately 60% of this population is human-habituated (Robbins *et al.,* 2011). With the outbreak of COVID-19, **international cooperation** between the three governments enabled the **management of this human-wildlife interface** by ceasing all tourism in the initial months of the pandemic (Gilardi *et al.,* 2022). Planning for the response involved all three range states coming together as the Greater Virunga Transboundary Collaboration to organise **information sharing** and **contingency planning**. The use of personal protective equipment (PPE) and gorilla health monitoring continued throughout the pandemic and the partnership developed an action plan to be used if a positive COVID-19 case in a gorilla was identified. While the cessation of gorilla tourism cost Rwanda alone $10 million USD, this and other measures protected gorillas from COVID-19 infection (Gilardi *et al.,* 2022). When tourism restarted visitors had to provide evidence of a negative COVID-19 test prior to entering the parks (Igihozo *et al.,* 2022).

This collaboration between wildlife and public health sectors successfully addressed a range of health issues through a One Health lens. However, further measures to **tackle the drivers** of infections, such as the prevention of encroachment into ape habitats by deforestation and road building, could aid the prevention of future disease outbreaks (Azevedo *et al.,* 2021).

WIDER APPLICABILITY

These examples highlight the importance of seeing One Health through both a human and animal health lens. While wildlife is often perceived as the source of infectious diseases impacting humans, wild species can also be impacted by infections transmitted from humans. This is particularly relevant for contexts involving pathogens with a wide host range and species genetically similar to humans that are habituated or come into regular close contact with people. Outbreaks of infectious disease in these situations can pose a serious conservation risk for highly threatened species such as gorillas. This case study has relevance for all range states involved in the CMS Agreement on the Conservation of Gorillas and their Habitats (CMS, 2020b).

LESSONS LEARNT

In the Greater Virunga Transboundary Collaboration example, the lack of availability of laboratory testing facilities was highlighted as a key issue, something that was further compounded in the Democratic Republic of the Congo by security issues. However, the overall success of these One Health approaches indicates some key takeaways. Firstly, the Dzanga-Sangha and Campo Ma'an examples show the benefits of a **One Health framework** that is prepared to address the impacts of novel issues. These examples illustrate how a preventative One Health approach can mitigate the impacts of costly disease outbreaks, however additional measures to limit habitat encroachment can further prevent health issues. Secondly, the success of **international collaboration** within the Greater Virunga example highlights the importance of cooperation and consistency in the response to infectious disease across range states.

BRACKEN CAVE PRESERVE AND MEXICAN FREE-TAILED BATS

Tackle drivers of disease | **Enable health frameworks** | **Reduce the risks at interfaces** | **Address funding needs**

Figure 5. Mexican free-tail bats (Tadarida brasiliensis) leaving the largest bat colony in the world, Bracken Cave, USA. Image credit USFWS/Ann Froschauer.

KEY STAKEHOLDERS

1. Local residents
2. Conservation organisations (Bat Conservation International and The Nature Conservancy)
3. Local government
4. Public health sector
5. Agriculture sector
6. Ecotourism sector

KEY POINTS

A private-public partnership purchased land next to a cave containing a large bat colony to prevent residential development.

The creation of a nature preserve pre-empted the risks to the health of the bats, the transmission of zoonoses to humans and the negative impacts on the wider environment that the development could have posed.

This was enabled by One Health cross-sectoral collaboration towards a common goal with significant financial support.

This example illustrates the benefits of a preventive approach which assesses and mitigates potential One Health impacts before they occur.

ISSUE

Mexican free-tail bats (*Tadarida brasiliensis*) are a CMS-listed species which migrate between Mexico and Southern USA. Bracken Cave, in Texas, has a female maternity colony of 20 million Mexican free-tailed bats, the largest bat colony in the world and a key location in the life and migratory cycles of the species. The preserve and the surrounding area are located on the Edwards Aquifer, an important source of drinking water for the city of San Antonio. The proposed development of 3,500 homes on the adjacent land posed a risk to the health of the bats, humans and the wider environment (Epstein, 2025).

IMPACTS

The proposed development of the area adjacent to the preserve had the potential to negatively impact the bat population. The increase in light pollution from home and street lighting would have disrupted bat activities such as foraging, commuting, emergence, roosting and hibernation (Stone *et al.,* 2015). Additionally, the increase in human population living near the bats could have increased roost disturbance (Wiederholt *et al.,* 2015).

Mexican free-tailed bats eat various agricultural pests, limiting crop damage and pesticide use. The value of the pest suppression from the Bracken Cave bats is estimated to be $3.42 million USD annually (Wiederholt *et al.,* 2015). The disturbance of the bat colony could have impacted the ecosystem services they provide.

The proposed development also posed a potential public health risk. The increase in the human population living near large numbers of bats would increase the risk of exposure to pathogens circulating in the bat population. This would have increased the likelihood of the spillover of zoonotic diseases with potentially far-reaching consequences (TNCa, n.d.). Additionally, the development posed further public health risks as the site is located on the Edwards Aquifer recharge zone. Therefore, any development could have impacted a delicate part of an aquifer system that provides drinking water for two million people (TNCb, n.d.).

ONE HEALTH APPROACH

A diverse partnership formed in opposition to the development as a pre-emptive response to the potential impacts. Taking a One Health approach, this campaign **enabled a framework for health** which involved stakeholders from a variety of implicated sectors, such as members of local government concerned with public health and bat conservation groups. A report, led by the EcoHealth Alliance, was written to capture the intersecting human, animal and environmental health risks of the development. This report and other fund-raising mechanisms were used to **raise funds** to purchase the land through a public-private partnership. The acquisition of the land in 2014 created two adjoining preserves, one managed by Bat Conservation International and the other by The Nature Conservancy. Access to the cave area is restricted to small, pre-booked groups. This approach **stopped one of the key drivers of disease**, habitat disturbance.

This approach was a One Health success as the cross-sectoral response prevented health risks emerging. This preservation pre-empted and potentially mitigated a variety of health issues, thereby **reducing the risk at the human-wildlife interface** that the development of residential properties would cause. The preservation of this land for nature also benefits the wider ecosystem within the preserve, an area which contains an important population of golden-cheeked warblers (*Setophaga chrysoparia*), listed as Endangered on the IUCN Red List, and found only in the Texas Hill Country (IUCN, 2020). Additionally, the site is a valuable tourist attraction contributing to the $6.51 million valuation of all Mexican free-tailed bat-related tourism in Texas (Bagstad and Wiederholt, 2013). However, it is important to note that it is difficult to accurately calculate the cultural value of a spectacle like the Bracken Cave bats spiralling out of the cave at dusk.

WIDER APPLICABILITY

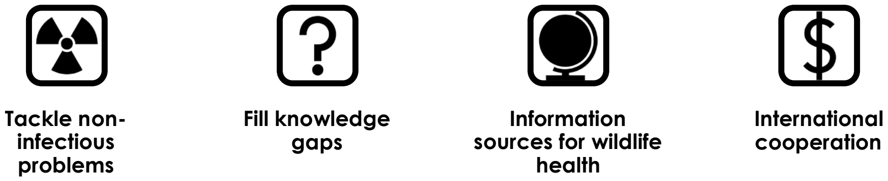
This approach could be applied in other situations where the **human-wildlife interface** creates health risks. The creation or expansion of protected areas to limit human encroachment on wildlife habitats has relevance in many other situations, particularly those involving bats (IUCN and Ecohealth Alliance, 2022). In other contexts, globally limiting regular contact between humans and bats, could **reduce health risks associated with this interface**, such as Ebola, Marburg virus and coronaviruses. This will reduce the risk of future pandemics as well as protecting the ecosystem services bats provide (Osofsky *et al.,* 2023).

In this example stakeholders capitalised on the identification of a shared goal, an approach which could apply in other contexts. Collaboration was enabled despite stakeholders having diverse motivations (Epstein, 2025), thereby overcoming a common issue with One Health implementation, the logistical difficulty of cross-sectoral collaboration between previously siloed sectors (WHO, 2022).

LESSONS LEARNT

As CMS Resolution 12.6 (Rev.COP14) acknowledges '*preventative approaches to managing health are much more cost-effective than addressing health problems once they emerge*' (UNEP/CMS, 2024a). The success of this pre-emptive action required large amounts of financial input from both individual donors and national conservation organisations. Although this funding may have been less than the potential costs of the negative consequences of having allowed the development, embedding appreciation of the value of prevention of problems is notoriously complex. This may be a barrier to implementing this approach in other situations, especially in instances where the potential for residential development increases land value. As a CMS issue, it is important to recognise that the financial ability to take measures such as this may not be equal across range states. Therefore, steps should be taken to **address these funding needs**.

LEAD AMMUNITION AND MIGRATORY BIRDS



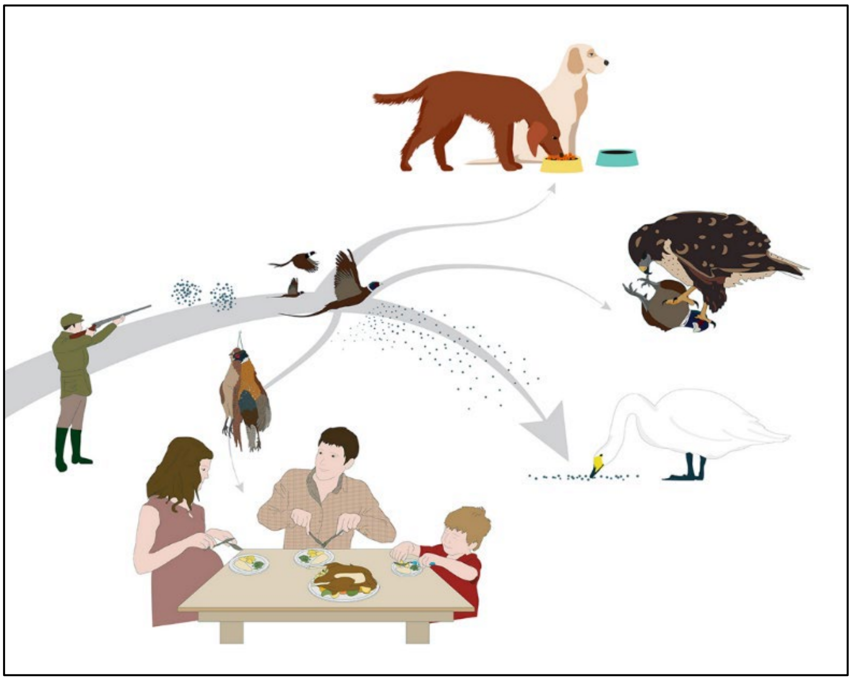


Figure 6. The health of wildlife, domestic animals and humans is impacted by the toxicity of lead ammunition through various pathways. Image credit: WWT

KEY STAKEHOLDERS

1. Conservationists and wildlife managers
2. Hunters
3. Game meat consumers
4. Agricultural community (farmers and livestock keepers)
5. Shooting and ammunition industries
6. Domestic dog owners
7. Policy makers including multi-lateral environmental agreements

KEY POINTS

Lead is a highly toxic substance and use of lead ammunition in hunting is a pathway to significant health issues for birds and other wildlife, domestic animals, humans and the wider environment. The switch to non-toxic alternatives like steel shot or copper bullets would alleviate this One Health issue and reduce the accumulation of lead in soils and food chains.

Transitioning away from lead ammunition would have positive population level impacts for some species, including CMS-listed raptors, and would reduce the high levels of mortality and morbidity caused to many migratory species. Benefits to wildlife of removing lead include improved ability to find food and evade predators, reduction of flying accidents and improvements in immunity.

Some jurisdictions have successfully undertaken this transition to non-toxic ammunition with benefits across sectors, in particular to migratory species. This represents working upstream and tackling a pollutant at source; thereby creating the double win for health and conservation.

For large scale removal of this known pollutant across ranges of migratory species, a collaborative international response is needed to address the impacts of lead. This can also improve compliance and normalise the adoption of non-toxic alternatives.

Resistance to changing ammunition types and associated socio-politics means that the One Health approach of transitioning away from lead is complex and involves both the dialogue between stakeholders as well as regulatory frameworks to enable change.

ISSUE

Lead is a heavy metal, toxic to all vertebrates. Hunting with lead ammunition results in the build-up of lead shot in the environment and the embedding of both shot and bullets/bullet fragments in hunted animals. This creates health risks via ingestion of the lead ammunition for wildlife, humans, livestock and companion animals. The evidence related to lead poisoning from ammunition sources in wildlife has grown substantially since the1960s, with human health impacts better understood since the 1990s (Green and Pain, 2019; ECHA, 2022). Livestock and companion animal exposures and risks are more recently understood. The wide range of animal, human and environmental receptors for lead derived from spent ammunition illustrates the One Health nature of the problem and the One Health justification of the requirement to use non-toxic alternatives. This approach would reduce exposures and stop the accumulation of lead in the environment which contaminates soils and waterways.

IMPACTS

Migratory bird species that feed on land where lead shot is or has been used are at risk of consuming the toxic pellets. Birds may mistake particulate lead for grit or seeds and consume it directly. Scavengers may be poisoned through the consumption of the tissue of animals containing embedded ammunition and fragments thereof, or tissues with elevated lead levels (Pain *et al.,* 2019a; ECHA, 2022). Lead poisoning can affect species at the population level and is of direct relevance to CMS, the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) and the CMS Raptors MOU, given their work in producing internationally coordinated actions to achieve and maintain the favourable conservation status of these birds (CMS Raptors MOU, n.d.). In the European Union an estimated one million birds die annually due to lead poisoning, which is 7% of the overwintering population (Andreotti *et al.* 2018; ECHA, 2022). Many species included in this analysis, *e.g.* Bewick's swan (*Cygnus columbianus bewickii*) and common pochard (*Aythya ferina*), are CMS-listed. Vultures are particularly vulnerable to lead poisoning from ammunition sources. In Southern Africa, testing the blood levels of 185 vultures found that 12% of birds had higher-than-expected lead concentrations, likely due to lead ammunition exposure (Naidoo *et al.* 2017). In Europe, the populations of 10 species of vultures and other raptors are 6.0% smaller than they would be without the effects of lead poisoning (Green *et al.,* 2022). Tackling the impacts of lead ammunition has been critical in the recovery of the California condor (*Gymnogyps californianus*)(Marcot *et al.,* 2025).

The human health impacts of lead exposure are well known. It can lead to cognitive and neurological developmental disorders in young children, is of particular concern for pregnant women not least due to impacts on the unborn child and is linked to increased risk of cardiovascular and kidney disease in adults. The consumption of game hunted with lead ammunition, which often has extremely high levels of lead, exposes human consumers, with greatest consequences to children in hunting/game consuming households (ECHA, 2022). Research has shown that approximately five million people in the EU are high-level game consumers at risk of lead exposure (Green and Pain, 2019). Additionally, companion animals such as dogs which are fed game meat and offal from animals hunted with lead, or those fed commercial petfood containing such game, are at risk of lead exposure (Fernández *et al.,* 2021; Pain *et al.,* 2023). Livestock such as poultry, sheep and cattle can also experience lead poisoning from grazing on land contaminated with lead shot (Shikha *et al.,* 2024).

Additionally, lead ammunition in the environment ultimately degrades into soils and can accumulate in plants, invertebrates and small vertebrates, which may in turn be consumed by other animals (Romano *et al.,* 2016). In terms of agricultural crops, soil contamination affects plant growth and exposes consumers to accumulated lead (ECHA, 2022).

ONE HEALTH APPROACH

The One Health impacts of lead pollution can only be reduced through a ban on the use of lead ammunition and the switch to non-toxic alternatives, such as steel shot or copper bullets. This approach **tackles the non-infectious drivers** of health issues and has particular CMS relevance given CMS Resolution 11.15(Rev.COP14)(UNEP/CMS, 2024b) and Decision 14.134 (UNEP/CMS, 2024c) about regulating lead use and supporting the transition to alternatives. Globally, there is a patchwork of national regulations on lead ammunition ranging from full bans, bans focusing on wetland habitats only or habitats of particularly vulnerable species or complete absence of restriction (UNEP/CMS 2014; Mateo & Kanstrup, 2019). As many affected bird species are migratory, regulation needs to be coordinated in all countries along flyways to be most effective. In Denmark a near total ban on the use, trade and possession of lead shot was implemented in 1996. The use of lead bullets for large game hunting was then also banned in 2024. Regulation decreased the average lead concentrations in game meat between 2001-2021. In contrast, lead concentrations in game meat remain high in countries with no ban (Tammone *et al.,* 2021; Pain *et al.,* 2022). In the EU the costs of combined health implications from the use of lead ammunition are estimated to be far greater than the cost of switching to alternatives (Pain *et al.,* 2019b; ECHA, 2022).

Partial and voluntary measures to transition to non-toxic ammunition have been shown to be ineffective in tackling the problem. In the UK the use of lead shot is regulated in wetlands. However, there is a low level of compliance with these measures both in Scotland (measured by one method as 50%) (Green *et al.,*2023) and non-compliance with English regulations has remained at about 70% (Strong *et al.,* 2024). A five-year voluntary phase out of lead shot driven by UK shooting and rural organisations failed with 99% of birds still shot with lead at the end of the five-year period (Green *et al.,* 2025). These failures in compliance have contributed to the UK decision in 2025 to ban lead hunting and sports shooting ammunition. It is notable that circulating misinformation in hunting communities and the influence of industry and lobby groups has made cross-sectoral collaboration to implement a One Health approach difficult (Cromie *et al.,* 2015; Newth *et al.,* 2019).

WIDER APPLICABILITY

The One Health implications of lead ammunition use have been highlighted from the Arctic (Arnemo *et al.,* 2022) to Australia (Hampton *et al.,* 2018) and therefore this approach has global applicability. There are implications for the Ramsar Convention as lead poisoning is a key health issue in wetlands. There is also overlap with issues relating to vultures and non-steroidal anti-inflammatory drugs (NSAIDs) and the CMS Multi-species Action Plan to conserve African-Eurasian Vultures (CMS/Raptors MOU, 2017), as the health of the same groups of species are impacted by these two issues. In contexts such as this, it is important to address the **multiple non-infectious drivers of health issues** concurrently. Costs to the polluters to change are often cited as barriers to transition but costs of ill-health across the various sectors involved are greater (Pain *et al.,* 2019b; ECHA, 2022).

LESSONS LEARNT

Polarised discourse and misinformation, with influence from vested interests, is unhelpful in attempting to achieve a One Health approach to lead poisoning from ammunition sources (Cromie *et al.,*2015). The success of Denmark in leading on this issue is in no small part due to information on both risks and the practical use of non-toxic ammunition from within the hunting community, alongside essential progressive government actions to introduce regulatory frameworks (Kanstrup, 2021). A 2025 decision in the UK to ban lead ammunition has come only after protracted initiatives and strong resistance to regulation from shooting bodies.

The lengthy timelines for addressing the problems caused by lead ammunition, despite the availability of non-toxic ammunition substitutes, has allowed unnecessary poisoning to continue and extensive and on-going accumulation of lead in the environment creating a toxic legacy (*e.g.* Bechet *et al.,* 2025). Arguably cross-government attention of this One Health issue, *i.e.* involving human health, agriculture and environmental ministries, would encourage the health-protective action required.

Key lessons from this case study are the benefits of multistakeholder and collaborative One Health approaches and the need to address misinformation and lobbyist opposition. This shows the importance of **not just filling knowledge gaps** but also **making information sources** available and acceptable to stakeholders.

Another lesson is the ineffectiveness of voluntary regulations to change practices relating to non-infectious drivers of disease without clear communication of the reasons why change is needed and a motivation and incentive to change. In these situations, measures to ban the availability and use of lead ammunition may be more appropriate.

Finally, given the impact on migratory birds, coherent regulation is required to mitigate these impacts across range states. This highlights the importance of **international cooperation** alongside addressing context specific barriers to change.

POLLUTION MONITORING IN MARINE MAMMALS

Tackle non-infectious problems | **Improve preparedness, planning, and** | **Improve reporting and information sharing** | **Fill knowledge gaps** | **International cooperation**

Figure 7. Bowhead whale (Balaena mysticetus) and calf in the Arctic Ocean. Image credit: NOAA.

KEY STAKEHOLDERS

1. Marine mammal conservationists
2. International Whaling Commission
3. Subsistence hunting communities
4. Polluting industries
5. Public health sector

KEY POINTS

- Marine pollution threatens the health of marine ecosystems, including migratory marine mammals and also humans. Contaminant accumulation in marine mammals, particularly those which represent top predators, allows them to be used as sentinels for the wider presence of contaminants in oceans.

- Monitoring of pollution through *post-mortem* examinations has contributed to the case for banning harmful chemicals and enabled the safe consumption of whale and other marine mammal meat by subsistence hunting communities.

- Using monitoring to inform action on restricting harmful chemicals has the co-benefit of improving health and removing a conservation threat.
- The recognition of the interdependence of aquatic ecosystems, marine mammal and public health allows a One Health approach to identify the presence of contaminants and their potential wider health impacts.

ISSUE

Marine pollution is a key threat to migratory species and their habitats that needs to be addressed (UNEP/CMS, 2024d). This pollution can come in various forms, including persistent organic pollutants (POPs), heavy metals and litter including plastics. While many land-based sources of pollution are particularly impactful on coastal environments, their effects can extend throughout oceans globally. Some acute pollution threats are short term in nature, whereas legacy chemicals such as poly-chlorinated biphenyls (PCBs) have long lasting impacts.

IMPACTS

Examples of pollution in marine life include baleen whales having high risk of microplastic ingestion via trophic transfer (Kahane-Rapport *et al.,* 2022) and high levels of contaminants such as PCBs being found in important food sources such as Arctic plankton (Pouch *et al.,* 2022). Of particular relevance to CMS are long lived toxic substances such as PCBs, POPs, DDT and heavy metals which accumulate higher up the food chain including in marine mammals, many of which are listed under CMS, ASCOBANS and ACCOBAMS. As examples, PCB exposure can impair marine mammals' ability to reproduce, which can result in long term population declines (Jepson *et al.,* 2016). Contaminants such as DDT and PCBs are linked to increased risk of mortality due to infectious disease or cancer due to a compromised immune system (Gulland *et al.,* 2020; Williams *et al.,* 2020).

Human health is also impacted by these forms of pollution. The presence of PCBs in the ocean can cause a range of health problems such as cancer and serious developmental issues (Landrigan *et al.,* 2020). Communities that consume marine mammals are particularly at risk (Weihe and Joensen, 2012).

ONE HEALTH APPROACH

A One Health response to this issue is the use of marine mammals as sentinels to **conduct surveillance and reporting** on ocean pollution. Marine mammals have long life spans, some feed at a high trophic level and accumulate anthropogenic toxic substances in their fat stores which makes them prime candidates to indicate levels of pollution in the wider environment (Bossart, 2011; Williams *et al.,* 2020; 2023; Andvik *et al.,* 2024). By recognising the interdependence of health, monitoring the presence and levels of toxic substances in the bodies of marine mammals can be used to evaluate aquatic ecosystem health and the potential impacts on human and animal health.

Stranding networks enable marine mammal strandings to be **reported;** researchers can then collect data on contaminants through *post-mortem* examinations. For example, the UK Cetacean Strandings Investigation Programme (CSIP) collects information on contamination levels and has been used to inform wider decision making. Brominated flame retardants were previously used in a variety of industrial and consumer products. These chemicals impact human endocrine, neurological, reproductive, immune and cardiovascular systems (Feiteiro *et al.,* 2021). Information collected by CSIP found that stranded harbour porpoise (*Phocoena phocoena*) blubber contained accumulating levels of brominated flame retardants (Law *et al.,* 2012; ZSL n.d.). This information directly contributed efforts to tackle the **non-infectious drivers of this issue** via the EU ban on the chemicals in 2004.

Since the mid-1970s bowhead whales (*Balaena mysticetus*) landed by Alaskan Inuit subsistence hunters have been inspected by hunters, veterinarians and biologists. These *post-mortem* examinations test for the presence of chemical contaminants, along with other aspects of the whale's life history and cause of death. Recently, **monitoring** of this species in the Western Arctic has found that levels of POPs in marine mammals, including PCBs, have declined significantly since their peak (Bolton *et al.,* 2020). This indicates that international measures to halt the use of POPs have been, to some extent, successful. The levels of chemicals in this species of whales are of particular importance as the local communities consume whale meat and so are at risk of associated health issues.

In Argentina, the Southern Right Whales Health Monitoring Program has been collecting data since 2003 (Rosas *et al.,* 2012; Torres *et al.,* 2015; Gallo *et al.,* 2024; Marón *et al.,* 2024). These data are used to understand the variations in Southern right whale (*Eubalaena australis*) annual mortality and identify causes of unusually high mortality years. While some high mortality years, such as 2022, can be explained by harmful algal blooms, the causes of many other excess deaths remain unexplained (McAloose *et al.,* 2016; Sironi *et al.,*2023). This example shows the importance of continued monitoring and attempts to **fill knowledge gaps** as the cause of death could represent a wider systemic One Health issue (WCS, 2024b).

WIDER APPLICABILITY

Marine mammals stranding and monitoring networks globally could expand their remits to ensure all marine mammals are included (rather than primarily a cetacean-focus) and utilise this One Health approach to detect the levels of a variety of pollutants (IWC, 2025). A particularly beneficial use is the continued monitoring of chemicals after legislation has been introduced in order to evaluate the success of regulations. For example, continued surveillance of PCB levels in the EU after the 2004 ban illustrated that PCB levels had stopped declining and had reached a 'steady state' due to their environmental persistence, as well as identifying pollution hotspots (Jepson *et al.,* 2016).

The taking of aquatic wild meat is a key CMS issue (UNEP/CMS, 2024e). Contamination level monitoring through sentinels could become a key factor to allow communities to understand the health impacts of consuming wild meat (recognising that some animal tissues such as blubber and viscera can pose greater hazards than muscle consumption). This has relevance for the CMS Action Plan to address aquatic wild meat harvests in West Africa (UNEP/CMS, 2024e) and CMS Decision 14.187 (UNEP/CMS, 2024c) on the need to understand the human dimensions of aquatic wild meat use and its health impacts.

LESSONS LEARNT

Those implementing surveillance efforts should be aware of the opportunities that subsistence hunting communities provide as they will regularly land animals that can be tested. Additionally, the human health impacts in subsistence hunting communities may be most acute and so should be considered a priority for monitoring.

Both pollutants and some of the species being used as sentinels travel large distances across a range of countries. Therefore, as with any surveillance initiative, **international collaboration** involving **information sharing** across locations would create a more holistic view of the status of contaminants, as well as allowing the identification of contamination hotspots.

RABIES VACCINATION IN AFRICA

Tackle drivers of disease | **Improve reporting and information sharing** | **Fill knowledge gaps** | **International cooperation**

Figure 9. Rabies is a threat to populations of African wild dogs (Lycaon pictus). Image credit: African Conservation/ Wikimedia.

KEY STAKEHOLDERS

1. Local communities
2. Livestock farmers
3. Wildlife conservationists
4. Domestic dog owners
5. Pastoralists
6. Government veterinary departments
7. Government wildlife authorities
8. Rabies elimination NGOs

KEY POINTS

In addition to global annual death toll of 59,000 human cases, rabies impacts the health of wildlife and livestock. However, mass domestic dog vaccination has limited the human health impacts of rabies in some areas of Africa.

Currently, vaccination campaigns are locally focused and so have limited coverage. Additionally, the high turnover rate of domestic dogs limits the degree of immunity at a population level. These, together with movement of domestic dogs with pastoralists and the migration of other animals, can carry the virus into areas that previously had vaccination coverage.

Canine rabies represents a conservation threat to multiple wildlife species in Africa. Transmission in wildlife is currently poorly understood and requires more research and surveillance to fill this knowledge gap. However, coordinated vaccination of domestic dogs has the potential to reduce risks to wildlife such as African hunting dogs (*Lycaon pictus*).

ISSUE

Canine rabies is a neglected tropical disease which predominantly affects marginalised human populations, with children at particularly high risk (WHO, 2024). The zoonotic disease is prevalent in most African countries, with domestic dogs acting as a reservoir for the virus. From domestic dogs, the virus can spread to both humans and wildlife. It has been identified as a health issue in a variety of African wild mammals, including the endangered CMS-listed African wild dog (Stuchin *et al.,* 2018).

IMPACTS

Globally, rabies results in an estimated 59,000 human deaths annually, with 34.6% of these deaths occurring in Africa (AHO/AFRO/WHO, 2023). It has an estimated total cost of $8.6 billion USD per year globally and causes significant social impacts on those affected. Approximately 99% of these rabies cases are caused by domestic and feral dog bites and scratches (WHO, 2024).

Rabies also impacts the health of various wild mammal species across Africa (Stuchin *et al.,* 2018). Notably for CMS, the rabies virus has been detected in African lions (*Panthera leo*) in Zambia and has resulted in the death of the majority of African wild dogs in some packs (Canning *et al.,* 2019). The effect of rabies on African wild dogs is compounded by their small and fragmented populations, which makes it difficult for them to recover from disease events (Kipperman *et al.,* 2024). In addition to terrestrial species, deaths due to rabies infection have been reported in Cape fur seals (*Arctocephalus pusillus pusillus*) in South Africa (NICD, 2024).

In addition to the presence of rabies in wildlife, livestock are also at risk of rabies infection, for example, in northern South Africa between 1998-2022 livestock accounted for 21.9% of rabies cases (Mogano *et al.,* 2024).

ONE HEALTH APPROACH

A One Health approach to eliminating rabies has been advocated through the vaccination of domestic dogs (United Against Rabies, n.d.). Research shows coordinated dog vaccination, and post-exposure treatment of humans across Africa could result in estimated welfare gains valued at $9.5 billion USD between 2024-2054 (Bucher *et al.,* 2023). In the Serengeti ecosystem, a vaccination programme of the rural dog population **dramatically reduced the transmission of the infectious disease** transmission from animals to humans. Over four vaccination campaigns, rabies cases in domestic dogs dropped by 97%. The vaccination of 70% of domestic dogs in this area resulted in the rapid decline in the need for post-exposure treatment in humans with significant socioeconomic benefits (Cleaveland *et al., 2003;* 2006; 2014).

Elsewhere in Tanzania, mass domestic dog vaccination has been linked to decreased circulation in the three species of jackal found in Tanzania, a primary wildlife reservoir for the disease in some wildlife ecosystems (Lushasi *et al.,* 2021). Additionally, of relevance for CMS, it has been suggested that domestic dog vaccination over the large spatial areas covered by

African wild dogs could prevent the impacts of rabies on this endangered species (Prager *et al.,* 2011).

In Ethiopia, there was an outbreak of rabies in a population of Ethiopian wolves (*Canis simensis*) despite the long running vaccination of dogs in the area (Randall *et al.,* 2004). It has been suggested that this was due to a failure to meet rabies vaccination coverage targets, as well as the seasonal movement of pastoral communities and their unvaccinated domestic dogs into wolf habitats (Randall *et al.,* 2006). This is particularly relevant given CMS Decision 14.180, which highlights the need to analyse the connections between pastoralism and zoonotic disease and provide recommendations to mitigate the negative impacts of pastoralism (UNEP/CMS, 2024c). Wild carnivore populations also commonly cross international boundaries so **international cooperation** to coordinate vaccination programmes is an important component of One Health approaches to manage canine rabies across range states. Without this there is a risk of pathogen importation from areas without vaccine coverage.

Rabies control in Namibia has been framed as a One Health success story (WOAH, n.d.). Through mass dog vaccination and other measures, human rabies deaths were reduced from 25 in 2015 to seven in 2022. However, there is evidence of an independent transmission cycle of rabies within wildlife which is causing the death of mammals such as greater kudu (*Tragelaphus strepsiceros*). Research indicates that these two geographically distinct transmission cycles are driven by different reservoirs of rabies, one in domestic dogs and the other in wildlife (Hikufe *et al.,* 2019). The wildlife-livestock rabies transmission cycle is less well understood but it is likely that the virus is sustained by rabid jackals (*Canis mesomelas)* and bat-eared foxes (*Otocyon megalotis*).

These examples can be thought of as One Health successes in that the collaboration between animal health and public health sectors reduced rabies instances in target locations. However, wildlife health is the 'poor relation' within these approaches and a systems-based One Health approach that is integrated across health and conservation sectors is required to ensure that all health concerns are considered appropriately (Kipperman *et al.,* 2024). Given the complexity of rabies transmission cycles, **knowledge gaps** about the transmission of the disease in wildlife, need to be addressed to increase the effectiveness of vaccination campaigns at mitigating wildlife health impacts. While it is more complex than vaccination of domestic animals, in some cases vaccination of wildlife can be a cost-effective prevention and control strategy (Knobel *et al.,* 2008; Hampson *et al.,* 2009; Stuchin *et al.,*2018).

WIDER APPLICABILITY

Rabies is prevalent in other parts of the world, particularly Asia, so this approach has wider geographical applicability. However, it is important to note the context specificities which will require locally tailored approaches, such as understanding and attending to local transmission cycles.

Canine distemper virus (CDV) is another disease where domestic dogs may be part of the reservoir community and which has had significant impact on African wild dogs (Prager *et al.,* 2012). Efforts to mitigate the wildlife health impacts of rabies should also account for the potential impacts of CDV. However, a CDV vaccination programme would need to target the wildlife species of concern which represents a broader reservoir community.

LESSONS LEARNT

Domestic dog vaccination can reduce the human and wildlife health impact of rabies with additional benefits to livestock and the broader ecosystem. Engagement of the wildlife sector in **surveillance and reporting** is needed **to fill knowledge gaps** and to improve understanding of the wildlife component of this complex disease system in order to maximise these benefits (Lushasi *et al.,* 2021).

As a CMS issue, the migration of affected species such as African wild dogs over sizeable distances creates the need to coordinate vaccination over large areas and across international boundaries. Currently there is a large variation in vaccination coverage across different areas, with mass domestic dog vaccination campaigns tending to be locally focused and complex due to the high turnover of dogs within vaccinated populations (Nyasulu *et al.,* 2021). Additional to the main problem of issues with localised vaccination programmes, is the issue of the movement of guard dogs with pastoralists, which can transmit the disease into areas which previously had vaccination coverage (Randall *et al.,* 2006).

PHARMACEUTICAL POLLUTION AND VULTURES

Tackle drivers of disease | **Enable health frameworks** | **Tackle non-infectious problems** | **Improve preparedness, planning, and response** | **Improve reporting and information sharing** | **International cooperation**

Figure 10: Eurasian griffon vultures (Gyps fulvus) are at risk from non-steroidal anti-inflammatory drugs. Image credit: Pierre Dalous/Wikimedia.

KEY STAKEHOLDERS

1. Livestock farmers
2. Veterinary professionals
3. Public health sector
4. Vulture conservationists
5. Veterinary pharmaceutical industry
6. Government animal health and wildlife authorities

KEY POINTS

High levels of vulture mortality can be caused by scavenging on livestock carcasses treated with some of the non-steroidal anti-inflammatory drugs (NSAIDs) which are toxic to a range of wildlife species, in particular Old World vultures. This has had downstream implications for human health from loss of vulture ecosystem services(*e.g.* Frank & Sudarshan, 2024).

Banning veterinary use of NSAIDs along with compliance monitoring represents a highly significant conservation measure to protect vultures, especially where this is combined with wider awareness work at a local level.

Legislation banning the veterinary use of NSAIDs has been unevenly implemented in vulture range states but has so far been mainly, but not exclusively, confined to South Asia. Implementation of bans has arguably avoided total vulture extinctions in India and across South Asia but where it has been implemented more effectively, such as in Nepal, vulture populations have responded positively (Mallord *et al.,* 2024).

In Spain measures stop short of bans and there are reported cases of diclofenac poisoning (Green *et al.,* 2016; Herrero-Villar *et al.,* 2021). The application of diclofenac (one of the toxic NSAIDs) is only permitted in Spain under the supervision of qualified veterinarians which has apparently prevented serious impact on vulture populations so far.

Although perhaps too early to tell, the differences in context between South Asia and Spain suggest locally tailored One Health approaches may be appropriate.

Future impacts of NSAIDs use across the Middle East and Africa remain of concern (Botha *et al.,* 2017) although some Arabic states have banned veterinary use of diclofenac and discussions on withdrawal from the market are underway in others.

Promotion of the safe pharmaceutical alternatives is needed along with incentives for livestock keepers for their use (*e.g*. agreement with producing companies/local wholesalers, discounts, safe-vulture farm certification, subsidies if livestock keepers in vulture areas use vulture-safe pharmaceutical products).

Systems of environmental safety-testing of veterinary NSAIDs are urgently needed, but crucially, these need to link to government licensing protocols such that toxic drugs are avoided completely where they may reach the vulture food chain (Cook *et al.,* 2024).

ISSUE

All eight species of '*Gyps*' vulture (all of which are CMS-listed), other vultures and at least some eagles are at risk from veterinary application of diclofenac and at least four more NSAIDs are now established to be toxic in this context. These pharmaceuticals are often used in veterinary settings to treat livestock, particularly cattle, and significantly, there are now at least two tested safe alternative NSAIDs available (tolfenamic acid and meloxicam). If treated livestock die their carcasses provide a pathway for the NSAIDs into wildlife with downstream One Health impacts. This issue has been highlighted by CMS Resolution 11.15 (Rev.COP14), which urges measures to ensure the safe use of NSAIDs (UNEP/CMS, 2024b).

IMPACTS

When vultures and some species of eagle scavenge on carcasses of livestock treated with diclofenac, or other nephrotoxic NSAIDs, potentially fatal renal failure can occur. Uric acid crystals, indicative of kidney disease in birds, can be grossly visible in multiple organs on *post mortem* examination and may also be apparent in various tissues on histopathology. In South Asia in the 1990s to early 2000s this resulted in a decline in vulture populations of over 95% and for the formerly most abundant species, white-rumped vultures (*Gyps bengalensis*), declines were 99.9% (Oaks *et al.,* 2004; Prakash *et al.,* 2012).

Vulture population declines made more livestock carcasses available to other scavengers such as feral dogs. The resulting increase in feral dog populations increased incidents of dog bites and rabies infections in humans. Additionally, the absence of vultures meant a reduction in the number of carcasses removed from the environment. These carcasses could also carry pathogens, such as anthrax, which could then transfer to other scavengers or into water courses. These downstream impacts were estimated to have increased human mortality rates in districts of India with habitats that are suitable for vultures by 4% (Frank and Sudarshan, 2024). These far-reaching impacts show the need to address this as a One Health issue involving the health of vultures, humans, livestock and other animals.

Although this case study focuses on the South Asian and European situation, the impacts of NSAIDs on vultures are of relevance wherever there is veterinary use and where livestock carcasses can be accessed by vultures or some Aquila eagle species (CMS/Raptors MOU, n.d.).

ONE HEALTH APPROACH

In 2006, India, Pakistan and Nepal took a major step to **tackle the drivers** of this issue by banning the veterinary use of diclofenac. Bangladesh introduced a similar ban in 2010. This legislation aimed to **tackle the non-infectious drivers** of health issues. Simultaneously, NSAIDs identified as being non-toxic to vultures, such as meloxicam and tolfenamic acid, were promoted as alternative medications (CMS/Raptors MOU, n.d.). However, the inconsistent regulation and implementation of veterinary pharmaceuticals across the region have been a barrier to the recovery of vulture populations. In Nepal, the ban has been successful in removing diclofenac from the market (Galligan *et al.,* 2021). This has resulted in a stronger recovery of vulture populations than in other South Asian countries (Galligan *et al.,* 2020, Mallord *et al.,* 2024). Contrastingly, in India, diclofenac remained widely available after the ban (Cuthbert *et al.,* 2011), while other vulture-toxic NSAIDs (*e.g.* aceclofenac and nimesulide) increased. This difference is thought to explain why vulture populations in India have stabilised at lower levels but not recovered so far (Prakash *et al.,* 2024).

In 2013, diclofenac was approved for veterinary use in Spain, Europe's vulture stronghold. Measures were implemented to try and **minimise the impact of this non-infectious** health issue on vultures. The application of diclofenac can only take place under the supervision of qualified veterinarians. Additionally, veterinarians administering diclofenac are warned not to treat livestock if the carcass could become accessible to avian scavengers. There was also an **improvement in the monitoring and reporting** of diclofenac levels in carcasses provided to vultures as supplementary feeding, which shows that in some cases, *e.g.* diclofenac and other toxic NSAIDs have reached the potential vulture food chain (Herrero-Villar *et al.,* 2020; 2021). The measures are **enabled by a health framework** that involves collaboration between veterinary and wildlife conservation sectors. These measures have largely avoided diclofenac-associated risks (Moreno-Opo *et al.,* 2021). However, in 2020 the death of a cinereous vulture (*Aegypius monachus*) was caused by diclofenac poisoning. Additionally, between 2013-2019 three other vultures died due to the ingestion of carcasses with flunixin, another toxic NSAID. This shows that there are still pathways into vultures for toxic NSAIDs, and that their use is never risk free. It also highlights the importance of **continued monitoring, safety-testing and reporting**.

WIDER APPLICABILITY

Differences in livestock management, land-use patterns of vultures, accessibility to the drug and vulture population monitoring contribute to the different outcomes in different regions

(Moreno-Opo *et al.,* 2021) illustrating the importance of locally tailored approaches. As NSAID-induced mortality in vultures generally happens over 24 hours after ingestion, the bird is far from the toxic food-source and close monitoring and tissue analysis are needed, which may only be feasible through intensive tracking of wild vultures together with prompt follow-up to find dead birds. This means that extensive **monitoring and reporting** of vulture mortality and promoting the use of non-toxic alternatives would be beneficial in relation to a range of non-infectious health issues.

Beyond the impact on vultures, several species of eagles (all CMS listed) are also susceptible to the toxic effects of diclofenac (Sharma *et al.,* 2014; CMS/Raptors MOU, n.d.). This suggests that other accipitrid raptor species may also be susceptible to population declines due to NSAIDs increasing the range of countries in which restrictions on their use should be introduced.

A One Health approach to licensing of all pharmaceuticals and chemicals would include environmental safety testing.

LESSONS LEARNT

The severe One Health impacts of NSAIDs in South Asia highlight the need for a comprehensive assessment of the One Health risks before pharmaceutical drugs are licensed. As CMS Resolution 12.6 (Rev.COP14) acknowledges that '*preventative approaches to managing health are much more cost-effective than addressing health problems once they emerge*' (UNEP/CMS, 2024). The response in South Asia also highlights the need for **international cooperation** to enable a coordinated implementation of legislation across range states. A **coordinated health framework** across range states should be a key element in the One Health approach involving CMS species, given that animals of concern regularly cross national borders, entering countries with less stringent, or stringently implemented, legislation.

The continued occasional poisoning of vultures in Spain illustrates the difficulty of stopping *all* routes of NSAIDs into the environment following licensing of the drugs. This point is reinforced by the need for these routes to be prevented across the range states of migratory species. Changes in the approach to licensing are needed to prevent similar issues in the future. There is currently no regulatory obligation to test the safety of NSAIDs' impact on vultures in South Asia or the EU, nor indeed to act when testing indicates toxicity. Implementing such a process, as has happened with plant protection chemicals in the EU, could prevent similar issues in the future (Cook *et al.,* 2024).

HIGHLY PATHOGENIC AVIAN INFLUENZA

Figure 11. Highly pathogenic avian influenza has serious conservation impacts on numerous species globally. Image credit: AP

KEY STAKEHOLDERS

1. Livestock farmers of primarily poultry and domestic duck and geese
2. Wildlife conservationists (particularly wetland and marine site managers)
3. Global animal health organisations namely World Animal Health Organization and UN Food and Agriculture Organization
4. Global human health organisations namely World Health Organization
5. Government health, veterinary, agriculture and environment sectors
6. Owners of small scale backyard poultry and pet birds
7. Poultry industry
8. Public health sector
9. Wildlife rehabilitators
10. Gamebird farmers and hunters

KEY POINTS

- Highly pathogenic avian influenza (HPAI) has a devastating impact on poultry and duck farming with worrisome developments in the dairy industry.
- The disease is no longer just a concern for livestock; it is an unprecedented conservation threat to multiple wild bird and mammal species. Since the mid-2000s, wild birds, including many migratory species, have been seriously impacted. There have been sporadic cases of HPAI in humans and spread to a range of wild mammal hosts, most notably predators and scavengers, including marine mammals, some of which have experienced high mortality.
- The current HPAI panzootic represents a public health risk with pandemic potential.
- The 'escape' of a virus from a domestic setting has had global consequences for people, livestock and wildlife. A robust One Health approach, evaluating risks upstream, would have prevented this initial escape.
- An effective One Health approach should now include measures to prevent disease outbreaks in both wild and domestic settings as well as increase planning and preparedness to respond to outbreaks when they occur to reduce impacts and likelihood of spillover and spillback[2]. These require collaboration across livestock farming, health agency and environment sectors.
- The global scale of the issue highlights the need for international cooperation.
- Arguably the scale of the global problem and implications for wildlife, human and livestock health have accelerated impetus for extensive cross-sectoral working.

ISSUE

Low pathogenicity avian influenza (LPAI) viruses have a natural reservoir in wild aquatic birds, with apparently minimal health impacts. The mutations of LPAI viruses to HPAI are most likely to occur in high-density domestic bird farming and are associated with high mortality among domestic birds. The emergence of H5N1 Goose/Guangdong HPAI virus in domestic geese in 1996 ultimately led to this virus spilling into wild birds most significantly at Lake Qinghai in China in 2005. Currently, the virus circulates within wild and domestic species with frequent transmission events between the two. This spillover and spillback are most significantly facilitated by practices that increase interaction at the wildlife-domestic animal interface, such as the grazing of domestic ducks in natural wetlands (Gilbert *et al.,* 2006) and poor biosecurity at wet markets and poultry farms (Henning *et al.*, 2019; FAO and WOAH, 2025). As the virus has evolved over time and reassorted with other avian influenza viruses, new strains have periodically caused the resurgence of the disease. Wild migratory birds can spread the virus over large distances along flyways, as well as being victims of it (WOAH, n.d.). The absence of a One Health approach has resulted in a failure to adequately assess the cross-sectoral health risks of certain activities such as wild bird farming and grazing of domestic ducks in natural settings and approaches to land use such as intensive poultry production especially when near natural wetland sites.

[2] Spillover: transmission of an infectious agent from a host population or community where its prevalence may be relatively high, to a new host, usually crossing a species barrier. Spillback: transmission of an infectious agent in the reverse direction from that of the above.

IMPACTS

HPAI has been recorded in over 500 wild bird species, often resulting in unprecedented mass die offs (BirdLife, 2024). Recent outbreaks of HPAI devastated several important seabird colonies and the virus has now spread to remote areas like the Antarctic (CMS FAO, 2023; Aguado *et al.,* 2024; Banyard *et al.,* 2024; Bennett-Laso *et al.,* 2024; Ogrzewalska *et al.,* 2024; Kuiken *et al.,* 2025). During the early years of wild bird involvement in the epidemiology of HPAI, migratory birds were indirectly impacted as public perceptions of their role as a disease vector led to poorly considered responses such as retaliatory killing of wild birds, destroying habitats and draining wetlands (Kipperman *et al.,* 2024).

Notably the virus has more recently spread to a range of mammal hosts, such as dairy cattle in the USA and marine mammals in South America, with associated mass mortality and mammal-to-mammal transmission (Peacock *et al.,*2024; Rimondi *et al.,*2024; Uhart *et al.,* 2024; Campagna *et al.,* 2025).

HPAI has resulted in millions of domestic birds both dying and being culled as part of disease control programmes. As an example, in Europe between October 2021 and September 2022 47.7 million birds were culled (EFSA *et al.,* 2022). Culling of livestock can have serious consequences on the local and national economy, food security and individual livelihoods. There are also cases of human infection related to close contact with affected poultry and dairy herds. The instances of mammal-to-mammal transmission in the current HPAI outbreak mean there is a greater possibility that further mutations and/or reassortments will increase the impact on human health including pandemic risks (Peacock *et al.,* 2024).

ONE HEALTH APPROACH

Prevention:

- HPAI outbreaks can be mitigated by **limiting high risk activities driving disease** such as farming of wild birds (Gilbert *et al.,* 2017; Prosser et al., 2011), grazing domestic ducks in wetlands, wild birds having easy access to livestock and poor biosecurity at wet markets. The risks relating to wetland areas can be reduced by a good protection of those areas. In China, between 2004-2017, proximity to unprotected wetland sites corresponded with an increase in HPAI outbreaks, whereas proximity to highly protected habitats (*e.g.*, Ramsar-designated sites) had the opposite effect (Wu *et al.,*2020). This protection both mitigates One Health risks as well as benefiting the conservation of species that use wetland habitats and the ecosystem services they provide.

- Improvements in planning to **minimise contact at the interfaces between wild and domestic animals and humans** can further mitigate the risk of HPAI outbreaks (CMS FAO, 2023). For example, a separation of poultry agriculture and wetland habitats is advised (FAO, 2023; FAO and WOAH, 2025).

- Risks associated with poultry farming can be mitigated by reducing livestock density and the scale of production and through improvements to biosecurity. These measures are particularly important in areas near to natural habitats (CMS FAO, 2023). Modelling in France has calculated that even a slight reduction in the density of farmed ducks and geese would substantially decrease the number of poultry farms impacted by HPAI (Bauzile *et al.,* 2023).

Preparation:

Building health frameworks and the creation of **emergency response and contingency plans during 'peacetime',** *i.e.* before an issue arises, increases preparedness and the ability to react to HPAI outbreaks when they occur (Cromie *et al.,* 2012; CMS FAO, 2023).

Surveillance, monitoring and reporting are essential for detecting and responding to disease outbreaks and are essential for informing response and contingency plans. **International cooperation should enable** surveillance programmes through the sharing of standardised data (Kojima *et al.,* 2024). However, **improvements in reporting** detections and mortality of wildlife with full contextual data are needed to understand impacts and inform future planning. Moreover, integrating mortality data with population monitoring data would allow better understanding of impacts. For example, the International Waterbird Census collates population data information across 143 countries and along the five major global flyways (Wetlands International, n.d.). Additionally, the spread of HPAI beyond bird populations shows the importance of monitoring a range of species. For example, monitoring the die-offs of marine mammals in Argentina resulted in the detection of HPAI in South American sea lions (*Otaria byronia*)(Plaza *et al.,*2024; Rimondi *et al.,* 2024).

Engagement and collaboration with environment stakeholders (ecologists, biologists and wildlife managers) is critical to understanding HPAI as a biodiversity threat. This will ensure that biodiversity priorities are incorporated into preparedness planning and that risk mitigation measures involving free-ranging wildlife are identified and resourced.

Engagement and communication is a key feature of building HPAI preparedness (CMS FAO, 2023). In particular, the public have an important role to play in surveillance and reporting. Engagement of key poultry stakeholders is essential for addressing poorly informed management practices.

Vaccination of poultry has become a more acceptable approach to reducing risks. Vaccination of wildlife may be a feasible option in limited specific situations where there is the potential for the extinction of endangered populations which are closely managed, for example the California condor (*Gymnogyps californianus*) Recovery Programme (USFWS, 2023; WOAH, 2023).

WIDER APPLICABILITY

HPAI is a global One Health issue which has arguably been the most important wildlife disease issue to date to make clear the vital role for environmental sections of government in addition to those from the agriculture sector. As with any planning and response to disease, local contexts may require locally tailored approaches. Mitigation measures should be targeted at hotspots for activities that may be driving disease risk, *e.g.* tourism or intensive livestock production. The approaches to planning and preparedness for disease outbreaks outlined above are also applicable to many other disease issues.

LESSONS LEARNT

This disease continues to represent a serious threat to conservation of migratory species and has highlighted:

a. the importance of preventing spread of pathogens to wildlife from livestock as ultimately both sectors have been negatively impacted (with repeated viral spillback to livestock) with additional risks to human health,

b. the risks of intensive livestock management and some other livestock rearing practices,

c. the lack of planning and preparedness for HPAI outbreaks in wildlife,

d. the risks of use and legal and illegal trade of wild animals and associated lack of biosecurity,

e. the importance of wildlife health in responses *i.e.* ensuring a One Health approach,

f. the importance of cross-sectoral working of public health, livestock and environmental considerations which has been of direct benefit to planning for both HPAI and other diseases,

g. the value of improved international collaborative planning, preparation and implementation for HPAI in wildlife which would improve outcomes given proper funding and support by One Health initiatives,

h. the enormous economic costs of HPAI and that an original One Health approach could have ameliorated these costs,

i. the importance of health frameworks, improved surveillance and reporting systems as well as accurate information sources on wildlife health, and the dissemination of this information.

j. the cost of responding to HPAI is high, for example in 2014-2015 $879 million USD was spent on eradicating HPAI in USA poultry farms (Seeger *et al.,* 2021). These costs could be saved by preventive One Health action.

This example clearly shows the importance of **health frameworks, improved surveillance and reporting systems** as well as **accurate information sources on wildlife health**, and the dissemination of this information, to also prevent damaging and ineffective control measures such as culling wild birds or spraying habitats with disinfectant (CMS FAO, 2023).

Discussion

The purpose of this report was to provide tangible One Health case studies to help inform CMS Parties on what constitutes a One health approach in practice. The downside of the selection of case studies based around specific disease etiology is that it can embed a view of One Health as a response to a particular disease issue. Instead, effective One Health approaches proactively promote health through actions which reduce threats to health and actively promote conservation and resilient ecosystems.

Implementation of mandates under CMS including Resolution 12.6(Rev.COP14) (UNEP/CMS, 2024a) would support One Health by, for example, reducing habitat loss, fragmentation and degradation; addressing drivers of climate change and enhancing mitigation and adaptation; preventing pollution, including by effective regulatory action; preventing the spread of invasive non-native species; addressing high-risk agricultural and aquacultural practices; preventing over-exploitation; and reducing health risks at wildlife/livestock and wildlife/human interfaces. These actions in effect address multiple threats to health and, with some caveats, all of the health problems described within the case studies of this report would have been prevented or ameliorated by these actions.

Protecting and restoring biodiversity and ecosystems is a prerequisite to the health of people, animals, plants and ecosystems which, in turn, underpin conservation and sustainable development. Although the components of the concept of One Health have been in existence for some decades, and the term used for some 20 years, UNEP only recently became a member of the Quadripartite in 2022. This relatively recent relationship contributes to the continuing inequity in One Health approaches with a persistent focus on the human health perspective in One Health which in effect, acts as a barrier to maximising health benefits.

One way this is illustrated is by the over-representation of information on One Health approaches to issues involving bats, as these examples tend to be focused on the important implications for human health. For example, the cross-agency response to the Hendra virus in Australia to abate the human health impact has been described as a 'One Health success story' (Field and McCall, 2012). The zoonotic disease spread from a reservoir in bats to humans via domestic horses and the One Health response focused on removing the human health impacts with the ecological aspects being only recognised later in responses. From a livestock perspective, HPAI offers a good example of how taking a One Health approach would have prevented the conditions leading to the original spilling of H5N1 virus into wild populations. Moreover, effective One Health responses to the disease following emergence could have reduced continuing spillback and spillover which impacts wildlife and poultry alike.

Examples such as these illustrate the tendency for One Health implementation to be centrally concerned with human health and, to a lesser extent, livestock health. Less concern with wildlife health prevents equitable decision-making and health management. Difficulties persist however, due to significant knowledge gaps in health status and disease transmission in wildlife. This is illustrated in the lack of information about rabies transmission in wildlife and diseases such as peste des petits ruminants where the lack of epidemiological knowledge about the disease in wildlife hinders control efforts (Fine *et al.,* 2020). The lack of knowledge about disease in many CMS-listed species has been highlighted previously (Kipperman *et al*., 2024). Given the complex and dynamic ecological contexts and the varied species and pathogens and pollutants involved, gaining good understanding of how diseases emerge, persist and impact is difficult (Ibid). This is compounded by remaining problems with wildlife health reporting systems and the need to coordinate data collection efforts across international borders.

Despite valuable resources such as the Panorama Solutions website (Panorama, n.d.), information on One Health initiatives with policies and practices that benefit wildlife, and specifically migratory species, are difficult to find. Such examples tend to focus more on issues and recommendations, rather than implemented solutions. Examples such as Oceancare's approach to wild aquatic meat in West Africa show that some relevant initiatives are yet to be implemented or evaluated (OceanCare, n.d.). This initiative is in the research stage but plans to implement measures to aid local communities' transition away from wild aquatic meat hunting and towards more sustainable livelihoods. This aims to benefit both the health of marine mammals and those consuming meat.

Recommendations

The report highlights opportunities for CMS Parties to further actively contribute to One Health.

Proactive multi-solving

Implementing existing mandates under CMS which in effect provide proactive multi-solving solutions, as well as the specific health actions mandates in Resolution 12.6(Rev. COP14)(UNEP/CMS, 2024a), would provide a win-win for conservation and health. This would serve to enhance health of other sectors too due to the interconnectivity of health.

Collaboration

At the core of effective One Health approaches is enhanced multisectoral and transdisciplinary collaboration at the national level, often with cooperation at the international level, to prevent and respond to wildlife health threats. Such cross-sectoral collaboration with full involvement of the environment sector (rather than just those traditionally responsible for health) brings efficiencies as multiple needs and priorities can be concurrently co-managed for maximum benefits.

Preparedness

Both proactive and reactive One Health approaches depend upon preparedness. Parties and others managing wildlife are encouraged to develop and evaluate strategies for prevention, preparedness and response to wildlife health threats by developing national integrated wildlife health strategies with contingency and emergency response plans. Effectiveness is dependent on this preparedness, particularly given that cross-sectoral working is required for successful outcomes and maximising One Health benefits.

Filling knowledge gaps

As the case studies illustrate, planning can be affected by gaps in understanding of wildlife diseases. Therefore, Parties and others with responsibility for wildlife and health are encouraged to strengthen and support wildlife health systems and frameworks (Kipperman et al., 2024) to support wildlife health strategies by bringing together expertise, resources and organisational structures that enable effective early warning systems and risk assessment, supporting wildlife health, disease surveillance and reporting, and encouraging and supporting outbreak investigations.

Recommendations for further development of this resource

The case studies aimed to cover a range of geographical contexts and habitat types. The purpose was to find examples of where One Health approaches had been implemented and evaluated to illustrate the benefits of One Health. The selection of examples also aimed to illustrate the benefits of the key principles listed in Figure 2, and outline lessons to be learnt from any failures. However, the process of researching the case studies and identifying the possible examples highlighted the issues highlighted above.

Further development of this resource for CMS Parties would benefit from providing case studies that have clear benefits to biodiversity (rather than neutral benefits or reduced disbenefits), represent proactive multi-solving initiatives, greater focus on implemented approaches that benefit wildlife health and case studies from other regions of the world which may have been missed due to the authors' first language.

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Glossary

Disease	Impairment of normal functions due to the presence of an infectious agent or other, non-infectious impairment.
Ecosystem health	*"A comprehensive and multiscale measure of system vigour, organization and resilience, closely linked to the idea of sustainability, which implies the ability of the system to maintain its structure (organization) and function (vigour) over time in the face of external stress (resilience)"* IPBES (2020).
Emerging infectious disease	An infectious disease that has recently appeared in a population or is rapidly increasing in incidence or geographic range
Etiology	The cause, set of causes, or manner of causation of a disease or condition.
Infection	The presence of an infectious agent in an individual. An individual host can be 'infected' with an agent, but this may or may not cause 'disease' in the host.
Infectious	An ability for an agent to be transmitted from an infected individual to another individual.
Infectious agent	A parasite (infectious organism) or other agent that is transmissible between hosts, either directly (via *e.g.* contact or aerosol) or indirectly (via *e.g.* food or a vector species).
Infectious disease	Disease resulting from an infectious agent.
Non-infectious disease	A health impairment other than that caused by an infectious agent. This includes disease resulting from human-related toxicants or natural toxins; trauma; anthropogenic stress; physical extremes (heat, cold); nutritional deficiency or imbalance; genetic disorders or degenerative (*e.g.* age-related) conditions.
One Health	"*An integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals, and ecosystems. It recognizes the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and interdependent*" (WHOa).
Pathogen	An infectious agent that has potential to cause disease.
Population	A group of individuals of the same species living in the same, defined area.

Reservoir	A host population, species or environment that serves as a persistent source of an infectious agent to other populations of animals or humans in the same locality.
Spillover Spillback	Here, defined as transmission of an infectious agent from a host population or community (which may or may not be a reservoir), where its prevalence may be relatively high, to a new host, usually crossing a species barrier. Transmission of an infectious agent in the reverse direction from that of the above.
Target host/population	The host or population of interest.
Vector	An organism (frequently an arthropod) responsible for transmitting an infectious agent from one host to another.
Wildlife health	Here defined as, "*the physical, physiological, behavioural, and social wellbeing of wild-living animals measured at an individual, population and wider ecosystem level, and their resilience to change*" (Meredith *et al.*, 2022).
Wildlife-livestock interface	The physical space in which some form of contact or shared use of resources occurs between wildlife and livestock populations.
Zoonosis	Any disease or infection that is naturally transmissible from vertebrate animals to humans. 'Zoonotic' is the adjective of this.
Zooanthroponosis or reverse zoonosis	An infection transmissible from humans to animals.

The Convention on the Conservation of Migratory Species of Wild Animals (CMS)

is an environmental treaty of the United Nations that provides a global platform for the conservation and sustainable use of migratory animals and their habitats. This unique treaty brings governments and wildlife experts together to address the conservation needs of terrestrial, aquatic, and avian migratory species and their habitats around the world.

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