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Reducing Pandemic Risks at Source

Wildlife, Environment
and One Health Foundations
in East and South Asia



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LAO PEOPLE'S DEMOCRATIC REPUBLIC

Monitor lizards, squirrels and wild birds for sale in Attepeu, Lao People's Democratic Republic.

Photo credit: WWF / K. Yoganand



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Foreword

The majority of human infectious diseases are of animal origin, and many recent emerging infectious diseases (EIDs), such as HIV/AIDS, the Nipah virus, severe acute respiratory syndrome (SARS), highly pathogenic avian influenzas (HPAIs), and Ebola virus disease share a common feature: their wildlife origin. Wildlife-originated EIDs are also increasing in frequency over recent decades. As shown by the ongoing COVID-19 pandemic, the impacts of EIDs disproportionately affect the poor and other vulnerable groups, increasing inequality and threatening decades of development progress. The acceleration of EID events of epidemic and pandemic potential calls for a paradigm shift in how we manage and interact with our natural and built environments, while stressing the urgency to develop and implement comprehensive One Health approaches to achieve optimal health outcomes. Furthermore, it is important to recognize the interconnections between people, animals, plants, and their shared environments.

East and South Asia, renowned global hotspots for disease emergence, have suffered from and continue to experience major economic impacts from outbreaks. A team comprised of experts from the World Bank and FAO, and leading wildlife and One Health experts from around the world have worked together to analyze the causes. This report outlines the risks of EIDs of wildlife origin and proposes how to reduce emerging pandemic threats at their source; it includes background material, state-of-the-art knowledge, and recommendations for strengthening systems to prevent, detect, and manage EID outbreaks caused by wildlife trade, wildlife farming, food systems, and habitat degradation. Furthermore, it examines the scope of existing policy frameworks, institutional mandates, level of multisectoral engagement, investments, wildlife-health information systems, and capacity building related to wildlife in the context of emerging disease risks.

Despite being the origin of most zoonotic EIDs, the wildlife aspects of One Health systems have often been overlooked – this report provides the necessary blueprint for countries in East and South Asia on how to build or strengthen their One Health systems as a long-term priority, while implementing targeted risk-reduction activities. In addition, it presents a strong economic case for investing in the prevention of a pandemic at source. Investing in the prevention of wildlife-originated EIDs at source is extremely cost-effective and can also provide a link, as well as leverage biodiversity and animal health system initiatives to meet broader objectives.

This report complements the findings of a related, joint World Bank/FAO report to be published simultaneously. The second report analyses the drivers of zoonotic and emerging infectious diseases in the animal-sourced food systems, and offers strategic recommendations for preventing their spread in animals and humans using a cross sectoral approach. We hope these reports will engage policy dialogues with countries in East and South Asia, regional institutions, and the international community, while contributing to the growing pool of knowledge and practice in this area. Finally, our goal is to trigger investments in policy, institutions, and capacity building for the strengthening of One Health approaches in the region and globally.

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Abbreviations and acronyms

AMR	Antimicrobial resistance
ASEAN	Association of Southeast Asian Nations
CBD	Convention on Biological Diversity
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CoV	Coronavirus
COVID-19	Coronavirus disease 2019
EAP	East Asia and the Pacific
EID	Emerging infectious disease
FAO	Food and Agriculture Organization of the United Nations
FETP	Field Epidemiology Training Program
GEF	Global Environment Facility
GHSA	Global Health Security Agenda
HPAI	Highly pathogenic avian influenza
JEE	Joint External Evaluation
MoE	Ministry of Environment
NAPHS	National Action Plan for Health Security
NBSAP	National Biodiversity Strategy and Action Plan
OIE	World Organisation for Animal Health
PVS	Performance of Veterinary Services
SADS	Swine Acute Diarrheal Syndrome
SARS	Severe Acute Respiratory Syndrome
SDG	Sustainable Development Goals
UN	United Nations
UNEP	United Nations Environment Programme
WAHIS	World Animal Health Information System
WEN	Wildlife Enforcement Network
WHO	World Health Organization

CHINA

Pangolin scales seized in Shenzhen, China.

11 tons of pangolin scales were seized by customs in 2011.

Photo credit: Shenzhen Customs





Executive summary

Emerging infectious diseases (EIDs) are infections associated with new or significantly-expanded geographic scope or spread of zoonotic, vector-borne, and drug-resistant pathogens. These diseases pose a formidable threat to human and animal health and economies. The majority of human infectious diseases have animal origins, and of those, most recent EIDs are tied to wildlife and are increasing in frequency.

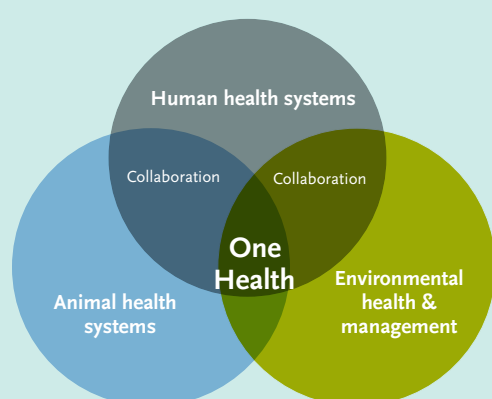
This report outlines the risks of EIDs from wildlife and provides guidance in building systems to reduce emerging pandemic threats at their source in East and South Asia. It provides background material, definitions, state-of-the-art knowledge, and recommendations for countries to initiate or strengthen systems to prevent, detect, and manage EID outbreaks from wildlife. It examines the scope and gaps of institutional mandates, programs, and investments related to wildlife in the context of emerging disease risk. The recommendations are geared toward high-level policy dialogue aiming to provide a blueprint for how to strengthen the “wildlife” pillar in “One Health” systems. The report complements and deepens an associated report (World Bank and FAO 2021, in print) that analyzes risks of diseases spreading from domestic animals and wildlife to human and gaps in animal health services.

Interaction with wildlife is the origin of most recent epidemics and pandemics. Rapidly growing pressures on ecosystems and biodiversity are associated with changing interactions among species, increasing opportunities for new outbreaks of epidemic and pandemic potential.

The impacts of EIDs commonly affect the poor and other vulnerable groups disproportionately, increasing inequality and threatening decades of development progress

Wildlife-originated human EIDs can exact tremendous health and economic costs on individuals and their families, on nations, and on the global economy (Figure 1). HIV/AIDS, Plague, Nipah virus, Severe acute respiratory syndrome (SARS), Highly Pathogenic avian influenzas (HPAIs), and Ebola virus disease together have cost the world over USD 680 billion since 1994. Recent International Monetary Fund estimates shows that prolonged impact of COVID-19 into the medium term could reduce the global GDP by a cumulative of USD 5.3 trillion over the next five years, further to the estimated loss in output relative to the pre-pandemic projected path of USD 11 trillion during 2020-21. McKinsey estimates that by 2025, COVID-19 will have cost the world between USD 16 trillion and USD 35 trillion. The impacts of these EIDs commonly affect the poor and other vulnerable groups disproportionately, increasing inequality and threatening decades of development progress. For example, COVID-19 has halted progress in poverty reduction in East Asia and the Pacific for the first time in two decades, with an estimated 32 million people in the region unable to escape poverty as a result of the pandemic.

Box 1. Defining One Health



One Health is a collaborative, multi-sectoral, and transdisciplinary approach — working at the local, regional, national, and global levels — with the goal of achieving optimal health outcomes while recognizing the interconnections between people, animals, plants, and their shared environments. **One Health systems** include elements or components combined to prevent, prepare, detect, respond to, and recover from threats to human health, animal health, and environmental health.

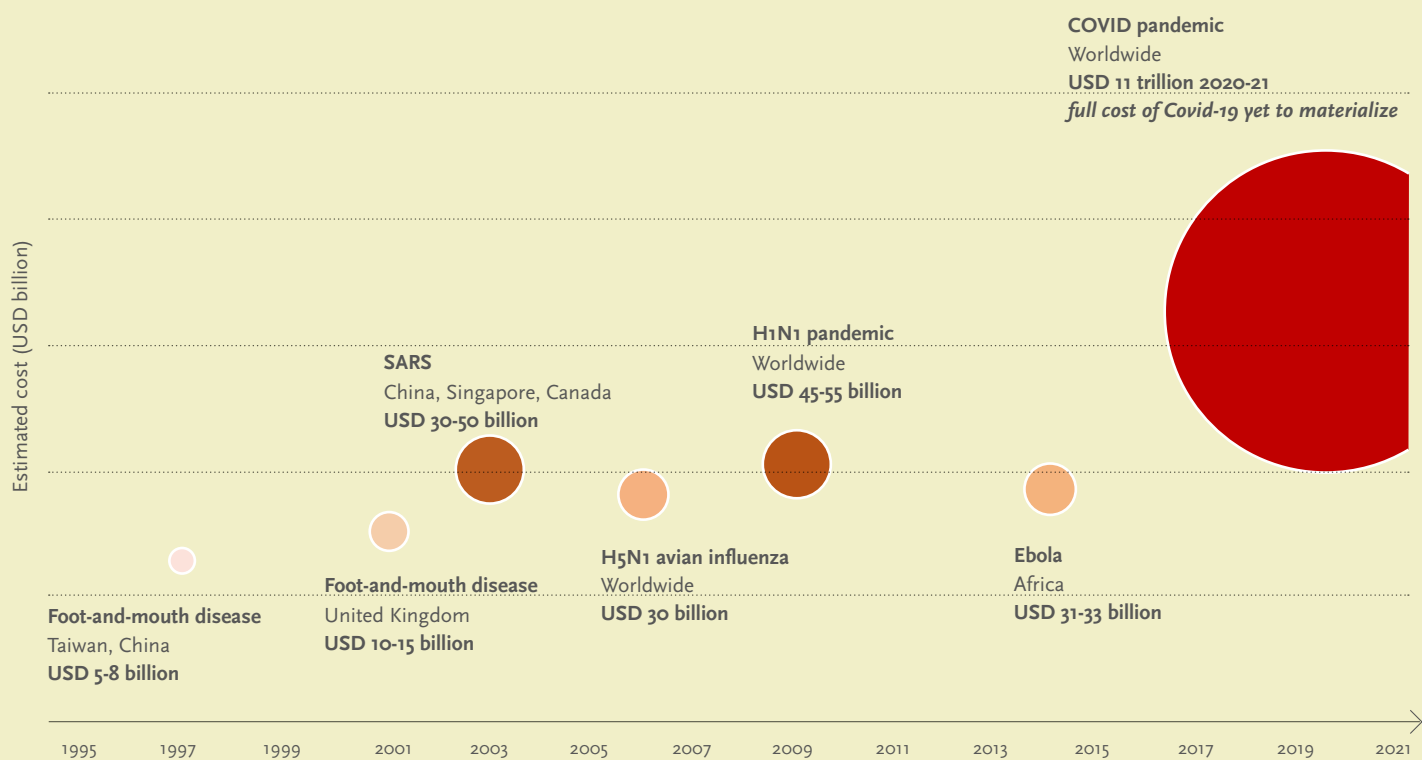


Figure 1. The rising global costs of animal disease and human health epidemics 1995-2021, including some of wildlife origin.

Source: Bio-era, adapted by the Authors

Investing in prevention of wildlife-originated human EIDs at source is extremely cost-effective. As illustrated by previous events (including the current COVID-19 pandemic, suspected to be of zoonotic origin), the costs associated with the *response* to an EID are extremely high (estimated in the trillions of US dollars globally), with severe and lasting impacts on countries' economies and incalculable human suffering. There is therefore a strong economic case for investing in pandemic *prevention* at source (with costs estimated in the millions to billions of US dollars globally). Investing in prevention at source is particularly cost-effective when optimizing and leveraging existing investments in biodiversity, forests, food safety, and veterinary and public health services. Such investments also bring co-benefits, such as in climate change mitigation and adaptation, biodiversity conservation, and related environmental services, creating an even stronger economic rationale for action. The current business-as-usual cycle of neglect and panic is not sustainable, and generates large negative externalities. Investments in improved pandemic prevention are thus to be viewed as public goods, delivering benefits that can be felt both within and across national boundaries. The cost of inaction is high.

East and South Asia are known global hotspots for EID emergence. This is due to a combination of high population density, livestock production, wildlife abundance, high levels of land use changes, deforestation, and habitat fragmentation. These regions have suffered and continue to experience major economic impacts from outbreaks. They also are undergoing large-scale and rapid landscape, trade, consumption, and demographic changes. Therefore, East and South Asia must prioritize EID risk reduction at both the national and regional levels (Figure 2).

East and South Asia must prioritize EID risk reduction at both the national and regional levels

Although most EIDs originate through close contact between humans and wildlife, wild animals do not present an inherent risk, risk is created by human activities in the region that change the ecology and evolution of infectious diseases as well as changing contact opportunities. The most direct and cost-effective way to reduce EID risk is for people to avoid practices that increase the likelihood of pathogen spillover from wildlife. Prevention strategies also may have considerable co-benefits in the form of biodiversity conservation and improved ecosystem services, likely improved livestock production yields, and other direct and indirect benefits across the Sustainable Development Goals.

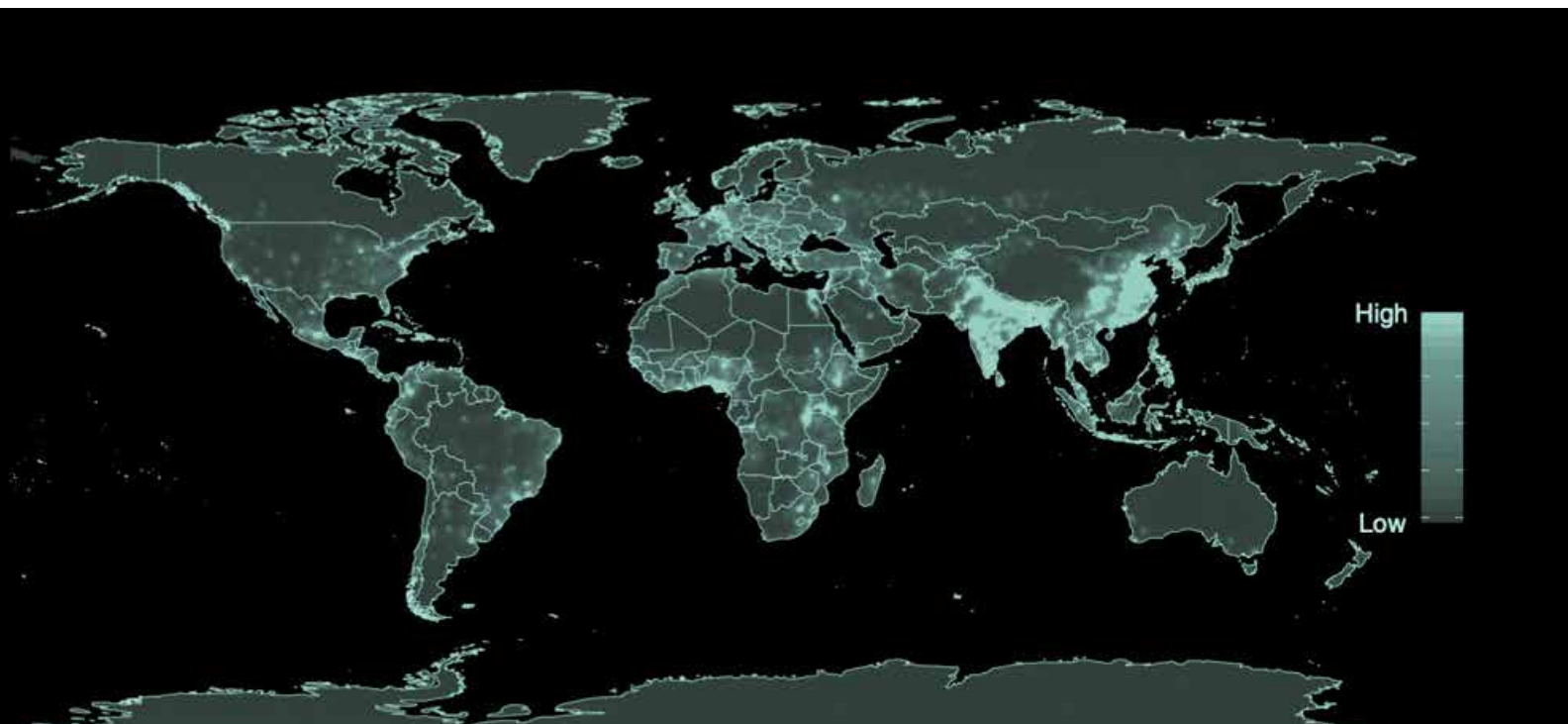


Figure 2. Predicted distribution of zoonotic disease emergence risk from wildlife (adjusted for reporting bias). Source: Allen et al. (2017)

Adequate risk monitoring helps to identify hotspots that require greater attention in the design and implementation of prevention, detection, and response efforts

Overall, many countries in East and South Asia are ill-prepared to prevent the next pandemic, as they lack comprehensive One Health systems that include wildlife and environmental health. This report is focused on low- and middle-income countries in the region. While substantial progress has been made in addressing disease threats linked to domestic animals, attention to the role of wildlife and environmental determinants — and appropriate risk reduction strategies — is limited in the region, instead relying on “end of the transmission chain”, reactive public health responses, leading to preventable outbreaks, often with high societal and human costs. Strategic, long-term investments are needed to develop, and/or enhance, wildlife health systems for effective EID risk monitoring and reduction. Adequate risk monitoring helps to identify hotspots that require greater attention in the design and implementation of prevention, detection, and response efforts.

This report provides two main sets of recommendations for countries in East and South Asia, related to building or strengthening their One Health systems as a long-term priority, and to implementing targeted risk-reduction activities along the way. Recommendations are specific for wildlife-origin EID risks, noting that animal (including domestic), environmental, and human health each have a much broader scope relevant for action under One Health systems in the region, including action on other sources of EIDs, endemic and non-communicable disease threats, conservation objectives, and food and water safety and security. The implementation of these two sets of recommendations should be closely coordinated, with risk-reduction activities as a short-term priority to achieve immediate prevention gains, and long-term One Health systems-building as fundamental for long-term, continuous improvement.

(i) Mainstreaming wildlife into One Health systems. This set of recommendations constitutes the main contribution of this report. It calls for significantly improving the entire range of detection and response systems around wildlife health to inform epidemiological analyses and other risk assessments; risk-based prevention strategies; and integration and coordination of wildlife health aspects with the more developed human and domestic animal health disciplines to ensure cross-cutting capacity and improved outcomes. A stronger, more comprehensive One Health system that integrates all disciplines involved in the origin and transmission chain is the basis for determining relevant sources of risk and developing appropriate risk-reduction interventions in a collaborative way.

(ii) **Reducing root causes of EID risks from human practices in at least three priority areas: wildlife trade, food systems, and habitat loss.** Wildlife farming and trade, and unsafe food systems, force wildlife — and the pathogens they carry — into close contact with humans and livestock, increasing spillover risks. Contact can also be indirectly increased through deforestation, habitat fragmentation, and ecosystem degradation, particularly in hotspot areas, all of which have been identified as underlying processes at the genesis of EIDs from wildlife. The priority strategies to reduce the risk of the next pandemic at source are: shifting the paradigm in how wildlife trade, production, and consumption are understood and managed, including through behavior change; and reversing pervasive land use change trends that threaten biodiversity and exacerbate spillover risks.

Main findings and recommendations

This report includes detailed findings and recommendations across the entire span of activities to monitor and respond to EIDs of wildlife origin. The following key messages were identified for countries in East and South Asia.

- Expand the scope of systems dealing with EID risks to include wildlife considerations.
- Adopt a range of specific laws and regulations, institutional improvements, sustainable investments, and improved coordination between sectors related to monitoring and response to those disease risks.
- Identify practices that increase exposure to EID pathogens (such as wildlife trade, food systems, and habitat loss), and implement targeted measures to minimize said exposure.

For many countries in the region, these measures constitute an ambitious agenda. Over time these steps could dramatically reduce the risks of pandemics. Where countries' institutional capacity is limited, these actions can be sequenced (see Figure 3). The hotspots for increased exposure to EID pathogens need to be identified in a timely manner (calling for short-term improvements in detection and risk-assessment systems), and exposure-reduction activities in those hotspots implemented without delay (through a risk-based approach to prioritize interventions, with wildlife trade and food systems as known, high-risk practices). Comprehensive development of the One Health system is an iterative, medium-to-long term process, more often requiring political and technical leadership rather than large investments (for example, for the formulation of laws or improving coordination between sectors). Reversing the widespread habitat fragmentation and loss in the region, and restoring key ecosystems and ecosystem functions, should also be seen as an ongoing priority requiring commitment, vision and leadership.

Comprehensive development of the One Health system is an iterative, medium-to-long term process, more often requiring political and technical leadership rather than large investments

1. Mainstreaming wildlife into One Health systems

National One Health systems

The key finding of this report is that national systems in the region are weak in their ability to assess and manage EID risks associated with wildlife, thus perpetuating a reactive versus preventive stance for pandemic and epidemic threats. Six systemic gaps commonly found are listed below.

- Policy frameworks:** Existing policies and regulations do not enable One Health approaches to meaningfully include wildlife considerations, leading to lack of clarity on related institutional mandates and leadership.
- Institutions:** Gaps in the policy framework result in unclear or non-existent institutional mandates in responsibility and authority over comprehensive coverage for disease risks of wild animals across species and settings (both captive and wild). Countries often lack a defined government authority/ ministry responsible for wildlife health.
- Multi-sectoral collaboration:** Although EID risks often originate in animals, health disciplines for wildlife, domestic animals, and humans are usually managed by different sectors, which do not systematically collect and share relevant information. This results in a siloed approach to EID prevention and management.
- Investment:** Countries in the region do not make adequate or sustained investments in wildlife health as a discipline. This results in the lack of a dedicated capacity assessment and financing mechanism and prevents wildlife health considerations from being included into the One Health approach.

v. Wildlife health information systems: Wildlife disease and pathogen surveillance activities are often ad hoc and tailored to exploratory research or a narrow group of species or diseases. This results in a piecemeal effort rather than supporting long-term strengthening of national systems for sustained and routine early warning and risk reduction.

vi. Training and career development: there are typically no defined and well-funded pipelines for applied training opportunities in the context of a One Health system. This leads to poor recognition of One Health's role as part of government operations, and limited career advancement opportunities.

East and South Asia countries reviewed in this report do not have national systems fully able to address EIDs from wildlife sources. Increasing institutional capacity to understand disease risk, expanding surveillance, and enabling wildlife practitioners to work closely with veterinary and public health personnel will support multi-sectoral benefits. The status of proposed key indicators for the countries reviewed in this report is summarized in Table 1. Evidence or lack of national-level indicators is not intended to reflect performance or completeness and is not comprehensive but rather qualitative (with progress in any given country as a result of the COVID-19 outbreak not being recorded in the table). Further assessment may be warranted, as many initiatives have been ad hoc or limited in scope rather than reflecting systematic development of a risk-based, sustained approach.

Table 1. Country comparison of proposed representative indicators for wildlife health systems (as of 2020).

Indicator	Countries showing evidence of indicator*
Policies (such as for livestock or land use development) account for disease risk from wildlife	China, Malaysia (for Nipah virus)
Institutional mandate for managing wildlife disease/pathogen risk	China, Indonesia, Malaysia, Thailand, Viet Nam
Wildlife authority included in national One Health body*	Indonesia, Malaysia, Thailand, Viet Nam
Mechanism for inter-agency coordination if authority for risk management is shared	China, Malaysia, Thailand
Risk analysis process in place for assessing and managing risk at wildlife-domestic animal and wildlife-human interfaces	Viet Nam
Plan/strategy in place for systematic surveillance and risk reduction	Thailand, Viet Nam
Dedicated budget for wildlife disease system	China, India, Malaysia
Wildlife monitoring network	China, Indonesia, the Lao People's Democratic Republic, Malaysia, Thailand
Access to laboratory for testing wildlife specimens	China, India, Indonesia, the Lao People's Democratic Republic, Malaysia, Thailand, Viet Nam
Wildlife disease database	Indonesia
Alert system in place for early warning and response	Indonesia
Pipeline for wildlife veterinary/para-veterinary workforce in non-zoo settings	India, Malaysia, Thailand
Applied field epidemiology training program for wildlife surveillance and investigation	China, Thailand

* NOTE: Evidence of national-level indicator (which represents existing activities beyond avian influenza virus monitoring) is not intended to reflect performance or completeness. Any progress as a result of a response to COVID-19 is not reflected in the table. Countries surveyed include China, India, Indonesia, the Lao People's Democratic Republic, Malaysia, Thailand and Viet Nam.

Table 2. Key recommendations for wildlife inclusion in One Health systems strengthening



Institutions

- *Wildlife risk-informed policies:* Include wildlife-specific disease risks in existing policies, such as land use planning, livestock or wildlife development activities, wildlife/eco-tourism, and biodiversity impact assessments. Regulate high-risk species/interfaces (for example, the wildlife trade) in national and regional natural resource protection policies and enforcement efforts.
- *Clear institutional mandates:* Map existing mandates against relevant risk interfaces to reveal areas of coverage as well as gaps, and define clear institutional responsibilities for authorities in charge of wildlife health. Develop a dedicated institutional mandate to assess and manage wildlife risks aimed at emerging disease prevention and detection.
- *Promote multi-sectoral collaboration:* Include wildlife and environment sector representatives in coordination of risk assessment and reduction. Ensure wildlife units are involved in the development of programs, plans, and protocols relating to EID risk assessment and management and broader health security initiatives.



Information systems

- Review existing evidence on disease and pathogens in each country and region to identify baseline risks and knowledge gaps, and to determine initial priorities.
- Establish/strengthen wildlife disease and pathogen surveillance systems.
- Ensure access to a sustainable annual budget sufficient to maintain wildlife health services, and a dedicated process for emergency funding and capital investments.



Capacity building

- Develop an assessment tool and a funding instrument to strengthen capacity and implementation to address identified deficits.
- Develop a dedicated and robust training base for World Organisation for Animal Health (OIE) National Focal Points for Wildlife and equivalent positions with responsibilities for wildlife disease risk management.
- Formalize and incentivize wildlife health/disease management with authority and career advancement opportunities.

Countries should refine institutional mandates for wildlife disease and pathogen risk management.

Mandates should be mapped against risk factors and interfaces to reveal areas of coverage and gaps. Wildlife and environment sector representatives must be included in national and regional multi-sectoral coordination platforms and initiatives. Where they exist, national One Health bodies provide efficient coordination. But these initiatives also require dedicated attention to involving the wildlife and environment sectors in assessment, planning, prioritization, in-service training, and implementation.

Developing wildlife health services to cover EID risk monitoring and reduction requires strategic, long-term support and investments. Efforts to detect and monitor risk can be concentrated in three areas: wildlife sources, wildlife-livestock-human interfaces, and human behavior change. Each of these requires targeted focus and stakeholders to assess and respond to known and novel threats. Core components of surveillance and laboratory, trained workforce, financing, information management, communication, risk assessment and management, and governance systems must be tested and trialed to make them ready for emergencies, ideally leveraging and coordinating investments in other sectors.

Three pillars of action are recommended for strengthening One Health systems against wildlife-origin EID risks in East and South Asia: institutions, information systems, and capacity building (Table 2). Key recommendations for each pillar are summarized below. Given the nascent stage in the development of One Health systems in the region, these recommendations apply broadly to all countries. Specific priorities for system strengthening may vary by country, and should be dictated by specific risk assessments. Section 5 expands on the recommendations.

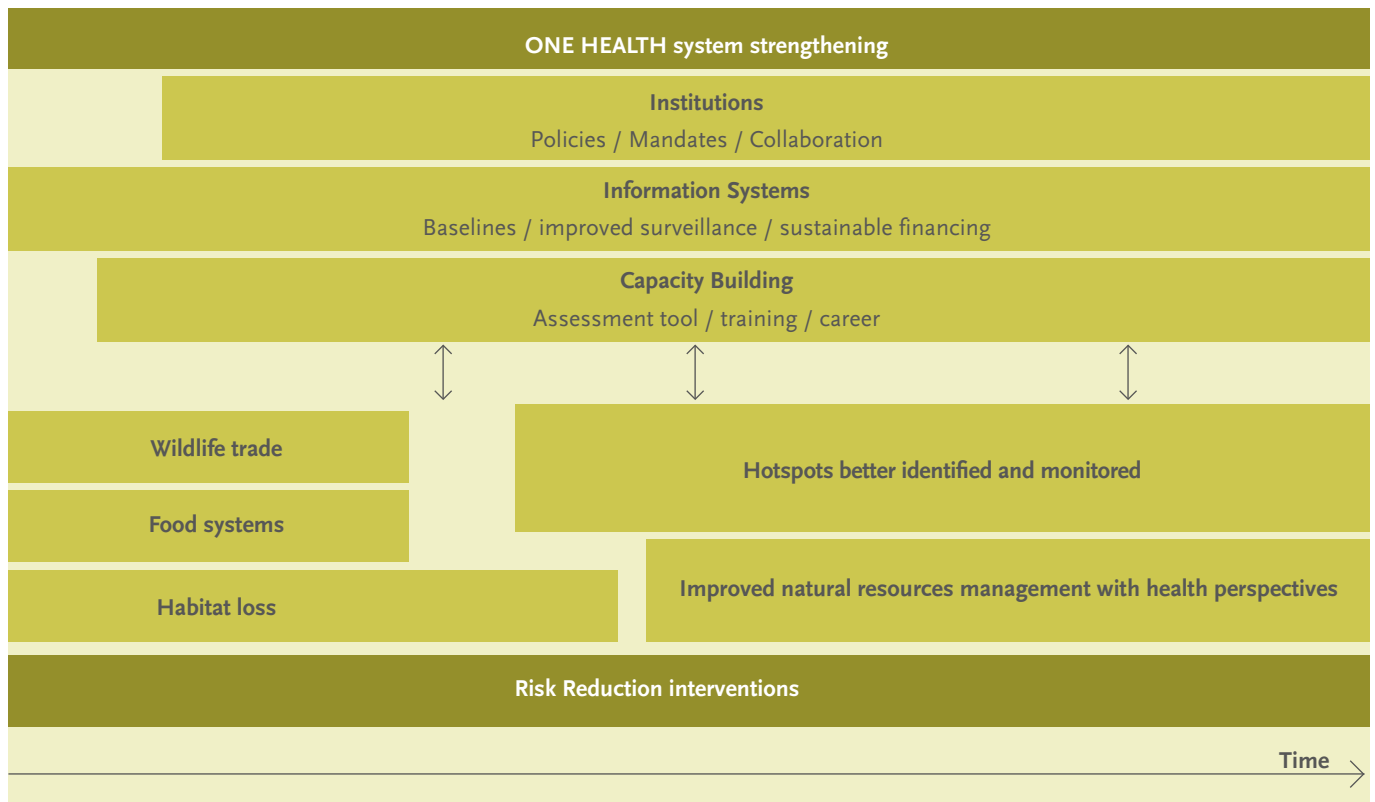


Figure 3. Suggested, qualitative schematic with sequencing of activities to strengthen the One Health system with systematic risk reduction actions *Source: Authors*

The case for regional One Health coordination

The lack of regional and international One Health systems contributes to important information potentially being missed in risk assessment and national decision-making. In addition to national shortcomings in One Health systems, there is no global authority ultimately responsible for wildlife health, disease, and pathogens, depriving countries of help in shaping their national implementation efforts. Transboundary disease and health security initiatives, including around wildlife value chains, need a coordinated, regional approach. Regional One Health systems are also needed to: harmonize trade standards within countries; incorporate disease standards into national and regional wildlife enforcement networks; establish regional and global databases of disease/pathogens; share and centralize information on risks; and provide surveillance and diagnostic support. Further justification for a regional approach is provided in the wildlife trade and habitat loss sections.

Regional coordination can support countries in operationalizing One Health and create a clear role for wildlife health systems in prevention, detection and response

Creating and embedding wildlife health systems expertise at the regional level will facilitate a comprehensive risk-reduction approach and access to needed capacity. One potential avenue for regional action could be through the Association of Southeast Asian Nations (ASEAN), in line with its “Comprehensive Recovery Framework and Implementation Plan,” which includes the implementation of the ASEAN Guidelines for Detecting and Preventing Wildlife Trafficking. Regional coordination can support countries in operationalizing One Health and create a clear role for wildlife health systems in prevention, detection and response. The development of regional expertise on wildlife health — for example through institutions such as the Thailand National Wildlife Health Center, whose goal is to become an OIE collaborating center in wildlife health — would be a much-needed asset for the region.

Partners and technical agencies can play a key role to help countries assess capacity and funding deficits and track benchmarks to strengthen national wildlife health services. A key challenge for identifying needs for strengthening wildlife health programs is the lack of a dedicated capacity assessment tool that complements the public health and animal health tools from the World Health Organization (WHO) and the World Organisation for Animal Health (OIE). Tracking competency and investment needs will put the wildlife and environment sector on an equal footing with other sectors and will inform program design. Benchmarking should be iterative, with follow-on planning, multi-sectoral bridging exercises, and technical implementation support.

2. Reducing root causes of EID risks from human practices

Identifying, reducing and risk-proofing human activities that change the ecology and evolution of infectious diseases and increase human exposure to pathogens is paramount in preventing pandemics at source. The previous section discussed how to strengthen One Health systems at country and regional levels with sufficient capacity and inputs from wildlife health authorities to support detection, prevention and early action on the root causes of EID risks. Systems strengthening is a pathway of iterative build-up and improvement that countries should follow, based on their capabilities and specific circumstances. As systems improve over time, the ability to better identify hotspots and vulnerabilities and act promptly will also improve. The following section illustrates key relevance and entry points for three known root causes driving risk in the region (wildlife trade and farming, unsafe food systems, and habitat degradation), showing how One Health systems can be operationalized to support pandemic prevention, and offers tailored recommendations for risk reduction in each.

Systems strengthening is a pathway of iterative build-up and improvement that countries should follow, based on their capabilities and specific circumstances

Wildlife trade

Wildlife trade is a high-risk interface because it creates artificial interactions between multiple species in ways that can promote the transmission of pathogens. East and South Asian countries are primary destinations of the international wildlife trade. Given the variety and volume of species traded, minimizing informal and better managing formal wildlife trade in the region, including through risk monitoring, are therefore necessary for pandemic prevention.

Most existing national and international wildlife trade regulations such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), while important for sustainability objectives, are not designed specifically to reduce disease risks. Environment and law enforcement sectors have helped to assess and address threats to biodiversity and ecosystems, including wildlife trafficking. However, these activities are not formally paired with health considerations at present. Although the trade in animals in response to international demand markets is increasing in scale and complexity, there are no effective regional mechanisms to manage disease threats from the regional wildlife trade (beyond sanitary trade standards such as OIE's listed diseases for animals), representing a missed opportunity.

Food markets are significant risk multipliers, concentrating many potential sources of risk within the wildlife value chain. Markets are often the final point of sale in the value chain, and typically aggregate animals from multiple sources, sometimes opportunistically. While many points of the wildlife trade value chain can have risk, several notable characteristics of markets include: holding of live or dead animals, or animal products in crowded conditions; multiple species present; low or no hygiene, sanitation, or cold storage practices; on-site slaughter; and a high-density human setting.

Wildlife trade demand reduction for high-risk species requires buy-in and adoption of behavior change. Regulations are unlikely to be successful without stakeholder input to the design of interventions, informed by social science methods and socio-economic considerations. If not properly designed and enforced, bans may drive the trade into illegal trafficking, which is less traceable and more difficult to control. Blanket bans overlook the nuances of disease risk, which is not uniform across species, settings, practices, and uses, and consumer motivations or needs, and thus are unlikely to be sustainable or effective, given their impact on livelihoods and because they overlook the complexity of the wildlife trade.

If not properly designed and enforced, bans may drive the trade into illegal trafficking, which is less traceable and more difficult to control

Efforts to reduce EID risks from wildlife trade, wildlife farming, and wildlife commercialization, need to prioritize specific species and practices. A tiered approach that considers both high-risk groups and species, and high-risk practices should be the basis for possible interventions:

- 1) Target high-risk groups and species.** A wide range of species are traded in the region. In general, mammals (primates, bats, rodents, some small carnivores) and some birds (especially waterfowl) are of greater concern for emerging diseases of pandemic potential than are reptiles, amphibians, and fish. Strong regulations, enforcement and demand reduction efforts against harvest, trade, and consumption of bats and primates should be viewed as a minimum standard. For wildlife farming, designation of permitted species should be based on risk assessment.
- 2) Target high-risk practices.** Holding, slaughter, and use of live animals throughout the value chain present inherent hazards, but the level of risk varies. Introducing safer practices in wildlife trade from source to end use can limit the potential for exposure and transmission.

Addressing the full value chain, from source to end consumer, provides risk monitoring and intervention opportunities at multiple critical control points. Three main recommendations are provided below and complete list is provided in Section 3.

- Conduct outreach with communities and wildlife breeders of high-risk species to reduce market for high-risk wildlife products and create buy-in for risk reduction.
- Ban sale of live animals in market settings and move slaughter activities off-site.
- Develop legislation, capacities, and infrastructure leading to prohibiting the hunting, sale and keeping of bats and primates.

Food systems

The world's nearly eight billion people rely on food systems on a daily basis. Interactions with food systems look different across the world, shaped by a mix of infrastructure, regulatory, socio-economic, livelihood, environmental, and cultural and religious traditions and factors, with resulting disparities in food safety and security. Disease risk related to wild animal sources can occur along the chain of food supply and acquisition, preparation, and consumption. While there are some similarities to domestic animal food system risk factors, the live wild animal trade adds risk factors along its value chain or when products or personnel are engaged with other market systems. A more comprehensive, risk-based approach will need to go beyond the common domestic animal farm-to-table chain to reach other pathways and entry points.

There are many possible sources of wild-associated disease risk in food systems. For EIDs specifically, risk pertains most to certain species and practices. Examples of key pathways for emergence include:

- **Wildlife hunting, rearing, slaughter, or handling:** In most circumstances, the major concern for emergence of high-consequence viral and bacterial pathogens is via exposure to live or freshly-slaughtered high-risk animals, particularly bats, rodents, and primates. Wildlife hunters and transporters, as well as others involved in the handling, slaughter, and preparation, are at elevated risk.
- **Perpetuation via intermediate host species:** Poor biosecurity allows for wildlife-livestock contamination, which may be further disseminated through the livestock value chain.
- **Contamination and consumption:** Ingestion of infectious material can lead to food-borne disease. Food-borne illness is often linked to bacterial and parasitic infections, including crops contaminated by wild animals. Recent contamination of surfaces by wildlife also can be a source of exposure to viral infection.

In some regions of the world, wild meat from terrestrial animals represents a primary source of protein on which populations depend. A substantial volume of wild meat is harvested for subsistence or sold locally to populations with few affordable protein alternatives. At the same time, growing demand is also driven via urban, wealthier populations willing to pay a higher price for wildlife as a luxury product. This collective volume of wild meat, little of which is processed and distributed to consumers with any modern hygiene practices, provides a constant opportunity for human exposure to food-borne pathogens.

Reducing wildlife-sensitive risk factors by transitioning to safer practices is a key prevention strategy. Phasing out consumption of wild-sourced high-risk species (especially, bats, rodents, and primates) is a priority. Over time, transitioning to alternative nutritional sources and reducing consumption of wild animal products can reduce EID risk as well as contribute to biodiversity conservation. In addition to standard food safety practices, three key risk mitigation measures for EIDs linked to wildlife in food systems are provided below (see Section 3 for a complete list).

- Ensure mandates and resources are in place to identify and address all high-risk interfaces in food systems.
- Monitor disease and conduct pathogen surveillance through meat inspections at point of sale or upstream in the value chain (farm, market, and slaughterhouse).
- Enhance hygiene and biosecurity measures at critical control points, and work with relevant stakeholders to find suitable alternatives to hunting, handling, and butchering of high-risk species.

Habitat degradation and loss

Wide-scale land conversion and encroachment on wildlife habitat are associated with approximately one-third of recent zoonotic disease emergence events. The practices typically associated with ecosystem changes allow for changing interactions between humans and other species, with resulting disease consequences. Fragmentation of forests and other ecosystems creates edges, with greater chance of exposures along the perimeter between humans, livestock, and wildlife. Expansion of human settlements, intensification of agricultural and livestock production, and extractive industries such as logging or mining often result in habitat degradation and loss. In South East Asia, the changes are of striking proportions, among them an average loss of 1.3 million hectares of forest annually from 1990–2010, largely for forest goods and agricultural expansion to meet growing urban population demands.

Fragmentation of forests and other ecosystems creates edges, with greater chance of exposures along the perimeter between humans, livestock, and wildlife

Climate-induced changes in land cover and land use, or extreme weather events, may shift species behavior and ranges, in the process changing ecosystems and disease threats. In general, climate change may act as a threat multiplier for other drivers. The tightly coupled links between climate conditions and species abundance and behavior are likely to affect risk, in ways that are hard to predict and potentially impactful.

Land planning processes, including project appraisals, must systematically factor in disease risk and impact assessment. A development project may be a direct or indirect driver of disease risk. Examples include mining that disrupts a cave ecosystem, road building that allows forest access and increases hunting, and newly-cleared landscapes with livestock-rearing activities. Prohibiting certain activities or redesigning plans from the onset can reduce disease risk.

Specific recommendations include:

- Integrate disease and environmental impact projections into cost-benefit calculations for potential development projects and potential intervention strategies.
- Require personal protective equipment when people are exposed to potential wildlife risks, such as when harvesting bat guano, visiting cave sites, and working in fields such as mining and logging.
- Minimize forest fragmentation and limit encroachment on wildlife habitat, especially in high exposure areas such as forests, grasslands, and wetlands.

Disease and pathogen monitoring programs must include wildlife habitats for ecosystems that face planned development, or that contain a high degree of human or domestic animal encroachment. With proper training, park rangers and natural resource practitioners can provide front-line inputs to surveillance systems to detect disease events and alert authorities. In particular, countries should:

- Engage rangers, hunters, and local communities in wildlife disease surveillance by encouraging them to report diseased and dead animals.
- Ensure monitoring systems are available to communities near forest areas to help detect infection and clinical illness.
- Improve early warning systems to better prevent, detect, and respond to changing threats and impacts, including those related to climate change.

Habitat protection measures should prioritize and promote health protection. This could be reflected for example in National Biodiversity Strategies and Action Plans. Ecosystem preservation is the most direct route for avoiding disease risks that result from changes to ecosystems, habitats, and species. Preserving biodiversity may in some cases assist in disease buffering, as well as ecosystem services such as pest and vector control that aid regulation of disease. Disease risk reduction should be calculated into the benefits of designing and managing protected areas. Similar approaches are already used to include other ecosystem services in environmental management strategies, including prioritizing the preservation of land with high mammalian biodiversity and designating off-limits areas for activities based on risk (for example, land planning and policies around distancing of bat roosting sites and livestock rearing sites).

Ecosystem preservation is the most direct route for avoiding disease risks that result from changes to ecosystems, habitats, and species

One Health in practice: selected examples

The emergence of Nipah virus in Malaysia in 1998–99 occurred when pig farms and fruit orchards were placed at the edge of tropical forests and native fruit bat habitat, with resulting bat-pig-human disease transmission. The detection of this transmission chain required collaboration between experts from forestry, wildlife (bats), veterinary (pig) and human health. Detection and characterization led Malaysia and Thailand to institute a policy of distancing fruit orchards and pig production, devoting additional attention and resources to surveillance programs, as well as identifying areas at high risk of disease spillover. It also led to intensive extension services and outreach, with farmers outside of these areas being encouraged and supported to take on alternative agricultural livelihoods. Malaysia's experience and strengthening of their One Health system, policies, institutional mandates and information systems around Nipah virus risk can be considered a good practice example with lessons for others in the region.

Better planning, coordination and collaboration are often affordable and can be achieved through political will and decisive action, without necessarily incurring high costs

In Bangladesh, a National One Health Strategic Framework and Action Plan for Infectious Diseases was developed in 2012, with joint approval from the Ministry of Health and Family Welfare, the Ministry of Fisheries and Livestock, and the Ministry of Environment and Forestry. A national One Health Secretariat has been formed, with a rotating chair position among the three government agencies, ensuring efficient convening of stakeholders for planning exercises, information sharing, and outbreak investigation. This shared ownership maintains important political will among ministries, guides external partner priorities and resources, and promotes awareness and collaboration to address areas of weak capacity in a recognized EID hotspot. This example illustrates how better planning, coordination and collaboration are often affordable and can be achieved through political will and decisive action, without necessarily incurring high costs.

Top

VIET NAM

In and around the Tam Dao Market area, northern Viet Nam. 2014.

Photo credit: Sulma Warne

Bottom

SRI LANKA

Indian Flying Fox Bat prepares to eat the orange fruit on the beach in Hikkaduwa, Sri Lanka.

Photo credit: Jan Arendtsz. Attribution-NoDerivs 2.0 Generic (CC BY-ND 2.0).



Introduction

The impacts of emerging infectious diseases (EIDs) extend far beyond the health sector, as do the factors that shape EID risk and the opportunities to reduce likelihood of outbreaks. The risks of both EIDs and endemic diseases are increased by exposure practices that allow pathogen transmission among species and facilitate their spread. Exposure types can be divided into domestic animal-to-human, wildlife-to-human, or wildlife-to-domestic animal. This report focuses on wildlife-to-human and wildlife-to-domestic animal disease and pathogen transmissions. It emphasizes opportunities to prevent emergence of both novel and known pathogens by controlling or avoiding conditions that enable pathogen spillover, and highlights areas of improvement in the detection of these pathogens in wildlife

Wild animals (Box 2) have a role in the initial transmission (spillover) of pathogens, leading to several diseases with serious consequences for human health, livelihoods, and economies, including the SARS, Nipah, and Hendra viruses. In some cases, wildlife may serve as a reservoir for maintaining pathogens; in others, wild animals may play an incidental role in the life cycle of the pathogen but not serve as the primary transmission route.

Wild animals do not represent an inherent EID risk, risk is created by human behavior that increases likelihood of pathogen spillover and spread

Wild animals do not present an inherent EID risk. Rather, risk is created by human behavior, through changes in the historical evolution and ecology of infectious diseases, and intensified practices that increase likelihood of pathogen spillover and spread. This relationship is not one-directional: wild animals are also at risk of contracting diseases from other species. Further, the pressures that facilitate these interactions and their outcomes are also associated with the global spread of deadly amphibian fungal diseases, facilitated by the international wildlife trade.

Three core and often overlapping, components shape disease systems: the pathogen, the host, and the environment. The dynamics among these components demonstrate the potential for emerging and endemic disease transmission and epidemics, as well as opportunities to intervene to reduce risk and impact. The role of climate change and other environmental determinants of disease risk on disease systems is often overlooked. However, their influence is critical and requires attention because climate and environmentally sensitive factors may affect disease systems in myriad ways. These include host distribution shaped by suitability of habitat and land cover, and the tightly coupled links between weather and climate conditions and changes in species abundance and behavior. A related reason for attention is the uncertainty about how changes in disease systems will appear, particularly at local scales and in response to climate variability. Understanding and addressing sources of climate change-related risk thus requires an integrated approach to guide early warning systems and proactively prevent, detect, and respond to changing threats and impacts.

Habitat destruction and encroachment, biodiversity loss, land use change, climate variability and change, demographic changes, and other dynamics are simultaneously occurring on a profound scale, often threatening human, animal, and environmental health in ways unique in modern history (Richardson *et al.*, 2016). These often co-occurring factors introduce further complexity in assessing risks and outcomes, requiring participation from multiple sectors to address root causes. The siloed approach typically taken to managing disease means these links and chances to take action prior to disease events are not readily appreciated, leading to preventable outbreaks, often with high societal costs. Effective solutions will require meaningful integration of wildlife health and environmental health capacity and operations to head off disease threats in cost-effective ways (Box 3).

Box 2. Defining “wildlife”

Wildlife means feral animals, captive wild animals, and wild animals. A **feral animal** is of a domesticated species that now lives without direct human supervision or control. A **captive wild animal** has a phenotype not significantly affected by human selection but is captive or otherwise lives under direct human supervision or control, including zoo animals and pets. A **wild animal** has a phenotype unaffected by human selection and lives independent of direct human supervision or control.

Source: Adapted from OIE, 2015.

Every development decision must consider public health. Health should be viewed as a possible co-benefit or trade-off of any specific conservation objective, such as forest preservation. In some cases, EID avoidance will directly align with other environmental objectives. However, as with other ecosystem services, different considerations and priorities may need to be balanced. Several examples exist in the forestry sector of possible health-related co-benefits estimates (World Bank, 2017; Potts et al., 2013). Estimating such co-benefits will promote coordinated and improved fulfillment of the Sustainable Development Goals.

Every development decision must consider public health

This report analyzes the regions of East Asia and South Asia, given the global importance of occurring interfaces for emerging infectious disease risk and other transboundary factors. This scope illustrates the value of context-specific approaches and country- and regional-level collaboration. Building systems capable of addressing the major EID risk drivers will yield additional collateral benefits in the form of reduced endemic wildlife- and vector-borne diseases that burden the region. The report results from an extensive review of existing peer-reviewed and grey literature, together with expert input. Country-specific information is summarized based on information from in-country experts and discussions with selected government officials.

The report uses the term “wildlife” instead of “animals” because animal health programs are biased toward domestic animals and thus have a reduced scope of mandates (Box 2 and Glossary). However, readers familiar with domestic animal and livestock health will see parallels throughout. There is overlap with environmental and natural resource management, including management of human-wildlife conflict and climate-proofing, as well as pathways to expand existing World Bank tools such as the Country Environment Analysis. This overlap provides opportunities to apply lessons learned from these other contexts to address EID risks from wildlife.

The report is structured as follows: Section 1 provides a background and is intended as a primer for understanding the dynamics behind emerging infectious disease risk. Section 2 focuses on mainstreaming wildlife into One Health systems and practices by examining cross-cutting system elements needed for countries and regional entities to address relevant interfaces. This section analyzes several East and South Asian countries, with a brief synthesis of current capacity and gaps. Section 3 focuses on key risk interfaces: wildlife farming and trade, unsafe food systems, and habitat degradation and loss. Section 4 provides an overview of current wildlife-relevant gaps in the state of One Health systems. Section 5 concludes with key operational recommendations.

The report includes a rich set of Annexes: Annex 1 summarizes two assessment tools under development to assist countries in evaluating and strengthening their national systems to reinforce wildlife and environmental health capacity needs: the World Bank Country Assessment for Environmental Health Services, and the Needs Assessment for National Wildlife Health Centers from the United States Geological Survey National Wildlife Health Center. Annex 2 analyzes the regulatory approach to commercial farming and trade of wildlife in China as a notable case study. Annex 3 provides useful case studies of zoonotic diseases emerging due to a combination of wildlife exposure and environmental factors (Hendra and Nipah viruses, Highly pathogenic avian influenza, plague and scrub typhus). Annex 4 contains a glossary of technical terms.

Box 3. Examples of environmental and natural resource inputs

Wild animal disease and pathogen monitoring can provide sentinel value, for example, as seen for West Nile virus in crows, yellow fever in howler monkeys, and Ebola virus in great apes. Ecological information routinely collected for biodiversity studies — such as species abundance, distribution, and migration paths — can provide a starting point for assessing disease risk and targeting risk reduction interventions. However, these inputs are not effectively captured without established information channels and points of entry into surveillance systems and risk analysis processes.

INDONESIA

Burnt and degraded forest within Tesso Nilo National Park,
Riau Province, Sumatra, Indonesia.

Photo credit: Flore de Preneuf / World Bank



i. What are emerging infectious diseases and zoonoses?

Emerging infectious diseases (EIDs) are infections associated with new or significantly expanded geographic scope or spread of zoonotic, vector-borne, and drug-resistant pathogens.¹ While EIDs present a threat to all species, this report uses the lens of wildlife-source infections as a starting point for addressing EID risks to improve health security. Zoonotic diseases (zoonoses) are caused by bacterial, fungal, parasitic, prion, and viral pathogens transmitted from animals to humans. While microbial diversity on earth is vast and many microbes provide positive benefits, a small fraction of microbes are harmful to humans (pathogens). Nearly two-thirds of known pathogenic agents in humans are zoonotic, making this an important source of known and future threats to human health, in addition to the health of other species.

¹ Plant-borne and water-borne pathogens may fit this description, but are not within the scope of this report.

Discussion of zoonoses often covers two domains: 1) pathogens initially of zoonotic origin which spill over at one or multiple points and then spread and evolve sufficiently to be maintained in human populations alone, as with the precursor virus (SIV) that led to what we know now as the human HIV/AIDS pandemic; and 2) pathogens maintained in animal populations that result in recurrent spillover events of the same agent, such as those associated with rabies and plague.

For the first category, the organism may not initially be pathogenic in the original host species but as it spills over between species, usually repeatedly, the chance for adaptation to new hosts increases. If this is a viable change with the host supporting the now-new pathogen, there are secondary epidemiological cycles or permanent cycles in the new host. In other words, there is a pathogen jump and the organism becomes adapted to human-to-human transmission. For the second category, there is a reservoir and a different spillover dynamic, with a sylvatic (wild) cycle that sometimes enables secondary epidemiological cycles in humans and occasionally permanent cycles in new hosts, as seen with yellow fever. These distinctions are important in terms of understanding ongoing risks and where to focus risk-reduction strategies (Figure 4).

Current and historical examples of emerging infectious diseases of zoonotic origin in the region are wide-ranging, including Severe Acute Respiratory Syndrome (SARS) caused by coronavirus (COVID-19 is also suspected to be of zoonotic origin); Nipah and Hendra viruses; and highly-pathogenic avian influenzas (for example, H5N1 and H7N9), among many others. Both domestic animals and wildlife are sources of zoonotic diseases (Figure 5). Wildlife-origin pathogens made up over 70 percent of the infectious zoonoses emerging between 1940–2006 (Jones et al., 2008). Both endemic and emerging infectious disease threats are important from health and economic standpoints, though the latter group is of greater concern for pandemic risk unless endemic diseases evolve to be more spreadable, or infect new host species. Changing conditions and activities, such as climate or travel and trade, can lead to previously endemic diseases spreading beyond their original locations and thus be considered as pandemic, such as the transition of Zika virus from Asia to the Americas.

This report focuses on wildlife-specific elements, given that management may involve different authorities — a dimension that has been largely neglected in EID prevention and detection as well as in the scope of overall wildlife and ecosystems management. Both wildlife and domestic animals warrant dedicated attention based on their health and economic implications, and may benefit from synergies in surveillance, information-sharing, capacity enhancement, and coordinated messaging and risk management.

However, there are several broad reasons for the increasing trend of wildlife-related zoonotic disease events when compared to new diseases from livestock. These include human co-evolution with domestic animals over millennia, the relatively high surveillance for the study of the 16 domestic animals² compared to thousands of wild species, and, critically, the increasing frequency and changing types of wildlife-human and wildlife-domestic animal exposures seen from wide-scale human-caused changes.

² Cattle, sheep, pigs, goats, chickens, turkeys, horses, camels, donkeys, buffaloes, dogs, cats, guinea pigs, mules, llama, alpaca.

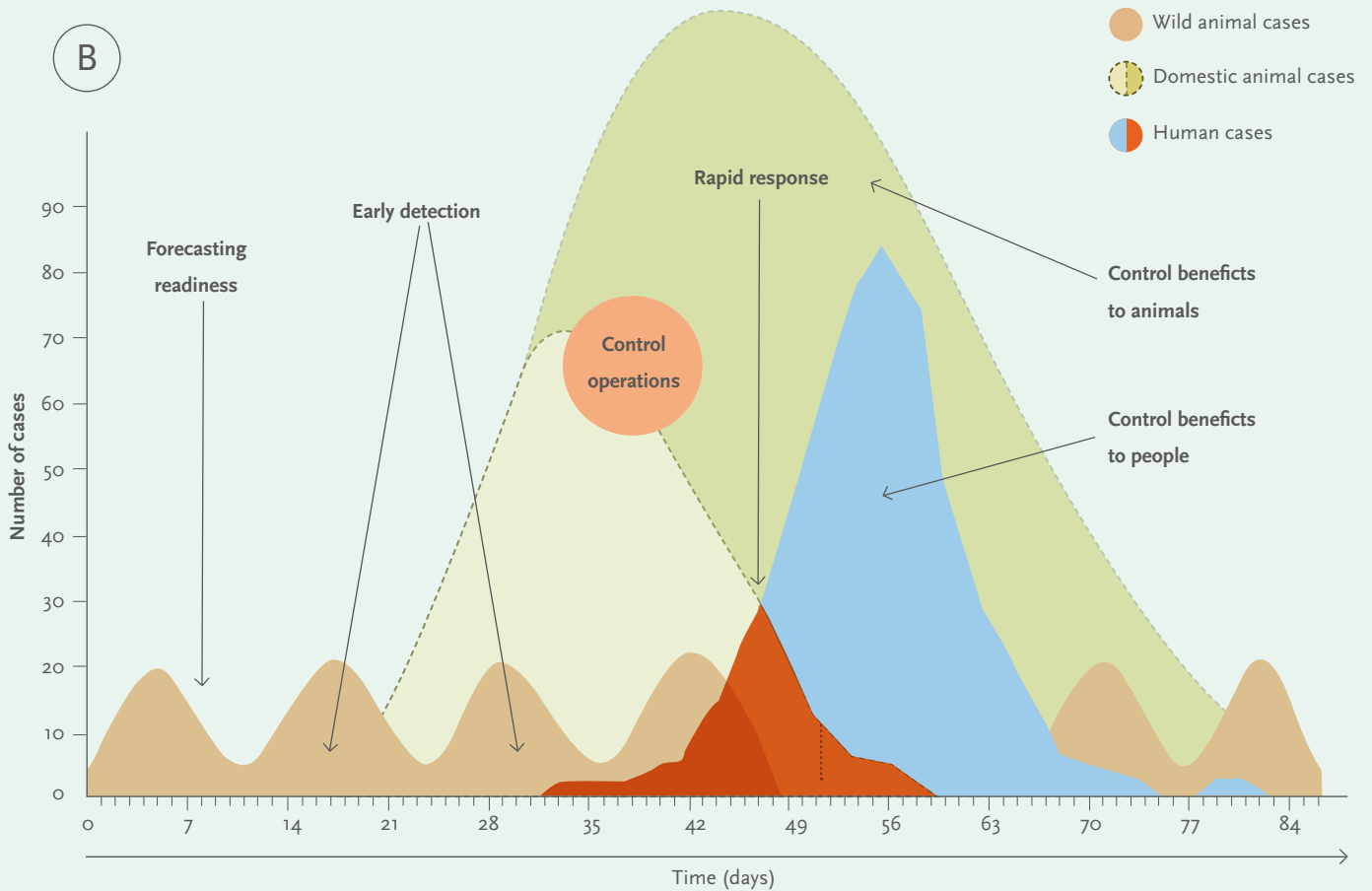
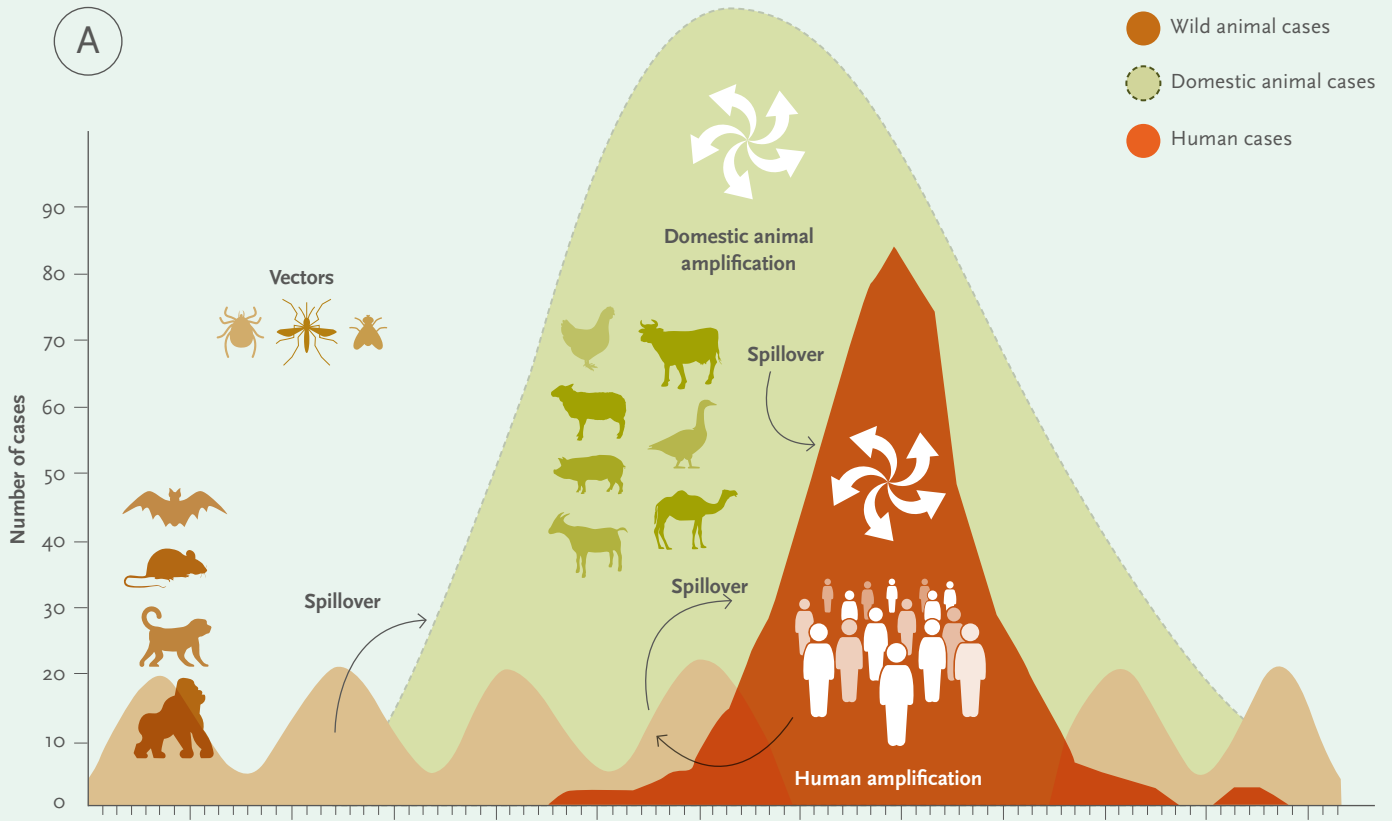


Figure 4. Spillover dynamics. (A) Transmission of infection and amplification in people (bright red) occurs after a pathogen from wild animals (pink) moves into livestock to cause an outbreak (light green) that amplifies the capacity for pathogen transmission to people (spillover arrows show cross-species transmission). **(B)** Early detection and control efforts reduce disease incidence in people (light blue) and animals (dark green).
 Source: Karesh et al. (2012).

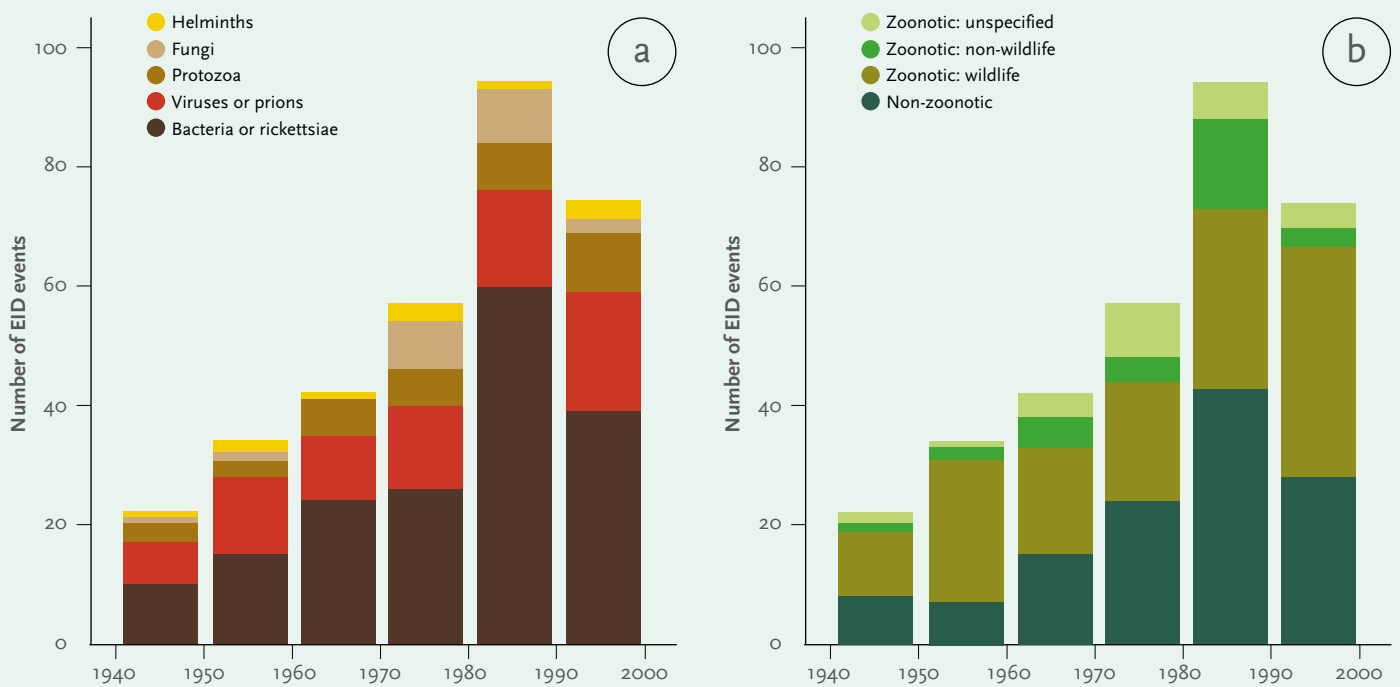


Figure 5. Number of emerging infectious disease (EID) events per decade (based on first emergence event) by a) pathogen type; and b) transmission type (non-zoonotic includes vector-borne, drug-resistant, and plant-borne pathogens). Source: Jones et al. (2008).

In the broadest terms, communicable diseases require three elements: a suitable host, pathogen, and environment. Changes to one may potentially increase or decrease the risk of exposure and the likelihood of successful infection. For viruses, which need a living host to reproduce, making the jump from one species to another is merely an opportunistic strategy aimed at exploiting new hosts and environments for the greatest chance of evolutionary success. Pathogen and host characteristics, such as their pathogen-binding capabilities to host receptors which serve as a lock-and-key function to determine entry into host cells, must be suitable to allow for crossing the species barrier. The environment encompasses the many factors that would allow for animal-human contact to occur, such as species distribution and specific practices. While zoonoses look specifically at the animal to human pathway, the direction of transmission is not unidirectional; humans may also transmit diseases to other species.

ii. How diseases emerge

Species may play different roles in pathogen maintenance and transmission. A reservoir host is the species that naturally harbors a pathogen with or without signs of disease. Identifying the source helps assess ongoing spillover risks. The existence of reservoir hosts also makes true eradication in nature impracticable. Other species may play a role as incidental host or as an intermediate carrier, potentially contributing to circulation or epidemics but not be the long-term or original source. Intermediate species, which may or may not experience disease, play a role in the context of increasing likelihood or efficiency of onward transmissions to humans. While theoretically any species could be an intermediate species in the transmission chain, invertebrate vectors and domestic animals are often connectors between wildlife and human infections, given contact practices or exposure patterns that may allow for transmission or amplification of infections.

Understanding the mechanisms of pathogen transfer from wildlife to or from humans and wildlife to or from domestic animals is crucial for designing risk reduction strategies (see Annex 3 for well-researched case examples). Transmission mechanisms vary by type of pathogens, type of practices, and transmission route (including airborne, food-borne, blood-borne, and vector-borne). Infection may occur after exposure to animal blood, urine, feces, saliva, or other infectious material via direct contact (for example, hunting or slaughter) or via a contaminated mechanical vector. Transmission may occur also via an intermediate wildlife host and sometimes through a domestic animal.

Specific transmission chains may vary widely by context and setting. For Nipah virus, for example, the first detection was via a bat-pig-human transmission chain in Malaysia in 1998. Fruit trees planted around pig sties attracted foraging fruit bats, which dropped partially eaten, contaminated fruit that infected pigs, leading eventually to onward transmission to pig farmers. In that case, encroachment of livestock production into forested habitats, coupled with poor biosecurity, promoted contact between wildlife and livestock and were primary factors in the emergence and scale of the Nipah outbreak. In Bangladesh, recurring outbreaks of Nipah virus have been attributed to direct contamination of date palm sap by fruit bats during the collection phase, with transmission to humans when they consumed the contaminated raw sap, which is a local delicacy. Outbreaks have also been reported in several states in India. Although Pteropodid bats (flying foxes) prevalent in the East Asia and Pacific (EAP) and South Asia regions are reservoirs for Nipah virus, the transmission routes are uniquely influenced by human actions: livestock production systems and cultural practices.

While exposure to reptiles, amphibians, or fish transmits some pathogens to humans, the most relevant groups for emerging, high-consequence viral zoonotic pathogens are mammals and birds. This is because of their relative genetic similarity that supports the potential of pathogens to exploit new hosts. Based on estimates from field studies, there are an estimated 1.6 million mammalian viruses on Earth, the vast majority of which have not yet been discovered by science and a portion of which likely have zoonotic potential (Carroll et al. 2018). This crude estimator is important for understanding the scale of unknown viral threats and building broad risk reduction measures that can target risks from viral families, high-risk species, or taxonomic groups, or from high-risk exposure settings or practices.

For viral families, those with known high-consequence pathogens can help prioritize detection efforts. For example, screening for coronaviruses, filoviruses, paramyxoviruses, and orthomyxoviruses is a solid starting point for recognizing related viruses (including SARS-like viruses) that may have selected genetic differences that increase pathogenicity (ability to infect) or virulence (severity). Based on existing detections and viral richness studies, we can reasonably target where there are likely to be “missing” zoonoses not yet detected or emerged. In East Asia, for example, primates have been identified as an under-sampled taxonomic group that may pose elevated emergence risk (Figure 6). While disease risk in communities living near primates in parts of East Asia and engaging in primate-trade practices have received limited study, expanded testing panels or next-generation sequencing may facilitate early warning of pathogen threats. Such steps would enable faster discovery of an outbreak that may be outside of existing animal and human diagnoses known to occur in a given location (Box 4).

The high return on investment from epidemic and pandemic risk mitigation through animal and human health systems strengthening has been articulated in prior reports (see, for example, World Bank 2012, 2017), although wildlife dimensions have been a largely neglected area of focus.

Delays resulting from mistaking a novel disease for a known one can be costly in terms of health and economic losses. In East Asia, this was seen with the first detections of Swine Acute Diarrhoea Syndrome (SADS) coronavirus and Nipah virus. The emergence of SADS coronavirus in 2016 at pig farms in China's Guangdong Province was initially suspected as Porcine Epidemic Diarrhoea Virus (PEDV) based on prior PEDV infection, and some detection at the first farm known to be affected. However, high pig mortality continued even as detection of PEDV ended, and the novel SADS-CoV was eventually identified as the cause. The disease resulted in the death of nearly 25 000 piglets (preceding the African Swine Fever epidemic that began the following year). Based on closely-related coronaviruses found in *Rhinolophus* spp. horseshoe bats roosting in caves near the index farm, the emergence event is suspected to be via initial introduction from bat-pig contact (Zhou et al., 2018; PREDICT Modeling & Analytics).

In Malaysia, the emergence of Nipah virus in 1998 was initially misdiagnosed as suspected cases of Japanese Encephalitis (JE) based on initial detection in some human samples. This diagnosis led to strategies aimed at mosquito control measures and vaccination against JE but not effective against Nipah virus. As a result, the disease spread further within the country and into Singapore as pig trade and transmission continued (Looi and Chua, 2007).

Greater knowledge of viral threats circulating in wildlife may help authorities get ahead of, or more rapidly detect, similar disease spillover events. Capabilities for novel pathogen detection can serve two roles. First, infectious agents circulating in wildlife populations, with or without presence of disease, can be identified and catalogued to quickly inform decision makers about the possible source if outbreaks occur at a later date in humans or animals. The second use is to expand the diagnostic capabilities in sick people or animals to more quickly identify causative agents when routine testing for known pathogens fails to identify the cause.

iii. Circumstances that increase exposure

Many of the drivers of disease emergence from wildlife are those also associated with biodiversity loss and ecosystem degradation

Wildlife and the pathogens they carry do not intrinsically pose risks to human health. Risk is created via the human actions that increase potential for exposure and spillover. The following drivers, or broad factors associated with risk, demonstrate the types of circumstances that create potential for risk. Importantly, many of the drivers of disease emergence from wildlife are those also associated with biodiversity loss and ecosystem degradation, reinforcing the importance of multi-sectoral collaboration to address shared threats. Some of the exposure pathways described below will be further analyzed in subsequent sections.

- **Wildlife trade:** From harvest to markets, many interspecies interactions along the wild trade value chain may increase risk, particularly when involving live animals or fresh meat products (see Section 3). Wildlife may be traded for food, pets, or luxury items (including traditional medicine remedies). The trading and consumption of wild animals or their products — whether locally, between rural and urban settings, or among countries, regions and/or continents — presents opportunities for pathogen movement and spillover (Utermohlen 2020). Traceability is an issue for wildlife trade, especially given the high volume in some settings, the typically limited resources allocated for enforcement and monitoring, and the variable condition of the animal or product, all of which may make taxonomic identification challenging. Except for a few species which may be regulated on the basis of internationally-notifiable livestock diseases and trade implications, veterinary controls for legal wildlife trade are virtually non-existent.

- **Wildlife breeding:** Similar to livestock breeding, there are several potential sources of risk associated with wildlife captive-breeding for human consumption as food, medicine, fur, and other commercial products. Farmed wildlife has been industrialized in some countries, contributing to the local economy, but the trade also includes a significant share of animals sourced from the wild, creating a potential pathway for disease introduction. Multiple species may be housed together, including species not typically (or ever) overlapping in nature, providing novel opportunities for pathogens to adapt to new hosts. Additionally, the farm rearing of genetically similar animals may allow for efficient pathogen amplification (see example from the China case study at the end of this section).

- **Hunting and wildlife food preparation:** Hunting, handling, and butchering of wildlife intended for food consumption can present zoonotic disease risks via contact with infectious materials. While risk of food-borne illness is a significant problem, sufficiently cooking meat typically degrades most pathogens. In many parts of South Asia and EAP, the consumption of wildlife is considered a delicacy and is often an expensive symbol of economic status. Wildlife or bushmeat is also a fundamental staple, often offering the only protein source for communities who traditionally live in or around protected areas and wildlife habitats.

- **Commercialization practices in markets:** Market contexts and risks may vary widely in terms of size, species, hygiene conditions, formality and regulations, and other factors. Animals may come from multiple sources (farms or wild-caught) with multiple wild and domestic animal species present, often transported and housed in close quarters and in stressful conditions that increase the likelihood of viral amplification and shedding. Markets, especially in rural areas, are often insufficiently regulated, or regulations are insufficiently enforced. The presence of live animals in markets, and on-site slaughtering and butchering, increase exposure to potentially risky pathogens.

- **Encroachment into wildlife habitat:** Encroachment by humans and livestock into existing wildlife habitats, in new or intensified ways, creates opportunities for novel exposures. Examples include bat guano farms which create artificial bat habitats and put humans in close contact with their excrement harvested for fertilizer; human visitation of caves or other wild habitats for mining or tourism; hunting and other natural resource extraction; and expansion of human settlements. Extractive industries such as logging or mining may be associated with road building and greater access to forest areas that allow for intensified wildlife hunting. By contrast, other activities such as wildlife-based tourism, when properly carried out and avoiding direct contact with wildlife, have not been described as representing an additional zoonotic disease risk.

- **Deforestation and habitat degradation:** The wide-scale loss of species habitat and changes in land use have negatively impacted biodiversity and the provision of ecosystem services over recent decades. These factors are often associated with land fragmentation, resulting in so-called edges between forest areas and human settlements or agricultural activities, or shifts in land use that maintain some level of wildlife habitat while also fundamentally changing ecosystems. Such changes may displace wildlife, restrict their habitat, or disrupt their migration paths — all potentially allowing for changes in inter-species interactions and heightened stress levels in wild animals. These changes also affect zoonotic disease risks as altered habitat suitability and predator-prey relationships change species distribution and abundance, potentially giving rise to more generalist species that may be competent disease vectors and/or more able to adapt to changing environments.

The wide-scale loss of species habitat and changes in land use have negatively impacted biodiversity and the provision of ecosystem services over recent decades

- **Agricultural intensification and wildlife-livestock contact:** Expanded livestock production often occurs in concert with habitat destruction and degradation. Domestic animal production that occurs in newly modified natural habitats without previous wildlife-livestock-human contact presents an opportunity for disease spillover. For example, the emergence of Nipah virus in Malaysia in 1998 occurred when pig farms and fruit orchards were established together at the edge of tropical forests and native fruit bat habitat.

- **Climate change:** Climate change, along with climate-induced changes in land cover, land use, or extreme weather events, may shift animal movement, migration patterns, or species abundance: in the process changing ecosystems and disease systems, including the distribution of pathogens (Bouley et al., 2014). In general, climate change may act as a threat multiplier for other drivers. For example, changes in habitat suitability may increase the establishment of introduced alien species and the pathogens they may harbor. Certain diseases are particularly climate-sensitive because prolonged rainfall promotes the conditions (for example, rodent density and flooding) associated with their outbreak cycles. The potential net and localized impact of climate change and climate variability in future emerging and zoonotic disease risk still remains largely unknown, due to insufficient research, but are likely to serve as drivers or threat multipliers for some.

iv. Hotspots and avenues to risk reduction

a. Hotspots of zoonotic disease emergence

Hotspots of zoonotic disease emergence are broadly associated with areas of high mammalian biodiversity, expanding human populations, and land use change

Relative risk of zoonotic disease emergence varies around the world. Mapping disease emergence events in recent decades, and correcting for surveillance bias, indicates the hotspots of emerging infectious diseases. When looking specifically at disease emerging from wildlife (Figure 2), the hotspots are broadly associated with areas of high mammalian biodiversity, expanding human populations, and land use change (for example, change in pasture). These characteristics signify environmental and anthropogenic changes that increase the likelihood of wildlife-human or wildlife-domestic animal exposures (Jones *et al.*, 2008; Allen *et al.*, 2017).

In the East and South Asia regions, human populations have varying but, in some cases, high-risk contact with wildlife, makes them vulnerable to emergence and spread of disease. Many communities also have limited access to public health systems and other socio-economic safety nets, which are essential for resilience in the event of disease outbreaks. Known hotspots provide an initial indication of areas that require greater attention and capacity enhancement to ensure adequate surveillance, risk monitoring, and risk reduction. As with the utility of targeting certain high-risk practices (the “what”) and taxonomic groups (the “who”) as a starting point for designing prevention, detection, and response efforts, hotspot information can be helpful when prioritizing the “where” for intensified efforts. As more information is collected, regional hotspots maps can be refined and downscaled to finer-scale resolutions.

As risk is shaped by several factors (broadly relating to the host, pathogen, and environment) risk reduction strategies must be context-specific. Using findings from regional analyses can be helpful as a starting point, and defining local emergence, spread, and vulnerability factors provides context for local strategies. General strategies for reducing exposure can be considered for different scales and parts of the exposure and transmission process, pertaining to wild animal sources, high-risk interfaces, and human practices.

b. Avenues to risk reduction

A useful framework to systematically consider spillover risks, and potential actions to reduce this risk, is provided by following the pathogen along the transmission chain. Risk-reduction measures, therefore, may be grouped along three main pillars: (i) the wildlife populations where the pathogen originates; (ii) the interface that brings the pathogen into contact with other animals and/or directly with humans; and (iii) the human populations and their behaviors (see Figure 7 and Table 3).

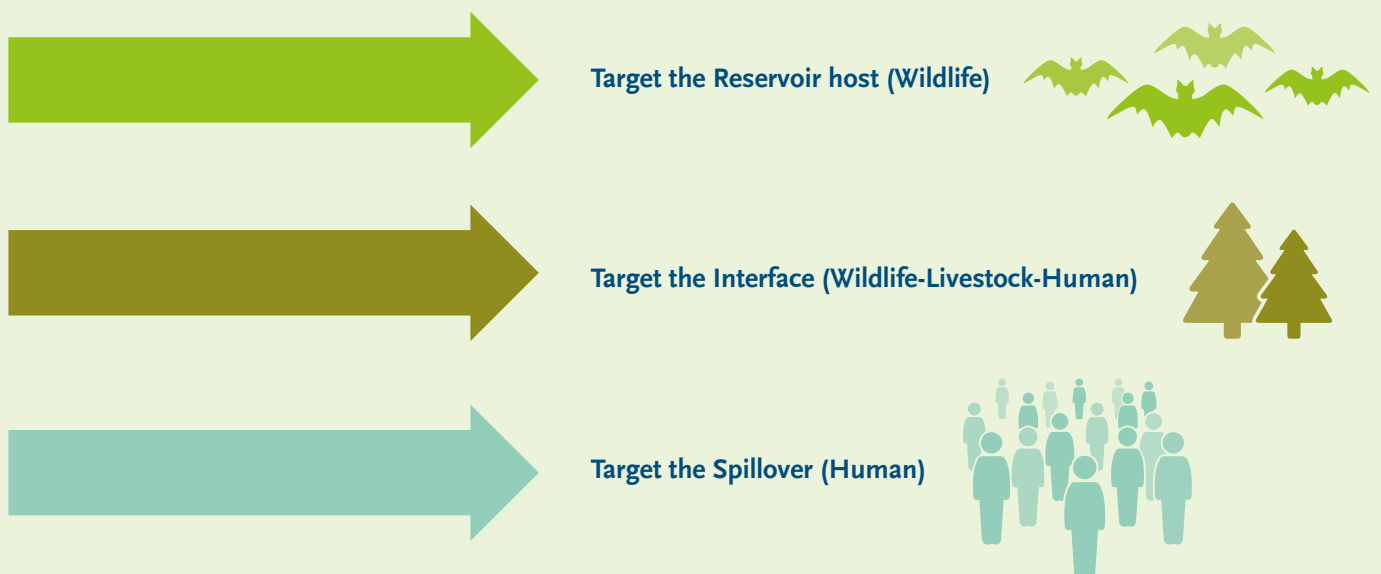


Figure 7. Foci of action for reducing EID risks from wildlife Source: Author's own elaboration (based on Sokolow *et al.* 2019)

Measures targeting wildlife sources or reservoirs

Both historical and recent establishment of pathogens in a wildlife reservoir makes complete eradication practically impossible. A key challenge for some diseases has been identifying a reservoir species, given the number of wildlife species, low sampling effort for many wild species, and low prevalence rates or periods of active viral shedding that would help differentiate a reservoir from an incidentally-infected intermediate host species. Bats, rodents, primates, and carnivores are recognized to be among the taxonomic groups of greatest concern for emerging viral zoonoses globally (Box 5) (Olival et al., 2017). Wildlife-specific risk-reduction measures differ from livestock-oriented measures based on factors including objectives (that is, conservation versus production and trade status considerations) and viability in different settings — ranging from free-ranging wildlife on one end of the spectrum and highly-concentrated animal production systems on the other. While culling is an effective management strategy for several livestock diseases, it is not typically appropriate in the management of wildlife diseases and pathogens other than a few conditions due to over-crowding, or artificially induced overpopulation. In China, the outbreak of COVID-19 resulted in misguided proposals to move hibernating bats, which are highly sensitive to disruptions, or worse, to implement a mass culling effort (Zhao, 2020). Disease-related efforts to kill wildlife often target the wrong species, are an ineffective use of resources, threaten ecosystem services, and may actually increase disease risk (Olival *et al.*, 2016; Amman *et al.*, 2014).

Ecosystem approaches consider the connections among species and habitats, providing a helpful frame for examining the evolutionary and ecological dynamics relevant to disease risk and considering ideal ecosystem adaptation and management strategies (Convention on Biological Diversity, CBD; Karesh et al., 2012). In a healthy ecosystem and population, species abundance and composition are kept in check by natural processes such as predator-prey relationships, availability of resources such as food and water, and other factors. Altering these natural rhythms will affect disease dynamics (with changing pathogen prevalence, species composition, vector abundance and distribution, etc.), particularly as humans and livestock encroach on these settings. Therefore, protecting biodiversity and habitats — ideally through protected areas and other strategies to prevent disruption or loss of habitat — is critical for reducing zoonotic disease risk. Reducing human contact, or reducing human or livestock activities in some seasons, may be warranted as part of biodiversity management. An example is cave ecotourism operations that encourage wildlife viewing from a safe distance. The most direct risk reduction measures can focus on reducing exposure with wildlife reservoirs to minimize chance of spillover.

Altering ecosystems will affect disease dynamics, particularly as humans and livestock encroach on them

Box 5. The role of bats in disease emergence, and the importance of bat protection

Bats have been linked to the origins of several high-consequence pathogens, including SARS-CoV, Nipah, and Hendra viruses, prompting some studies to examine whether bats are “special” as a reservoir for viral diversity. Assessing the potential risks they pose and designing appropriate intervention strategies warrant consideration of several factors. Bats represent a diverse taxonomic group with over 1200 known species (as an order in the class of mammals, their diversity is second only to rodents), with more than 330 found in Southeast Asia. Their viral diversity for known diseases that infect humans is at least partially related to species richness (Mollentze et al., 2020). Although bats are under-studied, they appear to be a major source of viruses from viral families with known zoonotic diseases, for example lyssaviruses, coronaviruses, and paramyxoviruses. Their species diversity reflects varying spatial distributions, migration patterns, and feeding and roosting practices, reinforcing the need for ecological information. In the region, several human practices allow for heightened risk of pathogen spillover from bats to other species. Examples include inadequate biosecurity to prevent bat-livestock interaction, bat harvest, handling and butchering for consumption, consumption of food products contaminated by bats, bat cave tourism, and bat guano harvesting for fertilizer.

Bats are important parts of ecosystems, contributing to pollination, seed dispersal, insect control, and guano production. These services contribute to production of cultivars, preservation of genetic diversity via maintenance of crop wild relatives, soil nutrient cycles, and forest regeneration. The latter includes a notable role in tropical forest ecosystems from trees dependent on bats for either pollination or seed dispersal (Kunz et al., 2011). In addition, their ability to resist or tolerate some infections holds promise for developing immune response therapies for humans. As a general rule, avoiding contact with bats and leaving their habitat intact is good practice for reducing disease risk and promoting biodiversity and ecosystem health.

Other examples of ecological control of disease risks include re-establishing balance of predator-prey dynamics, especially in cases where predators are endangered, or employing natural enemies of the reservoir host. Any of these methods, however, require a deep understanding of the ecosystem and its multiple variables, and if not properly implemented, might lead to further unintended risks.

Regular sampling and surveillance of pathogens in wildlife, as well as monitoring and reporting of wildlife disease events, can provide early warning information of potential risks, particularly in communities living near wild areas

Regular sampling and surveillance of pathogens in wildlife, as well as monitoring and reporting of wildlife disease events, can provide early warning information of potential risks, particularly in communities living near wild areas. This will enable risk control measures within the natural wildlife reservoir and at wildlife-human interfaces. Wildlife morbidity and mortality event reporting should be followed with an investigation for event determination (for example, viral or bacterial disease, toxicological agent, starvation, extreme heat) to provide information on the scale of impact and guide management strategies. With longitudinal tracking of wildlife disease and pathogens, patterns and mechanisms may become clear that will improve predictability (how pathogen prevalence levels and shedding periods may be associated with seasonality, life stage, and stress or condition factors). While most infectious pathogens can move between animals and humans, only a subset are efficient enough in human-to-human transmission to result in large epidemics or pandemics.

To more proactively and systematically anticipate and mitigate risks, safeguard assessments should consider how the changing ecosystems may affect EID risks. Land use changes are especially important given that they frequently involve change in wildlife habitat, paired with new or expanded human and domestic animal presence and movement. Land use planning is a key process where disease should be considered to avoid unintended externalities.

Box 6. A view from the other side: livestock-to-wildlife disease transmission

Disease risk is not unidirectional: wild animals are also at risk of diseases from domestic animals, humans, invertebrate vectors (such as mosquitoes), or other wild animals. This was shown by the 2017 outbreak of Peste des Petits Ruminants (PPR) in Mongolia, which resulted in transmission of PPR to wild antelope species including Saiga antelope, ibex, goitered gazelles and bharal. Mortality of Saiga antelope was estimated at 55 percent of the entire population. The event occurred during a PPR vaccination campaign of small ruminants that did not cover all livestock in the affected part of the country. Investigation suggested spillover from livestock, with outbreaks likely driven by movement of livestock (Privot *et al.*, 2019). This event reinforces the importance of a multi-sectoral approach to reducing risk, whether for public health, livestock production, or conservation objectives.

Source: Authors' own elaboration.

Measures targeting the wildlife / human interface

Identifying interfaces where wildlife-human contact or wildlife-domestic animal contact occurs, or may be increased or intensified as a result of development or other activities, is an under-utilized strategy to assess and inform disease risk-reduction measures. Sentinel surveillance in humans may also be useful for detecting evidence of pathogen exposure via serological tests. Another key area is expanding diagnostics panels, particularly for non-specific febrile or influenza-like illnesses that may commonly go mis- or undiagnosed. For these, a rapid differential diagnosis could help distinguish common diseases with existing treatments from novel spillover events that could potentially turn into wide-scale epidemics. Early detection is critical to ensure precious time is not lost in tracing and containing spread.

For some stakeholders, interfaces may be examined using different information than typical classifications used for enforcement or risk management. For example, wildlife trade may be legal on the basis of not posing a threat to the sustainability of a species, but may not (and often does not) reflect disease risk. Veterinary controls are limited for wild animals but could offer a route to safer trade. Both formal and informal trade may involve wildlife-human interfaces that could potentially increase the risk of disease transmission. Observational studies may help broadly identify the types of contact occurring and possible transmission opportunities.

It is important to note that effective law enforcement will likely result in an increased volume of confiscated animals, at least until demand is reduced. This will require infrastructure (holding facilities, standard operating procedures, feeding considerations, veterinary care, trained staff, and personal protective equipment) for proper care and welfare of animals, as well as management of disease risks as a consideration for occupational health and safety.

Ecological factors may also be useful to consider when targeting interfaces. For example, information about wildlife movement patterns, feeding preferences, and other behaviors can inform land zoning and other policies that might reduce potential contact between wildlife and livestock or human populations. To reduce the risk of future Nipah virus transmission, for example, Malaysia implemented a policy of establishing pig farm areas that included enhanced biosecurity: distancing from fruit orchards to minimize indirect contact between fruit bats and pigs. Farmers outside of these areas are encouraged to take on alternate agricultural livelihoods. As another example, migratory bird flyways may span thousands of miles, with migratory waterfowl potentially coming into contact with other animals and increasing the risk of transmission of avian influenza viruses that could potentially result in a highly pathogenic strain. Enacting improved biosecurity in poultry production facilities, or redirecting potential poultry farm investments away from areas where waterfowl congregate, can help prevent outbreaks of avian influenza.

Risk maps can bring together multiple sources of information that may help to identify regions or sites to target risk monitoring and risk reduction efforts, potentially as part of early warning systems. Mapping wild species distribution or ranges and livestock production activities can help identify areas at risk (see Figure 9). This information can be used to guide placement of country and regional investments, identify areas for targeting enhanced surveillance and strengthened biosecurity requirements, and readiness measures for timely detection and multi-sectoral epidemiological investigation if spillover events do occur. Systematically taking into account how development activities may change such interfaces (increasing or decreasing risk) can help to design safer investments to promote prevention of epidemics of known and novel diseases.

Behavior-change campaigns must be locally adapted and designed in environmentally sensitive ways to avoid creating adverse consequences for biodiversity and ecosystem services needed for resilience and recovery

Measures targeting change in human behaviors

Many people live in contact with wildlife and face a variety of exposure types related to their livelihoods, socio-economic factors, cultural, religious, or personal preferences. Acceptable alternatives to wildlife may be lacking on an individual or population basis. Because of this, policies that do not address feasibility and acceptability considerations are likely to fail. For example, blanket bans on all wildlife trade are unlikely to be sustainable or successful, given the impact on livelihoods and because they overlook the complexity of the wildlife trade.



Figure 8. Khmer language version of “Living Safely with Bats”, a biodiversity-sensitive zoonotic disease risk communication tool. Source: PREDICT One Health Consortium 2018.

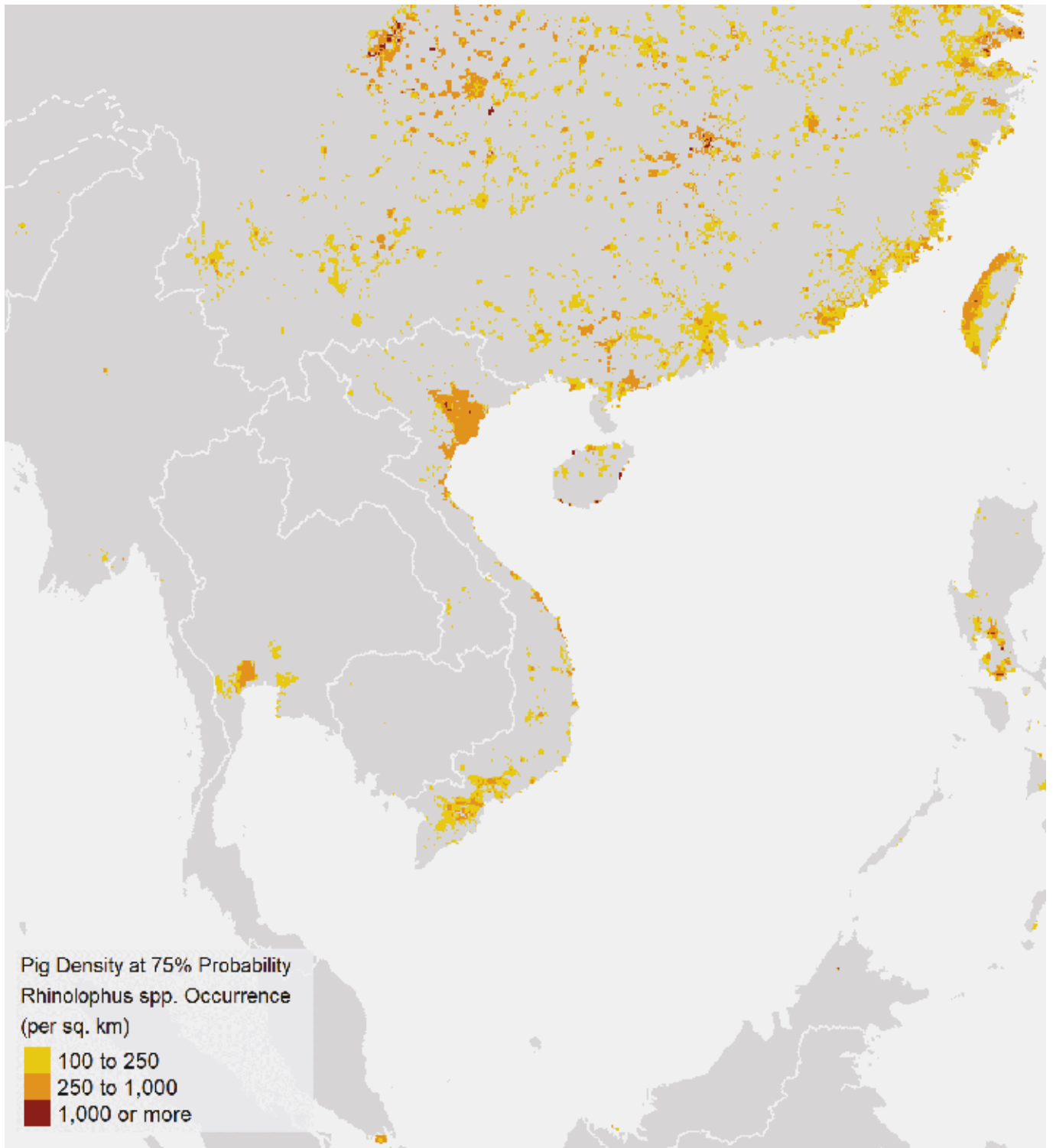


Figure 9. Areas of bat-pig overlap where probability of SADS-CoV *Rhinolophus* spp. reservoir occurrence is high (>75 percent) and pig densities are indicative of intensive pig farming (>100 pigs per km²)

Source: EcoHealth Alliance

Blanket bans on sale and consumption of wildlife and other natural resources, even if based on disease risk, are also unlikely to be effective without changing demand factors. Demand for products may vary widely by populations and regions, and wildlife trade bans may inadvertently drive trade into the underground market, where traceability and law enforcement become even more challenging. In addition, trading, farming and hunting of wildlife — depending on how managed and monitored — can be sustainable, economical, and even part of appropriate conservation efforts, where benefits are re-invested into communities and into conservation.

Risk could be reduced by improving health literacy levels, awareness of potential zoonotic disease risks from wildlife exposures, and uptake of safer alternatives, as well as engagement in or access to the formal healthcare and public health systems in many populations and regions. Sensitization and behavior-change campaigns must be locally adapted to ensure effective reach and reception. Consistency in risk messaging is crucial for clear guidance and should be designed in ways that promote lasting changes, not just during periods of disease emergencies (though increased vigilance may be warranted during outbreaks). It is also important that these are designed in environmentally sensitive ways so as not to inadvertently create adverse consequences for biodiversity and ecosystem services needed for resilience and recovery. For example, under the USAID Emerging Pandemic Threats PREDICT program, an illustrated “Living Safely with Bats” book was developed and adapted to 13 languages and contexts. The book informed communities about safe and harmless ways to reduce disease risks related to wildlife interactions, for example, practices for safe handling of sick or dead bats and addressing wildlife living in homes or roosting in village trees without the need to kill bats.

Behavior-change campaigns must be locally adapted and designed in environmentally sensitive ways to avoid creating adverse consequences for biodiversity and ecosystem services needed for resilience and recovery

Changes in policies and practices — whether through safeguards and regulations for land use or trade or by reducing human activities in or around wildlife habitat — are key for reducing risks. If human or domestic animal presence in wildlife habitats or contact with wildlife and wildlife products cannot be avoided, measures should focus on minimizing exposure, such as through adequate provision of non-wildlife protein sources for employees, enhanced biosecurity, and use of personal protective equipment. Specific risk-reduction measures should be tailored to specific risk contexts, with behavior change campaigns designed with input from anthropological and other social sciences to ensure cultural sensitivity, acceptability, and relevance.

Table 3. Examples of potential actions for reducing/managing emerging infectious disease risks

Target measure	Actions
Measures targeting wildlife sources or reservoirs	<p>Ecosystem restoration, protected areas, biodiversity management and ecosystem health: including infectious disease risk considerations in land use planning policies will help to more comprehensively assess costs and benefits of decisions and allow for building-in mitigation measures. Keeping ecosystems and biodiversity intact, and avoiding encroachment by humans and domestic animals or disruption of migratory corridors can help to minimize exposure. Re-establishing forest areas may introduce risk and therefore should be carefully planned.</p>
	<p>Medical countermeasures: Typically limited to treatment of individual animals, given few therapeutics exist for wildlife and logistical challenges of deployment. There are a few relevant exceptions, such as oral baiting vaccination strategies to protect wildlife against Rabies, and horse vaccination to prevent Hendra virus transmission. For research initiatives, the tolerance and resistance strategies used by certain reservoir species may hold promise for future medical countermeasures in other species.</p>
	<p>Culling: Not typically appropriate (and likely to be detrimental) in the management of wildlife diseases and pathogens. Exceptions might include a few conditions due to over-crowding or artificially-induced over-population, such as exclusion from previous range land, introduction of livestock, and artificial feeding of wildlife, or the eradication of invasive alien wildlife</p>

<i>Measures targeting the wildlife-human interface</i>	Phasing out high-risk practices and taxonomic groups/species: Transitioning from live animal markets to off-site slaughter and improved cold storage; reducing crowding and inter-species interactions in the holding and transport of animals.
	Zoning/regulations: Prohibiting or discouraging certain activities in high-risk areas, such as rearing of poultry near wetlands and other habitats where waterfowl tend to congregate.
	Improved biosecurity: May involve measures at different scales to avoid direct contact and indirect contamination between wildlife and humans or domestic animals. May be in the form of enhanced housing or separation methods (for example, distancing between fruit trees and livestock pens, separating animals of different species), or barriers (such as bamboo covering over date palm sap collection containers).
	Controlling wildlife farming and trade: Human exposure is increasing due to existing wildlife trade practices. These practices, especially when illegal or unregulated, act as conveyor belts through which animals, and the pathogens they carry, travel around the planet. Informal wildlife trade, often carried out irregularly in markets or in unauthorized businesses or e-commerce, make inspection and veterinary controls challenging, and increase EID risks.
	Transforming food systems: Shortcomings in food safety and sanitary practices, along the value chain from production to final consumption, increase EID risk. Safety gaps along the food chain should be evaluated, and food safety standards enforced.
<i>Measures targeting change in human behaviors</i>	Improving health literacy levels and awareness of potential zoonotic disease risks from wildlife exposures, as well as engagement in or access to the formal healthcare and public health systems in many populations and regions.
	Reducing demand: Shifting consumer preferences from high-risk wildlife products to safer alternatives, informed by behavioral and economic studies.
	Food hygiene practices: Avoiding food bitten by bats or other wildlife; rinsing and/or peeling raw fruits and vegetables; boiling/pasteurizing raw milk or sap; avoiding consumption of raw sap if unprotected from bat contamination.
	Increasing interest in and acceptance of safer practices, such as use of personal protective equipment and safe food acquisition practices.
<i>Supporting information systems</i>	Improving information systems, such as surveillance and warning systems, does not, per se, reduce exposure, but is a critical step to build and improve exposure-reducing practices. Disease or pathogen surveillance: Monitoring diseases or pathogens in wildlife can help detect real-time events, or potential outbreaks. In cases of wildlife morbidity or mortality, information may indicate a threat and guide action to avoid outbreaks in other species. Pathogens (known or novel from pathogen families of highest concern for emergence) can help with early warning. Sentinel surveillance in humans may also detect evidence of spillover, whether in the general population for evidence of prior exposure (antigens), or via screening of patients with non-specific clinical symptoms (influenza-like, febrile, or severe acute respiratory illnesses) that often go undiagnosed or potentially misdiagnosed.
	Early warning systems: The systematic collection and monitoring of relevant information, including via surveillance inputs, can help alert decision makers of impending harm, using short- or mid-term disease risk forecasting to guide appropriate interventions to mitigate risk and impact.

v. One Health: Definition and principles

The concept of “One Health” acknowledges the connections between the health of humans, animals, and the environment. It calls for integrating expertise from multiple sectors to guide optimal, cost-effective approaches to tackle zoonotic and other health threats. Antimicrobial resistance (AMR) is one such health threat (Box 7). Crucially, One Health does not mean that all sectors work together all the time. Rather, the premise is ensuring that all sectors are brought up to capacity, because relevant multi-sectoral expertise can offer information and tools to better understand, forecast, and reduce risks upstream of zoonotic EIDs to guide prevention or early warning before epidemics occur. Building wildlife health systems is a necessary part of larger One Health system strengthening to address EID risks.

Box 7. Antimicrobial resistance: are wild animals a concern?

Antimicrobial resistance (AMR) refers to the ability of microbes to persist in the presence of antimicrobial agents, such as antibiotics, designed to kill or stop their growth. This occurrence results in so-called superbugs for which previously effective treatments are no longer viable.

In theory, wildlife may potentially be a source of antimicrobial-resistant strains, naturally harboring a diversity of microbiota (Arnold et al., 2016). In practice, while wildlife carry AMR organisms, wildlife are not thought to currently play a major role in the development or spread of AMR. However, in intensive wildlife farming systems, the same selection pressures facilitating the rise and spread of antimicrobial-resistant strains in livestock production systems may be relevant. While not now considered a significant concern, changes in the scope and scale of wildlife farms, and particularly the excess and inappropriate use of antimicrobials, should be considered as possible drivers of AMR. While currently poorly studied, there is also evidence of heightened likelihood of AMR in wildlife correlated with proximity to human populations, suggesting transmission from environmental exposures such as via poor waste management.

These links reinforce the importance of a One Health approach to address AMR, possible routes for AMR-sensitive biosecurity interventions to mitigate transmission to or from wildlife, and the value of including wildlife health authorities in the development and implementation of National Action Plans on Antimicrobial Resistance.

vi. Economic imperative for strengthening wildlife disease systems for EID risk reduction

Epidemics and pandemics are typically considered low-likelihood but high-consequence events, though their frequency appears to be increasing with more opportunities for emergence and spread (Figure 10).

This uncertainty makes precise return on investment projections challenging, although previous events in the EAP region, even with relatively low incidence in human populations, have been linked to major losses, including an estimated USD 30-50 billion from SARS (2002–03) and USD 20 billion from HPAI H5N1 outbreaks (2004–13). The emergence of Nipah virus in Malaysia (1998–99) incurred costs from control measures, compensation to farmers, lost tax revenue, reduced local pork consumption, and pork trade bans implemented by other countries, in addition to human deaths and disability (Jamaluddin and Adzhar, 2011). The outbreak ultimately resulted in the culling of more than one million pigs, at least 100 human deaths, and economic impacts of more than USD 500 million (World Bank, 2012).

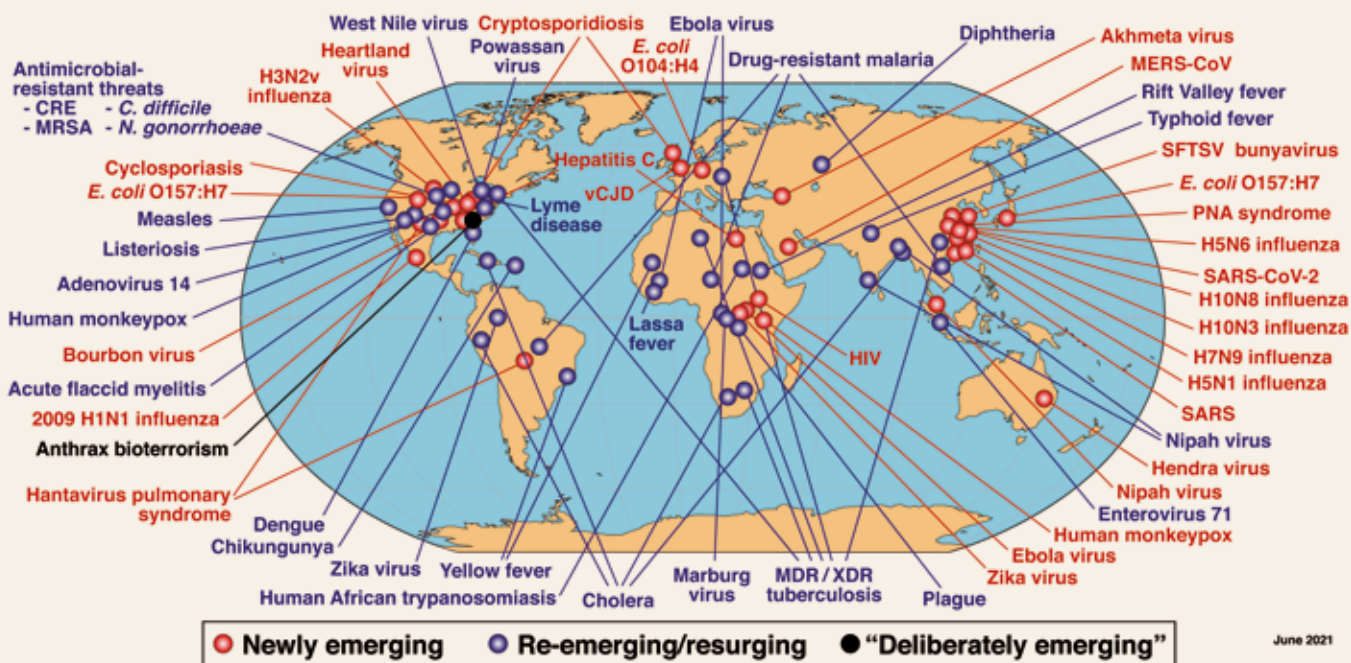


Figure 10. Examples of EIDs detected in recent decades (most between ~1980 to 2017). Not adjusted for detection/reporting bias.

Source: Morens and Fauci, (2021).

The economic impacts of EIDs are not consistently calculated, and studies of impacts are limited outside of major epidemics. However, impacts can be drastic from the household to the international scale, with indirect impacts to a range of sectors. Partial estimates of six disease epidemics in recent decades with wildlife origins — the global HIV epidemic, Nipah virus (Malaysia), Plague (India), SARS (global), H5N1 Avian Influenza (East Asia), and Ebola virus (West Africa) — conservatively account for more than USD 680 billion in losses. Much of these estimates reflect spending by donors, rather than the true costs of disease to society. COVID-19 is projected to cost the global economy an estimated USD 12.5 trillion in its first two years. A recent broad-strokes analysis estimated gross costs of EID prevention at USD 22–31.2 billion per year via disease monitoring in the wildlife trade, spillover risk reduction campaigns, forest protection, phasing out wild meat consumption, enhanced biosecurity to tackle livestock spillover risk, and early detection and control (Dobson *et al.*, 2020).

Even in the absence of ample EID impact data, trends in endemic diseases provide insight into costs that can be incurred from increasing incidence related to ecosystem alteration (Box 8). Taking these costs into consideration is necessary for more complete natural capital accounting and ultimately ensuring development decision making that includes health, and is based on sound cost-benefit analysis.

Prevention strategies may have considerable co-benefits in the form of carbon sequestration, improved livestock production yields, and other direct and indirect benefits across the Sustainable Development Goals. In the absence of a global program for EID risk reduction — and given the range of risks across different species and conditions, varied levels of government capacity, and acceptability of approaches across different populations — pragmatic regional and national investments are required.

vii. Case Study: Integrated biological-behavioral surveillance to assess risk

Using multiple sources of data for more robust bat coronavirus spillover risk assessment at the human-animal interfaces in local communities of southern China

Human-animal interactions occur in the daily practices of people who live in rural environments in close contact with wildlife and with livestock or wild animal raising as part of their livelihoods. A cross-sectional surveillance study was conducted in southern China’s Yunnan, Guangxi, and Guangdong provinces in the past ten years among wild animals (bats and rodents), domestic animals (pigs), and humans to discover novel coronaviruses that have zoonotic potential; detect early viral spillover from animals to humans; and identify risk factors to inform risk-mitigation strategies (Figure 11).

Box 8. Investing in risk reduction: lessons from the health cost of ecosystem alteration

Wildlife-linked diseases are often externalities associated with changing land use and agricultural and food system production transitions in the absence of adequate biosecurity measures. While these activities can yield significant economic benefits to communities and countries, certain types of development and related practices increase the risk of disease via changes in ecosystems, species assemblages and abundances, and contact practices. For example, mass conversion of forest to oil palm plantations has been associated with marked increases in malaria in Sabah, Malaysia, that resulted in an added costs of USD 21 million annually beyond the societally-optimal economic implications from oil palm production (EcoHealth Alliance 2019). As zoonotic and vector-borne disease risk is not typically built into development project cost and benefit equations and safeguard or impact reviews (Seifman et al., 2016), the related impacts are easily missed, highlighting the need for integrated approaches to anticipate and reduce risk in the context of sustainable development.

Notable findings	
→	Human index seropositivity rate of 0.45% - 2.9% for bat CoVs among local populations at the village/county level
→	SARS-related CoVs in bats: 6.7% mean PCR prevalence of SARS-related CoVs across bat hosts, with a small number of <i>Rhinolophus</i> spp. horseshoe bats having significantly higher PCR prevalence than other species sample (Li et. al. 2019 and unpublished data, EcoHealth Alliance)

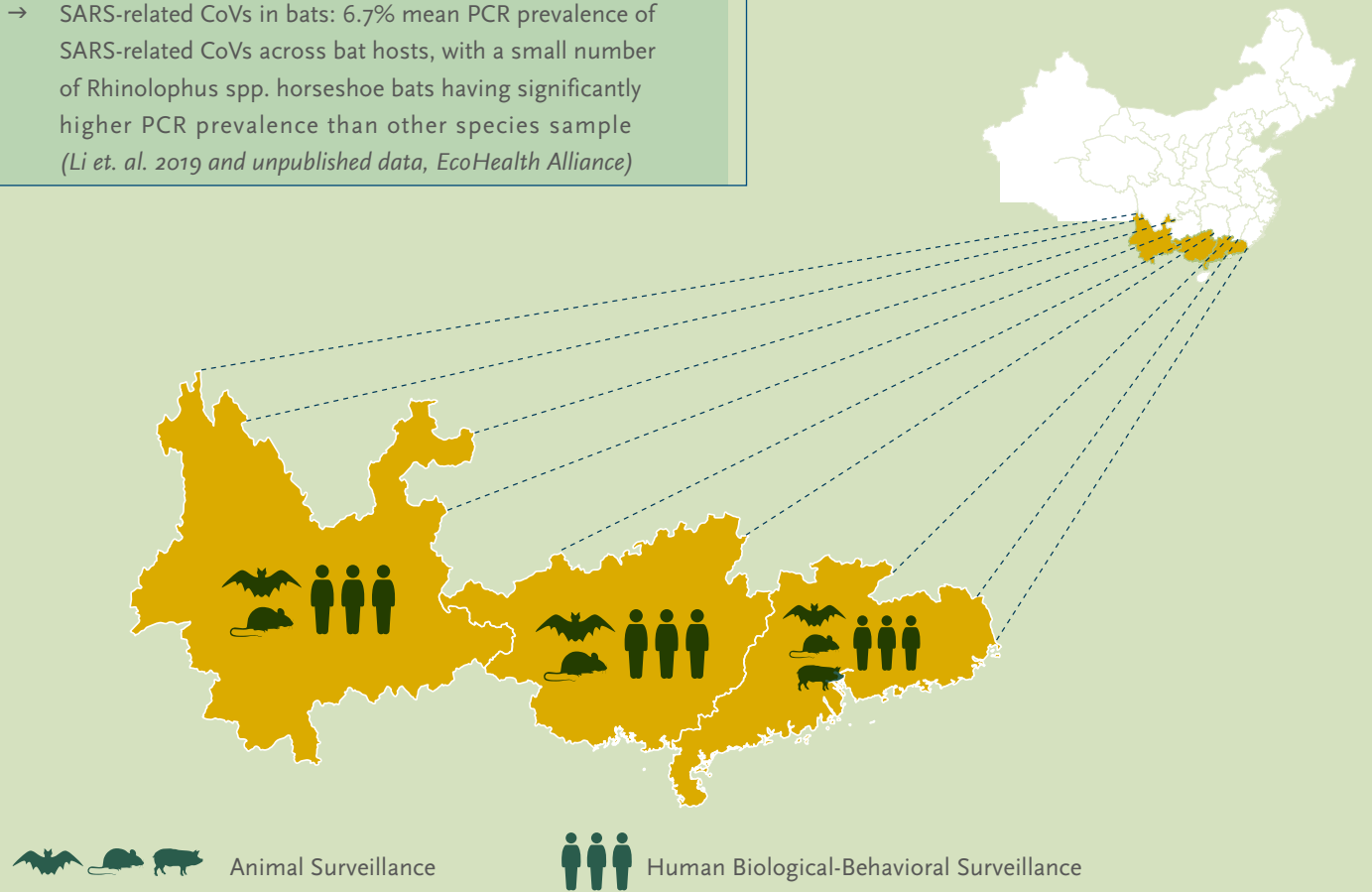


Figure 11. Map of surveillance among bats, rodents, pigs, and humans in southern China Source: Li et al. (2019).

This One Health approach to surveillance has discovered more than 500 novel coronavirus (CoV) strains from bats, including more than 50 SARS-related CoVs, some of which can infect human cells and cause disease in laboratory mouse models for SARS. Serological evidence of substantial spillover of these viruses was identified in the surveyed populations, suggesting local communities are exposed to bat SARS-related coronaviruses. The results indicated no strong association between exposure and behaviors in the wildlife trade, suggesting other possible pathways for viral spillover in this community. A bat-origin CoV (SADS-CoV) was found to be responsible for a new disease that killed more than 25 000 pigs in southern China; the virus is also able to infect human cells in laboratory settings. The surveillance also discovered the closest-known relative of the virus causing COVID-19 (SARS-CoV-2) and raised awareness of the likelihood of a SARS-like pandemic (Wang et al., 2019). In addition, the surveillance also employed both qualitative and quantitative methods to identify the risk factors for zoonotic disease emergence, and the opportunities to mitigate the risks. Contact with animals was prevalent among the survey population. Raising poultry and having rodents/shrews in the house were the most common types of contact.

Behavioral surveillance can help identify risk factors in local communities for further study. For example, results from Li et al. (2019) found that certain forms of contact with poultry and rodents/shrews, as well as with carnivores, were associated with self-reported Influenza-like illness (ILI) and/or severe acute respiratory infection (SARI) symptoms, with results varying by income and province. Eating raw or undercooked carnivores in the preceding 12 months was the most salient predictor of self-reported SARI and/or ILI symptoms over the same time period (Figure 12).

The results suggest that integrated biological and behavioral surveillance in healthy community settings can help identify potential zoonotic disease spillover events or target surveillance to at-risk populations. This approach represents a potential early-warning system that could be used under non-outbreak conditions to identify potential zoonotic emerging diseases and to design risk-reduction strategies prior to large-scale outbreaks.

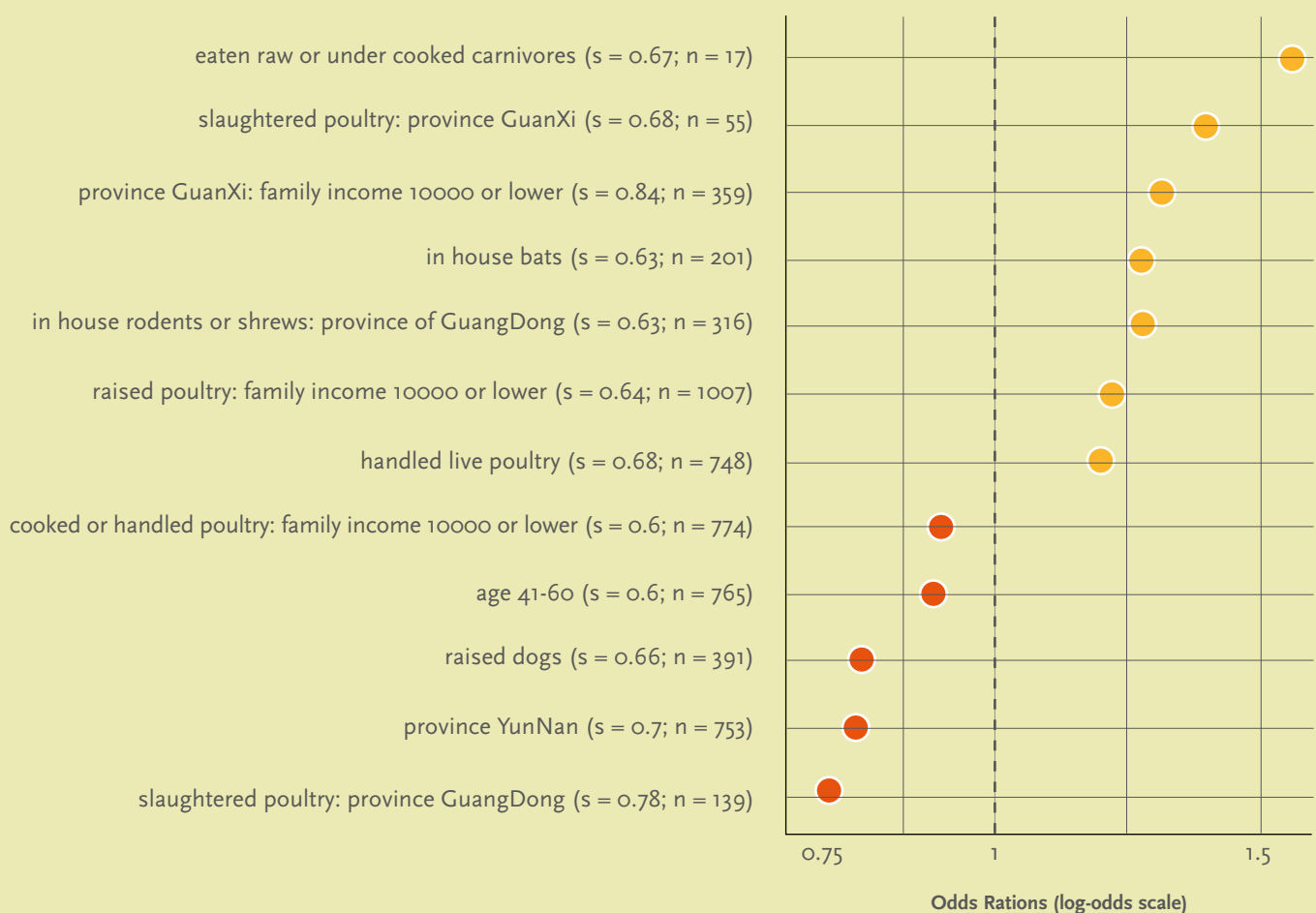


Figure 12. Most salient predictors of self-reported ILI and/or SARI symptoms in the last year. Odds ratios > 1 (orange) are positively associated with the outcome, and odds ratios < 1 (red) are negatively associated with the outcome. Source: Li et al. (2019).

Top

VIET NAM

In and around the Tam Dao Market area, northern Viet Nam. 2014.

Photo credit: Sulma Warne



Bottom

INDONESIA

Extreme Meat Market selling all kind of meat, Tornohon, North Sulawesi, Indonesia. 2014

Photo credit: Misbachul Munir / Shutterstock



MYANMAR

Along Dawei road, smoke rises from a man-made wildfire in a forest to clear land for a replacement plantation, commonly betal-nut or rubber, near Wah-Taw village, Myanmar.

Photo credit: Minzayar Oo / WWF-Myanmar



Section 2 | Mainstreaming wildlife into One Health systems

The previous sections have identified key interfaces for disease emergence from wildlife in the region. These collective pathways for emergence, and the varying ways they occur, even sub-nationally, reinforce the message that countries need capacity to assess and manage disease threats, however they occur. This horizontal systems-building (versus vertical programs) will allow countries and the region at large to be more agile and prepared to address changing sources of risk related to wildlife resources, whether demographic or environmental. Cross-cutting systems will enable monitoring and responses around the three focal points of action for preventing and managing disease risk: targeting the reservoir host (wildlife), targeting the interface (wildlife-livestock-human), and targeting the spillover host (humans).

Ideally, all three will be addressed, involving different entry points and coordinating sectors. Pragmatically, this supports protection against multiple pathogens (or pathogen groups) and will provide positive redundancies if one part of the system is lacking. While the first two focal points are more tailored to the core functions of wildlife health systems, the latter (human behavior modification) requires expertise from economics, anthropology, education, and other social sciences, and can be influenced by information on highest risks and riskiest practices to prioritize.

A key challenge for identifying targeted areas of need and systematic strengthening for national wildlife health program enhancements is the lack of a dedicated capacity assessment tool or process for countries' ability to assess and manage wildlife and wider environmental functions and prioritize areas of investment. There is a need for a parallel to the WHO Joint External Evaluation and OIE Performance of Veterinary Services used for public health and animal health. One such tool is currently under development and consideration at the World Bank (see Annex 1). The human and animal health sector use these assessments to meet international standards and obligations, prioritize domestic programs, and assist partners and donors in identifying gaps. They also form the basis for multi-sectoral National Action Planning for Health Security that countries are beginning to develop. These tools and processes are important to help countries prepare to detect and respond to emerging disease risks in humans and domestic animals. However, they do not include scope on wildlife- or environment-specific aspects, which are outside the mandates of their sponsor organizations and primary line ministries.

To address this gap for wildlife, a needs assessment for national wildlife health programs has been conducted in the Republic of Korea and Thailand in partnership with the U.S. Geological Survey National Wildlife Health Center. The needs assessment in Thailand was conducted as part of a formal OIE Twinning Project (see: <https://rr-asia.oie.int/en/projects/wildlife-health/oie-twinning-project-between-the-u-s-and-thailand/>), helping to inform training and capacity building plans and identify areas of enhancement for the Thailand National Wildlife Health Center. A draft World Bank Country Assessment for Environmental Health Services was designed as a follow-on to the One Health Operational Framework and ground-truthed through a pilot assessment in Liberia and Ghana (Annex 1). Ultimately, benchmarking will require a systematic approach to developing metrics for system performance and a funding and technical support mechanism at the global or regional level for investing in key gap areas.

While specific risks will vary from country to country, system development can begin to work toward broad standards that will support prevention and detection of EID threats from wildlife sources. Key system components identified in this report as requiring attention from national authorities are presented in Table 4.

The stocktaking conducted as part of this study and other recent analyses (for example, Machalaba et al. 2021) found that few investments, operations, and plans in the region have been intentional in building national wildlife health systems able to address EIDs from wildlife sources. A snapshot of the status of countries' attainment of so-called minimum benchmarks proposed in this report is provided in Table 5. Even where evidence of indicators is present, further assessment may be warranted, as overall initiatives have been ad hoc or limited in scope, rather than reflecting systematic development of a risk-based, sustained approach. The table has been created using data from expert input and dialogue with selected government officials, and is intended to provide an overall sense of the state of practice.

Table 4. Examples of important system components that could be used as indicators and standards when assessing country capacity to reduce disease risk from wildlife

Indicator	Standard
Policy/institutional mandate for managing wildlife disease/pathogen risk	- Complete coverage for relevant species and risk interfaces
Livestock or land use development policy accounts for disease risk from wildlife	- Integrated environment-health risk and impact assessment of potential plans with multi-sectoral input
Wildlife authority included in national One Health body	- Full inclusion via co-leadership role included in One Health body operational structure
Mechanism for inter-agency coordination if authority for risk management is shared	- Rapid and seamless information sharing; legal framework for multi-agency process for decision making related to surveillance and/or management strategies
Risk analysis process in place for assessing and managing risk at wildlife-domestic animal and wildlife-human interfaces	- Wildlife sector inclusion (leadership of or consultation) in each risk analysis steps (hazard identification, risk assessment, risk management, and risk communication)
Plan/strategy in place for systematic surveillance and risk reduction	- Detailed plan reviewed and updated as necessary at regular intervals, with responsible entities documented and progress tracked
Dedicated budget for wildlife disease monitoring and management system	<ul style="list-style-type: none"> - Sustained annual operating budget - Defined processes for requesting resources for capital investments
Wildlife monitoring network	<ul style="list-style-type: none"> - Identification of priority areas for monitoring nationally - Implementation of active monitoring system to provide coverage based on risk - Plan/strategy in place for systematic surveillance
Access to laboratory for testing wildlife specimens	<ul style="list-style-type: none"> - Diagnostic protocol in case of an unusual morbidity and mortality event (and selection of tests based on signs), for example, a) diagnostic panels available in country, b) diagnostic alternatives available if not captured by first-line test panels (next generation sequencing) - Collection and testing of wild animal samples as part of outbreak investigation or event trace-back for human or livestock disease – a) known or novel, b) viral, bacterial, fungal, parasitic - Agreements and permits in place for rapid movement of emergency diagnostic specimens within country and internationally
Wildlife disease database	- Functioning, timely all-hazard database maintained nationally that also supports international reporting requirement
Alert system in place for early warning and response	<ul style="list-style-type: none"> - Established network of both public and private multi-sectoral partners routinely reporting on occurrences of unusual events - Sentinel detection
Pipeline for wildlife veterinary/para-veterinary workforce	<ul style="list-style-type: none"> - Demonstrated free and in-service training to meet national needs - Wildlife health workforce plan in place and operationalized
Applied field epidemiology training program for wildlife surveillance and investigation	<ul style="list-style-type: none"> - Demonstrated free and in-service training to meet national needs - Wildlife workforce plan in place and operationalized

Table 5. Country comparison of proposed representative indicators for wildlife health systems (as of 2020)

Indicator	Countries showing evidence of indicator*
Policies (such as for livestock or land use development) account for disease risk from wildlife	China, Malaysia (for Nipah virus)
Institutional mandate for managing wildlife disease/pathogen risk	China, Indonesia, Malaysia, Thailand, Viet Nam
Wildlife authority included in national One Health body*	Indonesia, Malaysia, Thailand, Viet Nam
Mechanism for inter-agency coordination if authority for risk management is shared	China, Malaysia, Thailand
Risk analysis process in place for assessing and managing risk at wildlife-domestic animal and wildlife-human interfaces	Viet Nam
Plan/strategy in place for systematic surveillance and risk reduction	Thailand, Viet Nam
Dedicated budget for wildlife disease system	China, India, Malaysia
Wildlife monitoring network	China, Indonesia, the Lao People's Democratic Republic, Malaysia, Thailand
Access to laboratory for testing wildlife specimens	China, India, Indonesia, the Lao People's Democratic Republic, Malaysia, Thailand, Viet Nam
Wildlife disease database	Indonesia
Alert system in place for early warning and response	Indonesia
Pipeline for wildlife veterinary/para-veterinary workforce in non-zoo settings	India, Malaysia, Thailand
Applied field epidemiology training program for wildlife surveillance and investigation	China, Thailand

*NOTE: Evidence of national-level indicators (which represents existing activities beyond avian influenza virus monitoring) is not intended to reflect performance or completeness. Any progress as a result of a response to COVID-19 is not reflected in the table. Countries surveyed include China, India, Indonesia, the Lao People's Democratic Republic, Malaysia, Thailand and Viet Nam.

Regional Coordination

Regional coordination and action are needed to support national efforts. Indeed, progress on several indicators would benefit and/or require regional coordination. Specific areas where regional coordination could add value are listed below.

- Provide surveillance and diagnostic support, for example via a regional reference laboratory for wildlife disease/pathogens to supplement routine surveillance in high-priority species/settings and support event investigation.
- Share and potentially centralize information on risk, and develop guidance on risk reduction and a regional development trajectory away from disease risk.
- Promote higher-level meetings to articulate regional investment and operational needs and drive political will for refining mandates and commitment to inter-agency coordination.
- Share best practices and host cross-training and train-the-trainer events for strong country ownership and collaboration on transboundary disease issues.
- Provide training in epidemiological analysis, surveillance methods, and behavior change strategies. Host applied training, information generation, and methods testing events, potentially building on existing initiatives in the region (for example, through Wildlife Enforcement Network (WEN) activities).

One entry point for regional strengthening could be the ASEAN Comprehensive Recovery Framework and Implementation Plan, adopted at the 37th ASEAN Summit in 2020. Planned activities and programs include implementation of the ASEAN Guidelines for Detecting and Preventing Wildlife Trafficking, inclusive of

efforts to “Promote awareness on the risks of zoonotic diseases being spread through the illegal wildlife trade” and “Formulate recommendations/policy briefs to minimize risks of zoonotic diseases transmission from illegal wildlife trade and high risk consumptive behavior of and interaction with wildlife, especially associated with zoonotic diseases.” ASEAN has developed relevant tools on other issues of broad relevance to the region with multi-sectoral implications for implementation, including Sustainable Forest Management. Regional guidance, tools, and training to support bridging between public health, animal health, and biodiversity/environment authorities can reinforce One Health system building and promote laboratory and information sharing networks.

Budget needs may vary by country. In general, as countries build their wildlife health capacity and operations, budget needs will likely include a mix of capital investments (for example, field equipment, databases, and laboratories) and recurring/operating expenditures (see Table 6).

At a minimum, a dedicated budget should be in place to enable core functions to be completed and maintained.

Full diagnostic capabilities may not be available in all countries, particularly for next-generation genomic sequencing for detection of novel pathogens, as well as determining toxicants vs infectious agents. In this case, scenario planning, followed by institutional arrangements, may consider options and standard operating procedures and arrangements (Box 10).

Table 6. Examples of budget items for a wildlife health system

Hardware	Other
<ul style="list-style-type: none"> - Field equipment and supplies (e.g., nets, traps, anesthesia, swabs, vials, cryoshipper) - Laboratory equipment and supplies (for example, PCR machines, thermal cyclers, reagents) (may be shared with other sectors) - Data management (information systems) - Transportation to sites (vehicles and fuel) 	<ul style="list-style-type: none"> - Personnel - Data sharing agreements and processes - Clear leadership and chain of command - Multi-sectoral coordination - Standardized field and laboratory protocols - Training and capacity building - Meetings and workshops

Box 9. Special considerations for designing wildlife health programs

In many cases, wildlife health efforts can leverage existing human and animal health infrastructure and capacity enhancements. However, in some cases special considerations are relevant for pathogen surveillance and wildlife disease investigation that may initially add to the complexity of planning and operations until sufficient capacity is established. These considerations include:

- The implications of novel pathogen discovery and determining potential risk to other species and populations and appropriate management strategies;
- Epidemiological investigation for the source of pathogen spillover events, in terms of distinguishing reservoir and/or potential intermediate hosts;
- Interface, species, and sample type selection for efficient detection of specific agents;
- Safe sampling, in some cases requiring capture and immobilization of wildlife and proper protocols for human biosafety and conservation;
- Validated tests for wildlife; and
- Community sensitization, particularly for populations that have had limited contact with formal health systems but may be highly dependent on wildlife and ecosystems (e.g., some indigenous populations).

Box 10. Practical issues for timely diagnosis of wildlife specimens

Relevant factors may include transport time (and implications for sample condition), and risk of lost time when waiting for initial test results if suspected to be associated with something outside of routine test panels (for example, a novel virus). For CITES-listed species, international movement of biological specimens may face unique delays related to the CITES export and import process. In emergency situations, this may affect the speed of event determination and application of appropriate control measures. Ongoing liaising with CITES authorities about the relevance of wildlife health and awareness about disease emergencies, as well as pre-registration of partner international laboratories in the CITES registry, may help to facilitate efficient processes.

INDONESIA

The Pramuka bird market is the biggest bird market in Jakarta.

Indonesia, 2017

Photo credit: Lauren Suryanata/Shutterstock



Section 3 | Reducing root causes of EID risks from human practices

In addition to mainstreaming wildlife into One Health systems, as described in Section 2, three priority areas have been identified for systematic risk reduction: wildlife trade, food systems, and habitat loss. Wildlife farming and trade, and unsafe food systems, are potent amplification mechanisms forcing wildlife — and the pathogens they carry — into close contact with humans and livestock. Deforestation, habitat fragmentation, and ecosystem degradation, particularly in hotspot areas, are recognized processes at the genesis of Emerging Infectious Diseases (EIDs) from wildlife. Shifting the paradigm in how wildlife trade, production, and consumption are understood and managed, and reversing pervasive land use change trends that threaten biodiversity and exacerbate spillover risks, are priority strategies for reducing the risk of the next pandemic.

Wildlife Trade and Wildlife Farming

Minimizing (informal) and better managing (formal) wildlife trade are key to reducing EID risks and improving pandemic prevention

Minimizing (informal) and better managing (formal) wildlife trade are key to reducing EID risks and improving pandemic prevention. Wildlife trade is a high-risk interface, as it allows for interactions between multiple species or populations in ways that can efficiently allow for pathogen transmission. Efforts to address the wildlife trade are challenging, presenting overlapping and sometimes competing goals: promoting livelihoods and economic development, ensuring sustainability of food and natural resources, protecting animal welfare, and minimizing disease risk. Most existing wildlife trade regulations such as CITES, while important for sustainability objectives, are not designed specifically for disease risk reduction.

Asian countries are the primary destinations of international trade for different wildlife and wildlife products, including collections, traditional medicine, and food. Monitoring and reducing risks from wildlife trade in the region are therefore highly relevant, given the variety and volume of inter-species interactions and resulting potential for the introduction and evolution of pathogens. In Asia, mammals constituted approximately 50 percent of seizures between 1999 and 2015 as reported in the World Wildlife Seizures database (UNODC, 2016). Several ASEAN countries are known to be sources or consumers of primates (Krishnasamy and Zavagli/TRAFFIC, 2020), with documented practices that are broadly associated with disease risk. For example, a recent study found primate hunting, consumption, and trade around the North Zamari Key Biodiversity Area in Myanmar to be high, and also identified trade routes for multiple taxonomic groups from that area to the border of Southern China and middle markets in between (Smiley Evans, 2020a).

Trade may be intended for local, domestic, or international sale, and both supply and demand factors may be dynamic and complex. For example, the hunting, trade, and consumption of field rats are popular in Cambodia and Viet Nam along the Mekong Delta, with perceptions that the meat is disease-free, as well as affordable and nutritious (USAID PREVENT). A wildlife trade value chain mapping study in Indonesia's Sulawesi Island found that wildlife meat was available in nearly three quarters of the markets and supermarkets visited in Northern Sulawesi, with bats, wild pigs, rats, and snakes most commonly present (Figure 13). The study found that upwards of 1 million bats are hunted for food each year, a level that is unsustainable for the maintenance of bat populations on the island because of their low reproductive rates and high harvest rates (Latinne et al., 2020). Local bat populations are so low due to hunting and habitat loss that they are now imported from other islands in the region to supply demand.

Complete bans on all wildlife trade do not take into account consumer motivations or needs, and therefore are unlikely to be sustainable or effective

Understanding the motivations of consumers will be important for changing behavior to address demand. Socio-economic factors tend to shape demand for wildlife products. In the Sulawesi case, bats were sold at relatively high prices, with sales peaking during holiday periods. Studies in other countries in the region have examined perceptions of wildlife consumption, finding in China that it is viewed as a symbol of social-economic status, and primarily reported among the young, well-educated urban population. In Indonesia and Viet Nam, similar results showed that wildlife is a luxury food associated with power and wealth and is purchased by people from an economically affluent community (see, for example, Zhang et al., 2014; Sandalj et al., 2016). Complete bans on all wildlife trade do not take into account consumer motivations or needs, and therefore are unlikely to be sustainable or effective, given the impact on livelihoods and because they overlook the complexity of the wildlife trade.

Wildlife trade is a regional phenomenon, requiring a regional approach. The trade in animals to meet international demand is increasing in scale and complexity. Involved nations can be both end users and serve as transit routes to other markets. This is, for example, the case of Viet Nam and neighboring nations that consume wildlife products sourced from other countries and also serve as transit routes for legal and illegal wildlife trade chains in the region. From 2010 to 2014, Viet Nam reported 3823 cases of wildlife violations (World Bank, 2016). Regional oversight is therefore necessary, given the cross-border trade routes in the region, differing potential risks and impacts on origin and destination countries, and uneven capacity among trading countries, among other reasons.

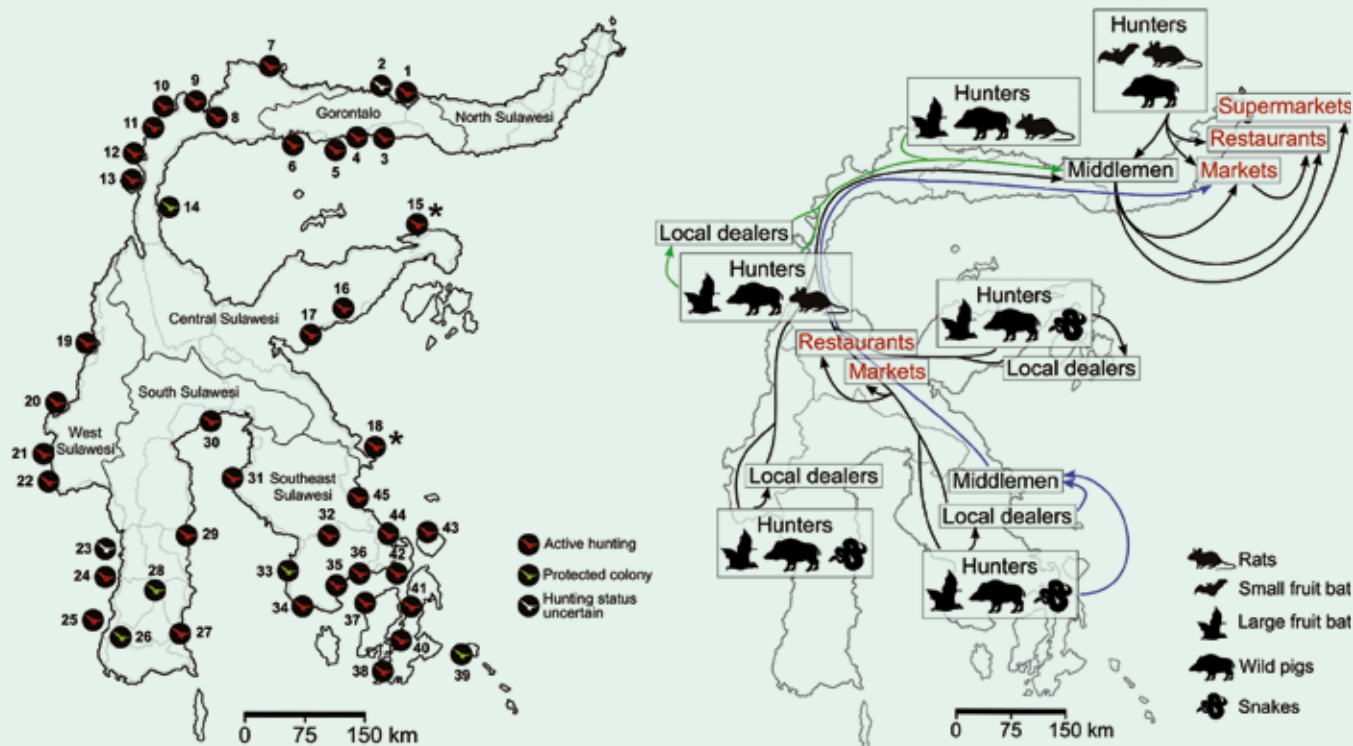


Figure 13. Wildlife trade network analysis, Sulawesi, Indonesia. Source: Latinne, et al. (2020).

Note: Information can be used to assess potential wildlife-human interfaces as well as inform biodiversity management strategies. Left: Map of Sulawesi showing the flying fox roosts identified in this study and their hunting status. Right: Overview of the wildlife trade network in Sulawesi and its key actors for the four taxa most commonly traded (bats, wild pigs, snakes, and rats). Wild meat sales places are highlighted in red.

The ability, resources, and priority given to controlling the wildlife trade varies by country in EAP, even though all have institutions and initiatives to regulate it. However, beyond sanitary trade standards such as OIE's listed diseases for animals, there are no effective regional mechanisms to manage disease threats from the regional wildlife trade; this represents a missed opportunity in the regional ability to reduce EID risks from wildlife. One potential avenue for regional action could be through the ASEAN "Comprehensive Recovery Framework and Implementation Plan," which includes the implementation of the Guidelines for Detecting and Preventing Wildlife Trafficking, as discussed in Section 2.

Food markets are significant risk multipliers, concentrating many potential sources of risk within the wildlife value chain. Markets are often end points of the value chain (see Figure 14), and typically aggregate animals from multiple sources, sometimes opportunistically. Market size may vary by the number of animals and space, and may be informal or modernized with electricity and other features. While many points of the wildlife trade value chain can have risk, several characteristics of markets are notable because they often co-occur. These include holding of live or dead animals or animal products in crowded conditions; multiple species present; limited or no hygiene, sanitation, and cold storage practices; on-site slaughter; and a high-density human setting. Additionally, given the high social media uptake in Southeast Asia, and the anonymity it offers to traders, the "market" concept has now expanded and goes beyond physical points of sales.

Food markets are significant risk multipliers, concentrating many potential sources of risk within the wildlife value chain

Blanket bans on all wildlife in food markets are unlikely to be successful. Instead of reducing risks, these bans, if not properly designed and enforced in parallel to reducing consumer demand, can drive the trade into illegal trafficking, which is less traceable and more difficult to control. Blanket bans also overlook the nuances of disease risk, which is not uniform across taxonomic groups, settings, practices, and consumption uses. Transport practices and animal/animal product forms and conditions vary, with different implications for risk (for example, live or dead animals, raw or cooked meat, or dried scales).

Wildlife farming is a zoonotic disease risk factor in EAP

Wildlife farming

Wildlife farming is a zoonotic disease risk factor in EAP. Though directly involving transport, market systems and consumers, wildlife farming is largely unregulated. There are often limited or no biosecurity or biosafety measures, veterinary oversight, food safety considerations, waste management, or animal welfare considerations. Several sources of EID risk may be common to wild-caught and farmed wildlife once in the trade chain, but the different origins of wild and farmed animals changes risk factors and requires different strategies for risk management.

Management of wildlife confiscated from illegal trafficking — as well as wildlife in breeding facilities, the pet trade, and other settings requiring rehabilitation — presents a particular challenge for conservation. This is because reintroduction into wild populations may pose a risk of disease introduction to native populations. As the risk may potentially outweigh the benefits in some cases, relevant factors should be carefully weighed in a risk analysis to determine appropriate management strategies, including euthanasia as a humane alternative when reintroduction is inappropriate (IUCN 2019 “Guidelines for the management of confiscated, live organisms” and IUCN 2013 “Guidelines for reintroductions and other translocations”).

Efforts to reduce EID risks from wildlife trade, wildlife farming, and wildlife commercialization should prioritize specific hotspots and practices. Because consumption of and trade in wildlife in the EAP/SA regions are pervasive, measures to reduce exposure risks and prevent future EID events need to be risk-informed. A tiered approach that considers both high-risk taxonomic groups and high-risk practices should be the basis for possible interventions:

1) Target high-risk taxonomic groups. A wide range of species are traded in the region. In general, mammals (primates, bats, rodents, some small carnivores) and some birds (notably waterfowl) are of greatest concern for emerging diseases of pandemic potential compared to reptiles, amphibians, and fish. Certain species may also play possible roles in intermediate transmission (for example, via mixing of wild and domestic animals). Adopting and enforcing strong regulations against the harvest, trade, and consumption of bats and primates should be viewed as a minimum standard. For wildlife farming, risk assessment should inform decisions on which species are safe.

2) Target high-risk practices. Holding and slaughter of live animals in rearing, transport, and market and post-market settings presents inherent risk through efficient pathogen reproduction and transmission. Animals are frequently held in high-density containers for long periods of time with individuals from the same or other species, exposed to feces, urine, and saliva. Immune status is typically compromised from stressful conditions and lack of access to proper nutrition and water, resulting in increased susceptibility to infection and pathogen shedding. In addition, use of animals and animal products varies widely, presenting different relative risk. For example, because heating (>70C) inactivates foodborne pathogens, consumption of sufficiently cooked food is not necessarily considered high-risk for emerging viral pathogens. However, butchering and handling during food preparation facilitates exposure to blood and other infectious materials. Introducing safer practices, such as phasing out the sale of live animals and moving slaughter away from markets, can help reduce risk.

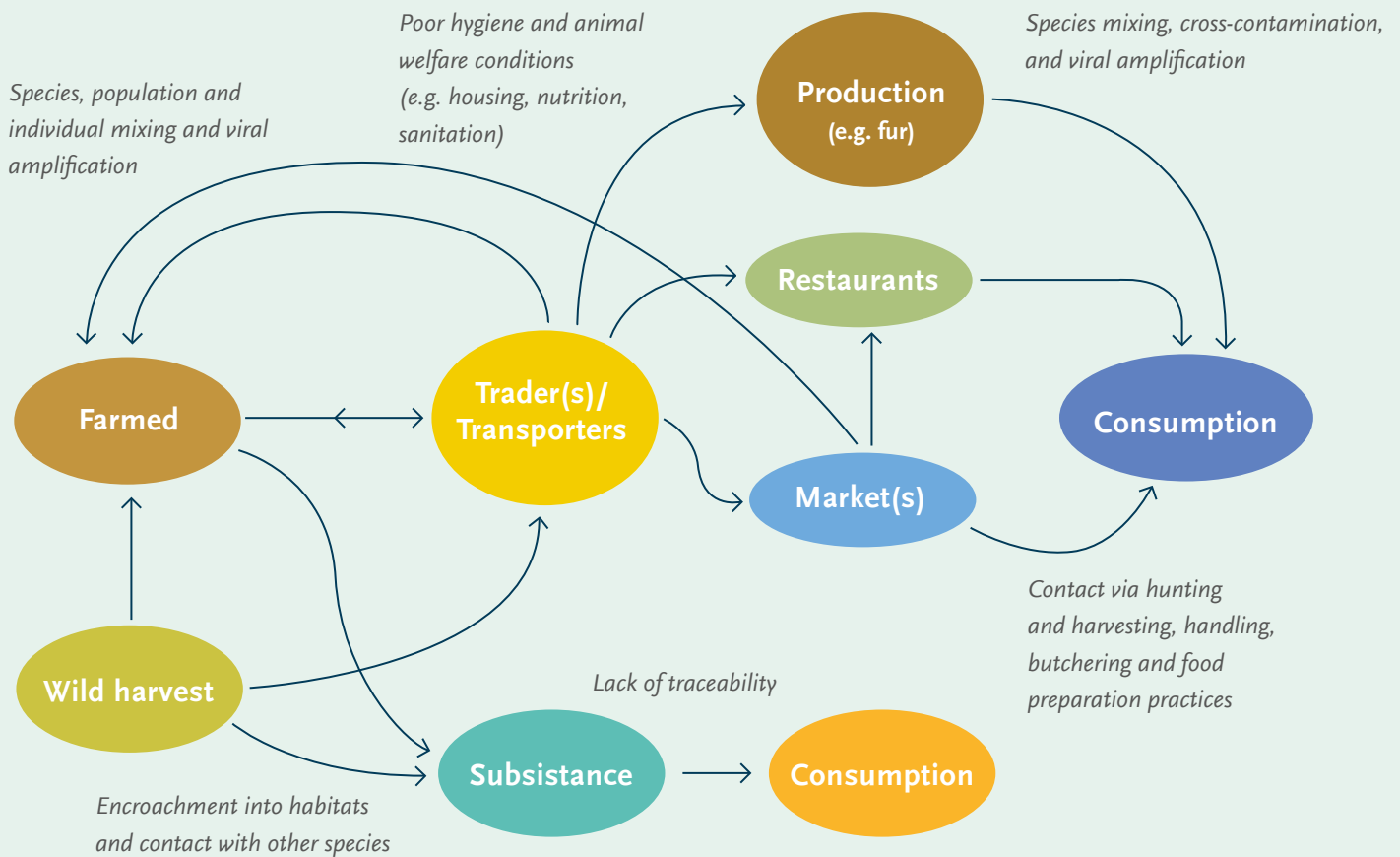


Figure 14. Examples of relevant interfaces and factors contributing to disease risk along the value chain for wildlife trade. Additional transactions may occur at local and international scales. *Source:* Authors' own elaboration

Policy and planning

- Prohibit hunting, sale and keeping of bats and primates, as well as other taxonomic groups and species as relevant based on disease risk assessment.
- Develop or strengthen mandate to continually assess and manage risk in trade, given emerging evidence and changing wildlife trade trends (for example, internet sales).
- On the basis of public health protection, strengthen deterrents, improve enforcement, and development alternatives for sellers or end-users of illegal trade of bats and primates and other relevant species, particularly for intermediate (“middlemen”) and endpoint trading entities that concentrate profits and perpetuate the trade.
- Harmonize trade standards within countries, regionally, and globally.
- Incorporate disease standards into national and regional (for example, ASEAN) wildlife enforcement networks (WEN).
- Restrict wildlife farming to specific species determined to be low-risk, based on disease risk assessments. Require adequate biosecurity practices, including minimizing or prohibiting inter-species contact and mixing of wild and farmed stock. Ensure animal welfare considerations meet the wide range of behavioral and environmental needs of wildlife species.
- Train inspectors on biosafety inspection practices and disease reporting protocols.
- Invest in alternative livelihood programs to deter wildlife harvest (for example, forest protection and biodiversity monitoring).
- While eliminating trade of high-risk species or taxonomic groups may improve their sustainability, care should be taken to ensure demand does not shift to black markets or in ways that increase pressures on other species beyond their carrying capacity.

Sentinel monitoring

- Establish national, regional, or global databases of diseases/pathogens detected in traded species.
- Develop a surveillance system with an infrastructure of investigation protocols, reporting by inspectors, and the sharing of results with public health and animal health authorities.
- Monitor disease and conduct pathogen surveillance in wildlife intended for trade (in wild populations sought for harvest, at breeding facilities, on importation, or at markets).
- Conduct broad pathogen screening (via antibody detection) in wildlife hunters, farmers, and sellers for detection of pathogens from high-consequence viral families such as filoviruses, henipaviruses, coronaviruses, and influenza viruses.

Direct risk reduction

- Ban the sale of live animals in market settings and move slaughter activities off-site into high-biosecurity settings.
- Provide training to law enforcement, wildlife authorities, and animal handlers on proper personal protective equipment (PPE) use and other safe practices such as protocols for animal bite or scratch.
- Impose quarantine or veterinary inspection requirements for species with elevated disease risk.
- Improve biosecurity through the trade chain (from source, either wild or captive breeding, to consumer) to reduce risk of pathogen proliferation among animals and spillover to humans.
- Improve animal welfare requirements through the trade chain to ensure optimal animal conditions and reduced stress, related to pathogen shedding and spread of infectious diseases.
- In wildlife farming operations, avoid mixing wild and captive stock, require high biosecurity, and reduce density.
- Conduct outreach with rural and urban communities and wildlife breeders involved in the supply or demand of high-risk species to reduce the market for high-risk wildlife products and create buy-in for risk reduction.

Food systems

The world's nearly 8 billion people rely on food systems on a daily basis. Interactions with food systems look different across much of the world, shaped by a mix of infrastructure, regulatory, socio-economic, livelihood, environmental, cultural, and religious traditions and factors, with resulting disparities in food safety and security.

A comprehensive, risk-based approach to food chains is needed to reach multiple pathways and entry points

Disease risk related to wild animal sources can occur along the chain of food supply and acquisition, preparation, and consumption. In any food production system, the typical gold standard for food safety management is a hazard analysis and critical control points (HACCP) approach. HACCP practices are usually incentivized by international trade partner or purchaser requirements for higher economic returns, and thus tend to focus on “modern” food systems where best practices are feasible and regulations are in place. While there are some similarities to domestic animal food system risk factors, the live wild animal trade adds additional risk factors along its value chain or when products or personnel are engaged with other market systems. A more comprehensive, risk-based approach will need to go beyond the common domestic animal farm-to-table chain to reach other pathways and entry points.

There are many possible sources of wild-associated disease risk in food systems. For EIDs specifically, risk is concentrated in certain species and practices. Examples of key pathways for emergence include:

- **Wildlife hunting, rearing, slaughter or handling:** in most circumstances, the major concern for emergence of high-consequence viral and bacterial pathogens is via exposure to live or freshly-slaughtered high-risk animals, particularly bats, rodents, and primates. Wildlife hunters and transporters, and others involved in the handling, slaughter, and preparation are at elevated risk.
- **Spread via intermediate host species:** poor biosecurity allows for wildlife-livestock contamination, which may then be further disseminated through the livestock value chain.
- **Contamination and consumption:** ingestion of infectious material can lead to food-borne disease. Food-borne illness is often linked to bacterial and parasitic infections, including plants contaminated by wild animals. However, recent contamination of surfaces by wildlife can also be a source of potential pathogen exposure and infection. This is seen with the transmission of Nipah virus via consumption of raw date palm sap, as the sap is consumed fresh when the virus is still viable.

In some regions of the world, wild meat from terrestrial animals represents a primary source of protein on which populations depend. A substantial volume of wild meat is harvested for subsistence, or sold locally to populations with few affordable protein alternatives. Growing demand is also driven via urban, wealthier populations willing to pay a higher price for wildlife as a luxury product. In Southeast Asia, 56 bat species, or 17 percent in the region, are known to be hunted, with bat hunting considered significant in Brunei, Cambodia, East Timor, Indonesia, the Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Thailand, and Viet Nam (Mildenstein *et al.*, 2016). In India, bat consumption is largely restricted to the Indian flying fox in certain communities, though. Antibodies for several filoviruses were detected in ethnic groups involved in bat harvest in India's Nagaland state as well as in the hunted bats themselves (Divoh *et al.*, 2019).

In some regions of the world, wild meat from terrestrial animals represents a primary source of protein on which populations depend

This collective volume of wild meat, almost all of which is processed and distributed to consumers with few or no modern hygiene practices, provides a constant opportunity for human exposure to common food-borne pathogens. In addition to terrestrial animal food sources, approximately half of all seafood comes from wild sources (mainly through commercial fishing). Raw or undercooked seafood can be a source of high-burden emerging or endemic pathogens (for example, *Vibrio cholerae*, norovirus, and parasites), with degraded marine and aquatic ecosystems potentially posing increasing public health threats.

Collectively, a large number of food-borne illnesses are caused by pathogens that can be associated with wild species such as rodents, deer, feral pigs, reptiles, and birds. The definitive identification of a specific source animal or species, however, is challenging. This is particularly true with wild species because the specific animals are typically no longer present when food-borne illness is detected in humans and by the time investigations are initiated leading back to farms, processing plants, or harvest sites. While the majority of these illnesses are caused by endemic pathogens, strengthened wildlife surveillance capacity can reduce risk for these as well as EIDs.

Changes in food production systems may introduce risk to livestock and humans via changes in contact with wildlife. Animal biosecurity is a key determinant of disease risk. For example, conducting livestock development or agricultural expansion activities near forest areas or other wildlife habitat, or introducing poultry production near wetlands and other areas where wild birds congregate, create opportunities for spillover, often in conditions favoring the spread of disease. In addition to encroachment on wildlife habitat, certain food system practices may attract wildlife to human settlements. Open sources of grains or animal feed, for example, can attract food-seeking wildlife pests and thus risk contaminating food supplies.

A key opportunity for risk reduction is via the health of local communities where products are sourced. This involves both reducing reliance on wildlife for food (for example, in logging settlements) and educating communities about safe and healthy practices in hunting, animal butchering, and consumption. This awareness is necessary to shift consumer demand toward safe products, as well as to identify acceptable and cost-effective risk reduction strategies. For example, bans on consumption of date palm sap, which is a delicacy in parts of South Asia, have been unsuccessful. While public health campaigns have called for consumers to boil the sap, the raw sap is widely preferred. Simple harvest container coverings, such as a bamboo skirt, can help protect sap from contamination by bats if harvesters are encouraged to use them. Regulation of wildlife in food systems may need to expand from laws based on sustainable use; for example, it was reported that in one country bat trapping was illegal but consumption was allowed if a bat had flown into a power line (Suwannarong *et al.*, 2016). In addition to standard food safety practices, key risk-mitigation measures for EIDs linked to wildlife in food systems include:

Policy and planning

- Examine country/community-relevant interfaces for wildlife risks in food systems to assess and prioritize high-risk interfaces.
- Harmonize laws and regulations to avoid loopholes in prohibiting consumption of high-risk species.
- Conduct integrated environment-health risk and impact assessments, from the onset of plans for development of livestock expansion sites, to guide disease-proofed zoning or build in risk mitigation strategies.
- Optimize the efficiency of production and use of existing food stores (avoiding unnecessary food waste) to avoid both additional encroachment into wildlife habitats and attraction of potential wildlife pests.
- Raise community and employer awareness and engagement in safe food acquisition practices and norms/regulations on wildlife utilization.
- Provide consistent sanitary measures and cold storage throughout the food chain to increase consumer confidence in and reduce demand for live wildlife.
- Conduct extension services with livestock owners, transporters, and market workers on risk reduction related to wildlife.
- Adopt food security measures and economic incentives to reduce reliance on wildlife food sources.

Sentinel monitoring

- Monitor disease and conduct pathogen surveillance through meat inspections at point of sale and/or upstream in the value chain (farm, market, and slaughterhouse).
- Monitor humans who are in contact with wildlife or wildlife exposures in food systems for evidence of infection and clinical illness.
- Engage hunters, farmers, and communities to report diseases or dead animals as part of wildlife disease surveillance and epidemiological trace-back in outbreak investigations.

Direct risk reduction

- Avoid hunting, handling, and butchering of high-risk species (bats, rodents, and primates).
- Enhance hygiene measures at critical control points (post-harvest storage practices, handwashing practices by food preparers, and safe cooking temperatures).
- Implement adequate biosecurity measures such as ensuring food stores such as grains and animal feed are not accessible to wild animals, and prevent inter-species mixing, including for farmed wildlife.

Habitat degradation and loss

Wide-scale land conversion and encroachment on wildlife habitat are currently altering biodiversity and ecosystems in unprecedented ways. In South East Asia, the changes are of striking proportions, among them an average loss of 1.3 million hectares of forest annually from 1990 to 2010, largely for forest goods and agricultural expansion to meet growing urban population demands; rates of mangrove deforestation in the region reaching upwards of 8 percent per year; and in some countries mass transition to monocultures, for example palm and rubber plantations (IPBES, 2018). Mining, guano harvesting, and cave tourism represent other relevant activities associated with habitat encroachment in the region and potential impacts on ecosystem integrity.

Wide-scale land conversion and encroachment on wildlife habitat are currently altering biodiversity and ecosystems in unprecedented ways

Land use change is recognized as a major driver of disease emergence, associated with approximately one-third of recent disease emergence events (Loh *et al.*, 2015). Such changes have a variety of direct and indirect consequences for the health of humans and other species at local and global scales, though the full extent of risk and impact from these specific changes is currently poorly assessed. While it is helpful to think about distinct risk pathways, in reality practices often overlap, requiring multiple risk-reduction strategies. For example, road building by extractive industries may also increase forest access and hunting pressures on local fauna. Fragmentation of forests and other ecosystems creates edges with greater chance of exposures along the perimeter, where humans or livestock may reside and may utilize or inadvertently attract wildlife, and thus facilitate pathogen spillover. The practices typically associated with ecosystem changes — introduction of humans or animals with naïve immunity, increased natural resource extraction — allow for new or intensified interactions between humans and other species, with resulting disease consequences.

Ecosystem change may result in loss of biodiversity, land degradation, and potential ecosystem collapse, each which may have long-term or permanent impacts. Changes in the functioning of ecosystems, and even habitat change at smaller scale, may alter community composition in terms of species abundance and richness. In some cases, these changes benefit generalist species that may be more competent disease vectors or more likely to come into contact with human populations than would other, more specialist, species. Biodiversity may in some cases assist in disease buffering, contributing to lower prevalence of pathogens in host species, as well as ecosystem services such as pest and vector control that contribute directly to disease regulation. It is important to recognize that disease risk is not static as ecosystems undergo changes, requiring continual monitoring and updates to mitigation strategies as needed.

Encroachment by humans and livestock activity into existing wildlife habitats, in new or intensified ways, creates opportunities for novel exposures. Expansion of human settlements, agricultural intensification and expanded livestock production — as well as extractive practices such as logging, mining, or bat guano harvesting — often occur in concert with habitat degradation and destruction. These alterations of natural habitats, often in places without previous wildlife-livestock-human contact, present opportunities for disease spillover. For example, the emergence of Nipah virus in Malaysia in 1998–99 occurred when pig farms and fruit orchards were grown together at the edge of tropical forests and native fruit bat habitat.

Encroachment by humans and livestock activity into existing wildlife habitats, in new or intensified ways, creates opportunities for novel exposures

The most effective route for managing disease risk is by avoiding the changes to ecosystems, habitats, and species that tend to increase the risk of diseases. Similarly, addressing drivers of biodiversity loss can directly and indirectly protect against disease risk. For example, habitat loss or alteration, sometimes in synergy with introduction of an invasive species, may promote increased incidence or geographic range of a disease, potentially enhanced by shifts in the ecological “niche” resulting from climate change pressures. Changes in population movement such as from the loss of habitat or corridor connectivity, or via shifts in the timing of annual migrations, may fragment populations or alter species composition, thus creating potentially novel species interactions. For these reasons, disease risk reduction should be calculated into the benefits of designing and managing protected areas.

Climate-induced changes in land cover, land use, or extreme weather events may shift animal movement or species abundance, in the process changing ecosystems and disease systems. In general, climate change may act as a threat multiplier for other drivers of disease.

The potential net and localized impact of climate change and climate variability in future emerging and zoonotic disease risk still remains largely unknown, due to insufficient research. Even so, the tightly coupled links between weather and climate conditions and changes in species abundance and behavior are likely to serve as drivers or threat multipliers. Understanding and addressing sources of climate change-related risk require an integrated approach to guide early warning systems and proactively prevent, detect, and respond to changing threats and impacts.

Land-use planning processes must systematically factor in disease risk and impact assessment in project appraisal

Land-use planning processes must systematically factor in disease risk and impact assessment in project appraisal. This informs the identification of relevant risks and their cost to society. A development project may be a direct driver of disease risk (for example, mining that disrupts a cave ecosystem), or an indirect one (for example, road building that allows access to forest areas and increases hunting, human settlements in newly-cleared landscapes with livestock rearing activities, and human encroachment in natural settings for recreation or other purposes). Prohibiting certain high-risk activities or redesigning plans from the onset can reduce disease risk. For example, signage and restrictions on entry into cave sites in favor of designated safe viewing areas balances demand for ecotourism activities and reduction of disease concerns, while reducing impact on sensitive habitats. Specific recommendations include:

Policy and planning

- Include disease impact projections in whole-of-society cost-benefit calculations for potential development projects and for potential intervention strategies to minimize trade-offs and optimize co-benefits.
- Prioritize preservation of land tracts with high mammalian biodiversity.
- Prohibit hunting of bats and primates, based on disease risk.
- Provide a reliable protein source for workers operating in forest areas to deter wildlife hunting.
- Designate off-limits areas for activities based on risk (for example, land planning and policies around distancing of bat roost sites and livestock-rearing sites).

Sentinel monitoring

- Monitor disease incidence and exposures during ecosystem alteration to detect changing risk and refine risk-mitigation strategies.
- Create early warning systems to detect diseases or disease-promoting conditions in communities and livestock around forest habitats, particularly for climate-sensitive diseases correlated with specific weather patterns or other environmental indicators.
- Engage rangers, hunters, and communities in the reporting of diseases or dead animals as part of wildlife disease surveillance and epidemiological trace-back in outbreak investigations.
- Engage communities living near forest areas to ensure access to disease detection and healthcare services for clinical illness as well as evidence of infection (for example, antibody detection).

Direct risk reduction

- Avoid encroachment and disturbance of wild habitat, including for ecotourism activities (for example by requiring a safe viewing distance).
- Require PPE for extractive practices with wildlife exposure risk (for example, bat guano harvesting and work in cave sites).
- Avoid keeping of livestock and domestic animals in or around forest areas.
- Minimize forest fragmentation and limit access to forest areas and activities such as road building that may increase wildlife extraction.
- Conduct outreach with communities to increase awareness of zoonotic disease risks and promote healthy ecosystem management practices.
- Require enhanced biosecurity for wildlife operations in high-risk areas (for example, on the periphery of forested areas, near wetlands or other waterfowl habitat, and in range of bat roosts).

Top

Lao People's Democratic Republic

Hog badger being sold by the roadside in Kasi district, Vientiane Province, Lao People's Democratic Republic.

Photo credit: Michael Brocklehurst

Bottom

INDIA

Baby Pangolin, India

Photo credit: Positive Snapshot / Shutterstock



CAMEROON

A pangolin and a porcupine for bushmeat on sale at the side of the road in Yaoundé, Cameroon.

Photo credit: Andrew Walmsley/TRAFFIC



Section 4 | Current wildlife-relevant gaps in One Health systems

Countries in the East and South Asia regions are at different stages of implementing wildlife health capacity and operations within a system designed to manage emerging infectious disease threats. The key finding of this report is that national systems in the region are weak in their ability to assess and manage emerging infectious disease risks associated with wildlife, thus perpetuating a reactive rather than preventive stance for pandemic and epidemic threats.

A summary of the main gaps are listed below.

- Current policies, laws, and regulations do not position One Health approaches to be able to meaningfully include wildlife aspects, leaving little incentive for an institution to advocate for and manage such considerations.
- Institutional mandates often leave gaps in responsibility and authority over comprehensive coverage for disease risks of wild animals across species and settings (both captive and wild).
- There are widespread gaps in investment in wildlife health as a discipline. These include the absence of a pipeline for applied training opportunities in a wildlife health system, limited career advancement opportunities, and poorly recognized value as part of government operations.
- Wildlife disease and pathogen surveillance activities are often ad hoc and restricted to exploratory research, or a narrow group of species or diseases. The result is a piecemeal effort that fails to support long-term strengthening of national systems for sustained and routine early warning and risk reduction.
- Wildlife health services are under-funded and lack dedicated financing mechanisms and capacity assessments.
- Even when information about wildlife disease risk is collected, multi-sectoral information-sharing channels and avenues for coordinated risk management are inadequate or non-existent.
- In general, the wildlife trade and the overall wildlife value chain are among the most important interfaces for disease risk in the region. Even so, wildlife and environment expertise and focus are largely absent from emerging infectious disease epidemiological investigations and risk-reduction measures, creating significant operational gaps that need to be addressed.

Wildlife protection and management typically fall under the ministry or department of environment, whereas animal health broadly is the responsibility of the veterinary services agency of the ministry or department of agriculture

Overall, countries in the region are at different stages of implementing wildlife health capacity and operations within a system designed to manage emerging infectious disease threats. Some countries do not have a defined government authority or ministry responsible for wildlife health. The institutional mandates covering wildlife health, wildlife surveillance, control of wildlife trade, health of wildlife for food and products, wildlife in breeding facilities, and other wildlife aspects vary by country and may involve a mix of agencies serving a range of functions (see, for example, the case study on wildlife policy in China in Annex 2). Wildlife protection and management typically fall under the scope of the ministry or department of environment and/or natural resources. In general, animal health broadly is the responsibility of the veterinary services agency of the ministry or department of agriculture. In practice, however, a veterinary agency's focus is largely on livestock or other domestic animal health. This is one reason for disconnects and gaps when connecting wildlife health with livestock and domestic animal health. Although the disciplines and the types of pathogens and diseases might differ between wildlife and domestic animals, there are commonalities between the two. If formal connections are not established, gaps appear in the detection and monitoring and prevention of zoonotic diseases transmitted from wildlife to livestock.

In the context of agriculture and zoonotic disease threats from wildlife, mandates may potentially involve several agencies for various aspects of risk assessment, monitoring, communications, and management (see example for China). Wildlife surveillance activities often are split across agencies. In some countries, oversight for zoonotic disease may have its own specialized institutional arrangements. An example is Indonesia's National Zoonosis Control Committee, first established in response to the Avian Influenza crisis and now managed through the Coordinating Ministry for Human Development and Cultural Affairs.

Legal and Policy Instruments

When establishing an institution to manage emerging infectious disease, governments also need to include wildlife and the environment in related policies, laws, and regulations. Failing to do this reinforces heavy biases to human and livestock health matters, even where One Health approaches are embraced. Even where policy mechanisms do exist for the environment, such as biodiversity impact assessments in land planning and project appraisal processes, health risks related to wildlife and environmental change often are ignored. At the global level, no authority is ultimately responsible for wildlife health, disease and pathogens, reinforcing the lack of an international mechanism to shape or influence national efforts.

Institutional mandates

Overall, most countries in the region lack dedicated institutional mandates to assess and manage wildlife risks aimed at emerging disease prevention and detection. Mandates often leave gaps in responsibility and authority over comprehensive coverage for disease risks of wild animals across species and settings, both captive and wild. This can inadvertently lead to incomplete monitoring, regulations, and enforcement. There are notable exceptions, such as the Republic of Korea’s established process for reporting relevant findings across ministries as part of its legal mandate. Most other countries have a patchwork of coverage for specific species and/or sites, for example free-ranging wildlife, active commercial wildlife farms, non-active wildlife farms, and markets, making it challenging to identify entry points (Figure 16).

Where there are existing mandates for wildlife diseases, it is unclear if they are tested and how performance is tracked. By default, emerging diseases often fall to the responsibility of the human health or livestock sector (ministry of health or ministry of agriculture) because the first detection is in human or livestock populations in the absence of a wildlife disease monitoring system.

Workforce

Many governments lack wildlife specialists with the epidemiological skills to conduct comprehensive investigations and monitoring of disease threats at a population level. There are major gaps in wildlife health/wildlife disease management as a discipline. The region faces several relevant workforce challenges that reinforce this situation, including the lack of a pipeline for applied training opportunities in the context of a system. Some countries in the region have low overall veterinary capacity, or face workforce shortages. Others have advanced capacity for research, but without an institutionalized workforce there is limited scope to translate that capacity to real-world applications.

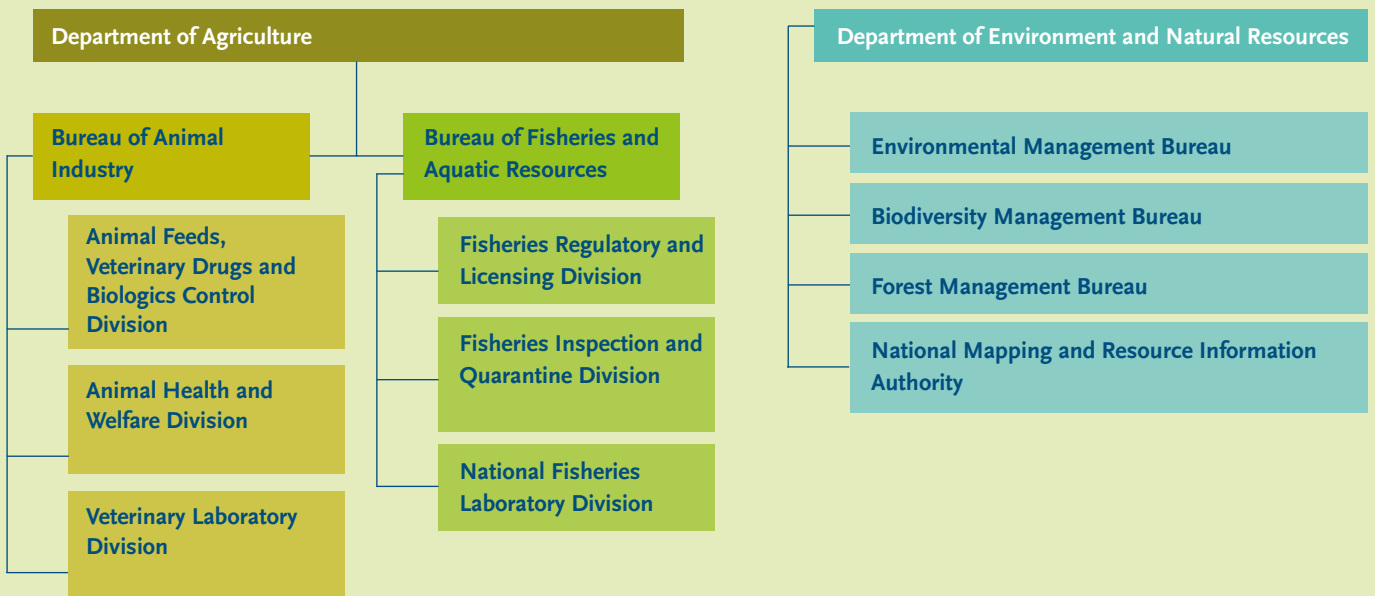


Figure 15. Example of an organizational chart. The lack of coordination mechanisms across units and departments is a common gap impeding assessment and management of EID risks. Source: OIE Asia Regional Office, 2021 <https://rr-asia.oie.int/wp-content/uploads/2021/07/philippines-20210727.pdf>

The wildlife health field is generally recognized as having limited career advancement opportunities and lacks recognized value within government operations

The wildlife health field is generally recognized as having limited career advancement opportunities and lacks recognized value within government operations. This in part contributes to high turnover in the public sector (and potentially in the private sector, too) that hinders animal health operations and long-term institutional knowledge. Where wildlife veterinarian capacity exists, it is often focused on dedicated and specific activities that are not readily scalable for a broader system oriented to tracking and mitigating zoonotic disease risk. For example, as of 2019, Myanmar employed only one veterinarian in its Ministry of Environment, who was focused on elephant health. Many private sanctuaries, field centers, and zoos in the region have staff veterinarians. However, their day-to-day operations may focus on monitoring and treatment tailored to the health and condition of individual animals, rather than ex situ considerations for disease risk in wild, or offsite settings. Wildlife veterinary and diagnostic capacities are especially targeted to anti-poaching and forensics investigations. As not all functions of EID risk monitoring and management require dedicated veterinary capacity, some programs have trained additional personnel (for example, park rangers) to serve as frontline eyes for the surveillance and reporting system. To date, this approach is underutilized in the region.

Surveillance and early warning systems

Wildlife disease and pathogen surveillance activities are often ad hoc and restricted to exploratory research activities or to a narrow group of species or diseases. A broader, more effective strategy takes a risk-based approach to a sustained and routine monitoring system for early warning. Several major wildlife disease and pathogen surveillance research projects and networks in the region over the past decade have identified high-risk zoonotic disease spillover interfaces and made notable viral discoveries and some capacity enhancement. While filling significant knowledge gaps, these efforts have not directly translated into an operational foundation for a national system in most countries and/or beyond select diseases.

Reporting both positive and negative results of surveillance findings is a critical component of risk monitoring

Reporting both positive and negative results of surveillance findings is a critical component of risk monitoring. Aside from wildlife cases of OIE-Listed Diseases, wildlife disease reporting is not internationally mandated. The OIE's World Animal Health Information System (WAHIS)-Wild is a voluntary approach that serves as the only global reporting system for wildlife diseases. This lack of international reporting requirement may contribute to the seemingly limited and variable (in terms of scope) national data systems. From a regional standpoint, based on migration and trade of animals, the lack of an international database results in important information potentially being missed in risk assessment and national decision-making. The focus on detection and reporting of known diseases leaves countries unprepared for rarer and novel disease threats.

Benchmarks and Financing

The lack of investment in wildlife health services reinforces its chronic absence in EID management strategies. A major contributor to this deficit is the lack of minimum standards and a designed set of assessment criteria to monitor capacity and performance. The public health and veterinary services use assessment tools that are aligned to standards to assess capacity and inform health security planning and costing processes. However, these are not wildlife-sensitive, and inclusion of the wildlife environment is typically broad, if included at all. As a result, priorities for wildlife and environment, such as National Biodiversity and National Invasive Species Strategies and Action Plans, are developed without a systematic pre-project assessment for capacity and resourcing needs, and do not give specific attention to their sectors' role in EID risk management.

National budgets in the region for wildlife activities in the context of EIDs appear to be limited, with no mechanism for building national systems, in contrast to a range of externally-funded research projects. While global benchmarks for wildlife health funding levels have not been set and no tracking is in place, a World Bank study found that overall investment in wildlife services was limited, and of that, the share to wildlife health services was a paltry 5 percent (World Bank 2012). This is emblematic of the larger underinvestment in environmental health services and resulting operational gaps and capacities to assess and manage zoonotic disease and other risks, such as pollution and other forms of environmental degradation. The lack of a dedicated budget for wildlife health programs and activities means that, even when wildlife health capacity is formed as part of animal health and health security projects, it is unlikely to be sustainably institutionalized.

Few health security instruments and investments include the wildlife sector in operational coordination, and vice versa, for the health sector in biodiversity initiatives. For example, the World Bank Global Program for Avian Influenza Control and Human Pandemic Preparedness and Response (GPAI), which had a funding envelope of more than USD 1 billion, involved coordination between human and animal health authorities and communication, but did not integrate environmental considerations important for understanding risk interfaces and informing risk mitigation strategies. This scope of emphasis is common in One Health-focused funding.

Multi-sectoral information sharing, communication, and coordination

Even when agencies collect information about disease risk, they typically do not share it across sectors, limiting the possibility for coordinated risk management. This can result in missed opportunities for early warning for public and domestic animal health. The lack of information-sharing across sectors makes it challenging to ascertain the extent of wildlife disease surveillance activities and gaps in monitoring and understanding of risks. In addition, countries often lack channels for reporting disease risk information to centralized government systems and do not provide for coordinated public-private responses. This is a concern for all interfaces but is most obvious for the wildlife trade and wildlife breeding.

Absence of channels for reporting disease risk information to centralized government systems do not provide for coordinated public-private responses

Risk-reduction focus

In general, wildlife and environment expertise and focus are largely absent from emerging infectious disease risk-reduction measures. Wildlife trade and the overall wildlife value chain are among important interfaces for disease risk in the region, but the lack of expertise underscores operational gaps and opportunities for hazard identification and other components of risk analysis.

Environment and law enforcement sectors have helped to assess and address threats to biodiversity and ecosystems that may be linked to disease risk, including wildlife trafficking. However, on the whole these activities are not formally paired with health considerations, limiting their potential value for assessing emerging disease risk and informing risk-reduction strategies. This is consistent with a larger global lack of coordinated design and evaluation that means the potential connections for assessing disease risk are easily overlooked. Risk reduction at wildlife-human and wildlife-domestic animal interfaces is a key knowledge and practice gap. Further, there is limited information on the relative effectiveness of interventions to prevent pathogen spillover and/or amplification for different intervention options (Stephen et al., 2021).

CHINA

Agriculture and forest landscape in China, 2014

Photo credit: Steve Harris / World Bank



Section 5 | Operational Recommendations

In addition to the specific recommendations on information systems and institutions, environmental protection, wildlife trade, and food systems, the gaps identified in Section 4 support the following eight high-level operational recommendations:

National and local governments must prioritize policies and regulations that are wildlife- and environment-sensitive, and specific interventions as part of systematic risk reduction for EID

1) National and local governments must prioritize policies and regulations that are wildlife- and environment-sensitive, and specific interventions as part of systematic risk reduction for EID. A multi-sectoral approach will effectively target risk by addressing its diverse sources in specific contexts and at local and national scales. Ecosystem protection, wildlife trade management, and farmed animal biosecurity are key pathways to reducing risk. Early detection of threats to enable proactive monitoring and response, along with improved management practices, can support risk reduction. Biodiversity-sensitive strategies for risk management can be promoted through integration with wildlife and environment objectives. This last approach can promote overall ecosystem health, help address the larger root causes or drivers associated with heightened risk of disease emergence, and harness environmental expertise to improve understanding of risk factors and inform prediction and early warning systems.

Specific actions

- Review existing policies for wildlife-specific disease risks, such as land use planning, livestock or wildlife development activities, and wildlife/eco-tourism, to ensure sufficient assessment and mitigation of potential disease risks.
- Expand national, regional, and international species and natural resource protection policies and enforcement efforts to include high-risk species and interfaces.
- Increase incentives, such as economic, social, and behavioral nudges or adoption of safer practices, as well as deterrents of high-risk practices if needed, including awareness, alternative livelihoods, enforcement, and penalties.

2) Countries should review and refine institutional mandates for managing wildlife disease and pathogen risks. The currently limited institutional mandates for wildlife in the context of disease monitoring and management often result in fragmented authority and gaps across the variety of relevant species and settings. Assigning mandates on the basis of health risk could unintentionally isolate authority further, making implementation more cumbersome. Therefore, countries should give priority to coordination when they design, implement, and refine their institutional mandates. Existing mandates should be mapped against relevant risk interfaces to reveal areas of coverage and gaps. The wildlife value chain often lacks coverage across the scope of extraction, rearing, transport, markets, and consumption as food, medicine, pets, and tourism. Countries should harmonize their regulations and enforcement procedures to address vulnerabilities in the detection of disease.

Specific actions

- Mainstream and reinforce national authority for wildlife health and disease to promote a whole-of-government approach to risk reduction.
- Provide training to authorities to 1) recognize the relevance of wildlife trade, biosecurity, ecosystem integrity, and early warning systems in EID risk reduction; and 2) adopt safe practices in the context of their work of forest rangers, inspections, confiscations, and rehabilitation.
- Designate an OIE National Focal Point for Wildlife and ensure that office has a mandate across operations and ministries.
- Form agreements with regional academic centers particularly for advanced diagnostic capabilities (a model example is Thailand's institutional arrangements for its National Wildlife Health Center).

3) National and regional multi-sectoral coordination platforms and initiatives must include wildlife and environment sector representatives. National One Health system initiatives offer efficiencies for coordination. However, they require dedicated attention to build wildlife and environment sector representation for optimal assessment, planning, prioritization, in-service training, and implementation. At a regional level, active engagement of these sectors is a necessary part of transboundary disease and health security initiatives.

Specific actions

- For countries with existing wildlife units in government, ensure these are involved in the development of programs, plans, and protocols relating to EID risk assessment and management, as well as broader health security initiatives.

- Include wildlife and environment authorities in assessment processes and simulation exercises.
- Include wildlife authorities and wildlife veterinarians in field epidemiology and other applied training programs.

4) Global environmental authorities and donors need to support countries to assess capacity and funding deficits and track benchmarks for wildlife health systems.

Much as the Joint External Evaluation and Performance of Veterinary Services provides an assessment framework for public and animal health, an assessment tool for wildlife and environmental health services is needed for systematic identification and prioritization of capacity strengthening. Gauging and tracking competency and investment needs will put the environment sector on an equal footing with other sectors. As with parallel tools, benchmarking should be viewed as an iterative process that evolves with ongoing best practices and scope development. It can be reinforced with follow-on planning processes and technical implementation support to client countries.

Global environmental authorities and donors need to support countries to assess capacity and funding deficits and track benchmarks for wildlife health systems

Specific actions

- Provide an assessment tool for wildlife and environmental health services to: i) systematically identify capacity and financing needs and priorities for EID risk reduction to complement the World Health Organization's Joint External Evaluation and the OIE Performance of Veterinary Services designed for public and animal health sectors and; ii) inform national plans and programs and investments.
- Develop a funding instrument to strengthen capacity and implementation based on deficits identified in baseline assessments.
- At a national level, ensure a sustainable annual budget for wildlife health services, as well as a dedicated process for requesting emergency funding and capital investments.
- Develop a dedicated, robust, and harmonized training base for OIE National Focal Points for Wildlife and equivalent positions with responsibilities for wildlife disease risk management, including a standard curriculum.
- Formalize and incentivize wildlife health and disease management with authority and career advancement opportunities.
- Establish or formalize a pipeline for wildlife health and disease management training, both external and in-service. In general, expertise should include: entomology, wildlife disease, veterinary medicine, pathogen/disease diagnostics, and safeguard assessors. Epidemiological training is critical and would greatly enhance wildlife veterinary and other conservation-based expertise to put environmental information into a population-level scope.
- Develop peer-to-peer collaboration and capacity and systems enhancement, including via regional mechanisms (for example, formalize collaborations via OIE Twinning Programs).

5) Countries need to make sufficient investments in wildlife health systems to cover the spectrum of functions required for effective risk monitoring and reduction.

As with public health and domestic animal health monitoring systems, an operational foundation is needed to assess and respond to known and novel threats. Core components — including surveillance and laboratory, trained workforce, financing, information management, communication, risk assessment, risk management, and systems underpinning governance — must be in place, tested, and practiced, to provide a basis for emergency readiness. Systems should move from reactive to proactive by emphasizing detection of known and novel pathogens in species and settings known to present elevated risk, together with human behavior that seems to encourage exposure. This pairs testing of wildlife and human populations to detect spillover events. Functions may be effectively shared across multiple agencies and can leverage investments in other sectors. However, coordination must be in place to ensure completeness and continuity.

Specific actions

- Continually review relevant interfaces and practices for EID risk associated with wildlife, and conduct hazard identification and other relevant stages of risk analysis.
- Review existing evidence on disease and pathogens in the country and region to identify baseline risks, identify gaps in knowledge, and determine initial priorities.
- Establish national, regional, and/or international agreements for access to laboratory diagnostics.

- Establish and maintain a national database for wildlife disease and pathogens, with data-sharing links to domestic animal and human health systems. Conduct routine (annual and real-time) reporting to OIE WAHIS and WAHIS-Wild.
- Identify areas of heightened risk or incidence through tools such as geospatial risk maps; and
- Support development of regional expertise. For example, the Thailand National Wildlife Health Center should be supported in becoming an OIE Collaborating Centre in Wildlife Health.

6) Governmental and non-governmental initiatives on wildlife trade should take a regional approach to addressing negative consequences and provide a foundation for transboundary disease-risk management. Trade flows can disproportionately affect source and recipient countries in different ways with regard to disease and endangerment risk of wild animal populations or species. Investments should focus on harmonizing policies and strengthening interagency law enforcement and regulatory capacity on illegal wildlife and timber trades, and oversight of live animal markets and food markets, along with inclusion of health standards. Addressing the full value chain, from source to end consumer, provides insights into sources of risk and entry points for interventions, whether practice- or policy-based.

Specific actions

- Incorporate health standards into national and regional WENs, including training on safe animal handling, protocols for disease monitoring and reporting, and waste management.
- Prohibit trade of bats and primates, as well as other relevant taxonomic groups and species for human consumption based on disease risk.
- Maintain a regional database of disease and pathogens in trade species (from wild and captive monitoring) to improve risk assessment.

7) Countries should transition to safer practices in food systems that address wildlife-sensitive risk factors and interfaces. While all people interact with and rely on food systems, exposures and vulnerability to wildlife-associated disease risk are highly inequitable and may be shaped by dynamics such as protein availability, socio-economic status, and cultural preferences. Weak hygiene, storage, and traceability measures exacerbate threats to food safety and security. Contamination of the food supply may occur in farm, harvest, transport, slaughter, market, and post-market settings. Avoiding it requires a targeted focus on relevant wildlife-linked disease transmission dynamics.

Specific actions

- Standardize regulations to ensure consistency in rules on harvest and consumption.
- Prohibit consumption of bats, primates, and other relevant taxonomic groups and species based on disease risk.
- In settings with wildlife contact, implement the same standard monitoring, hygiene, infection prevention and control, and biosecurity practices that are used in human health and livestock and food production.
- Facilitate safer individual consumption and demand practices by incorporating knowledge from anthropology, sociology, economics, and related social sciences.
- Utilize relevant socio-economic behavior factors for designing effective risk communication and encouraging social and behavior change.

Infrastructure to prevent EID should be leveraged where possible to reduce the burden of endemic diseases

8) Countries and donors should invest in strengthening systems that can help prevent endemic diseases. While investments in preventing high-consequence and novel spillover events must be a priority for “building back better” after epidemics, infrastructure for attacking emerging infectious diseases also should be leveraged where possible to reduce the burden of endemic diseases. Doing so can provide quick wins that demonstrate the value of improved health systems. Such investments may also help refine the monitoring of environmental and climate factors that can be broadened for wider scope.

Specific actions

- Strengthen systems across sectors with a variety of programs that effectively assess and manage all relevant risks.
- Leverage systems for monitoring and management of endemic diseases.
- Promote all-hazards risk reduction (beyond only known or “listed” diseases).

Special attention should be given to the necessity and value of risk analysis, from end-to-end, to prioritize wildlife and environment entry points for disease risk reduction. Examining and assessing risks based on current knowledge can be a valuable starting point. Examples of relevant work include a retrospective analysis of 25 years of wildlife disease reporting and a risk ranking conducted in the Republic of Korea (Hwang et al., 2017; Hwang et al., 2018), and a review of emerging and re-emerging diseases in China (Liu et al., 2014). Other examples might focus on taxonomic groups, mapping practices or volumes along a value chain to identify areas for further focus. Depending on resource and information availability, this could potentially take the form of an initial literature review, a quantitative or semi-quantitative risk assessment, or an expert consultation. These targeted initiatives can also provide quick wins to guide prioritization (for example, for surveillance, enhanced reporting, or policy review), sensitize stakeholders, and make targeted progress. This process may often identify data gaps and potential additional data sources: therefore risk-based efforts should be flexible and iterative. It is critical that the wildlife and environment sectors be part of, or even lead, the risk analysis process to ensure appropriate entry points are identified and approaches are biodiversity-sensitive (Box 11).

End-to-end risk analysis is critical to prioritize wildlife and environment entry points for disease risk reduction

While some aspects of putting in place a system oriented to reducing disease risk associated with wildlife will require specialized technical expertise, much of the process will be aided by pragmatic and applied efforts. It should not be daunting. Tools and strategies that are widely used to focus efforts in the public health and overall animal health sector provide a good basis for building and improving wildlife health systems. These tools include capacity and priority evaluations and planning processes, after-action reviews, simulation exercises, and risk analyses. Engagement of these sectors in the process consistent with a One Health approach can show the wider value of wildlife and environmental inputs, supporting biodiversity mainstreaming.

Box 11. Guidance on integrating biodiversity considerations into One Health approaches

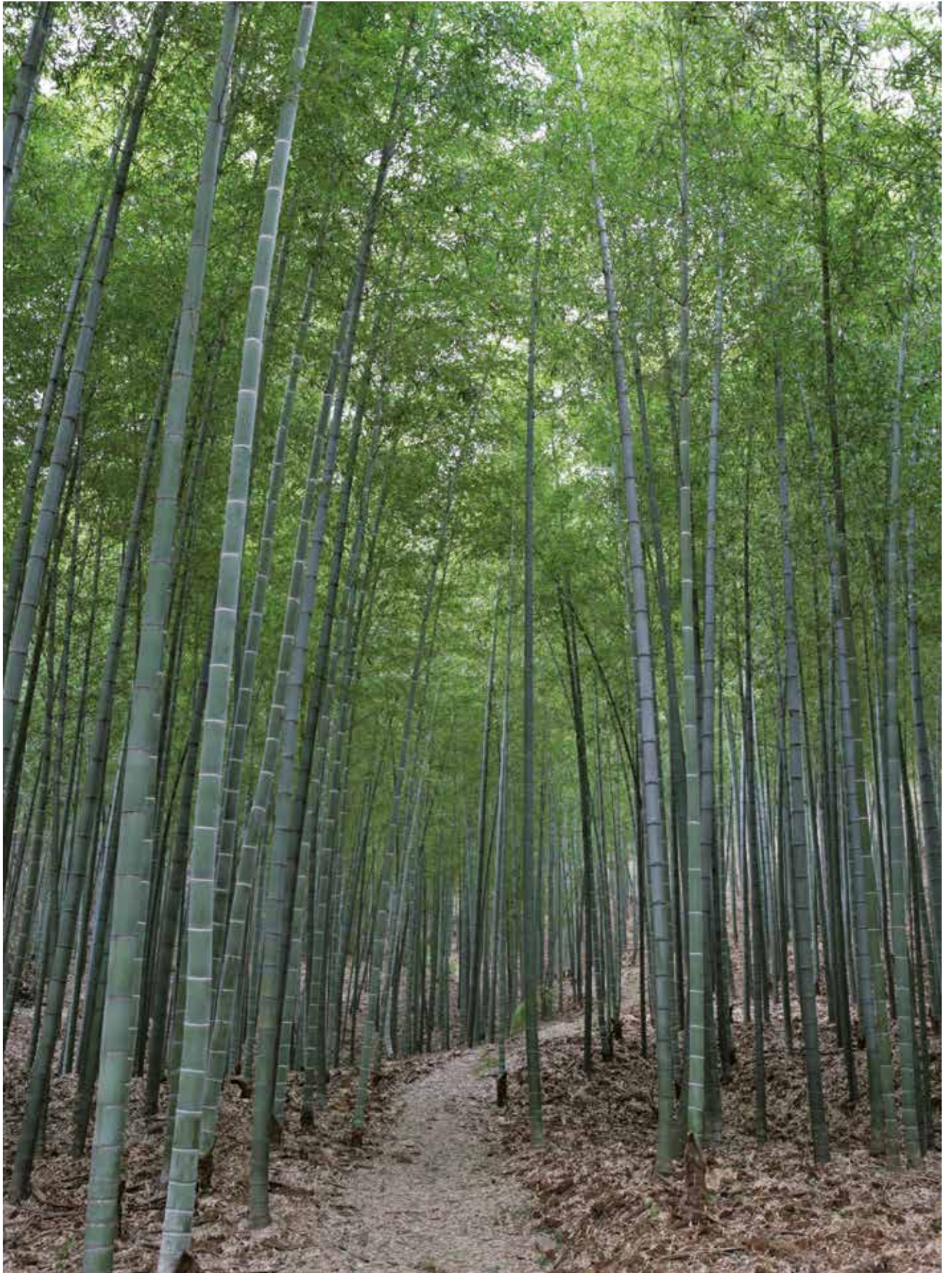
In 2018, the Conference of the Parties to the Convention on Biological Diversity (CBD) adopted Guidance on integrating biodiversity considerations into One Health approaches. The Guidance aims to assist countries in adopting a more balanced consideration of biodiversity and ecosystem dynamics in developing and applying One Health policies plans, programs, and research. It also aims to support a whole-of-government, whole-of-society approach that is not discipline- or sector-based. This supports the integration of biodiversity across all relevant sectors and disciplines, and provides examples of how to optimize synergies in implementation efforts, including via integrated data collection, monitoring, and surveillance (CBD 2018). National coordination bodies may benefit from using the Guidance to frame issues and establish common objectives across programs and plans.

Source: Authors' own elaboration.

CHINA

Bamboo patch. China. 2007

Photo credit: Wu Zhiyi / World Bank



Section 6 | Annexes

Annex 1. Assessment Tools

The One Health concept recognizes the connections between humans, animals, and the environment, encouraging coordination among sectors to understand and manage public health risks

Effectively addressing EID risk associated with wildlife sources requires participation from the environment sector, in coordination with animal and public health authorities. The One Health concept recognizes the connections between humans, animals, and the environment, encouraging coordination among sectors to understand and manage public health risks. National capacity assessment frameworks are available for the human and animal health sectors (i.e. the WHO's Joint External Evaluation under the International Health Regulations, and the OIE's Performance of Veterinary Services Pathway and Gap Analysis). No current capacity assessment exists for environmental health services, and in many cases, environmental health systems are not formally established with designated functions, sectors and other systematic scope. This hinders implementation capacity for biodiversity and ecosystem-specific objectives such as NBSAPs while also missing opportunities for EID prevention and detection.

In response to this gap, two assessment tools have been prepared to assist countries in developing their national systems to reinforce wildlife and environmental health capacity needs:

World Bank Country Assessment for Environmental Health Services

To complement national capacity assessment frameworks for the human and animal health sectors, a tool for country assessment for environmental health services was drafted as an extension of the World Bank One Health Operational Framework. The tool seeks to fill a major gap in the global architecture for environment and wildlife capacity assessment, planning, and prioritization for strengthening health security and multi-sectoral coordination. Developed by EcoHealth Alliance and the World Bank and informed by key input from the Secretariat of the UN Convention on Biological Diversity (CBD) (and envisioned to support implementation of the CBD and other environmental agreements), the tool was tested in Liberia in 2018 and in Ghana in 2021.

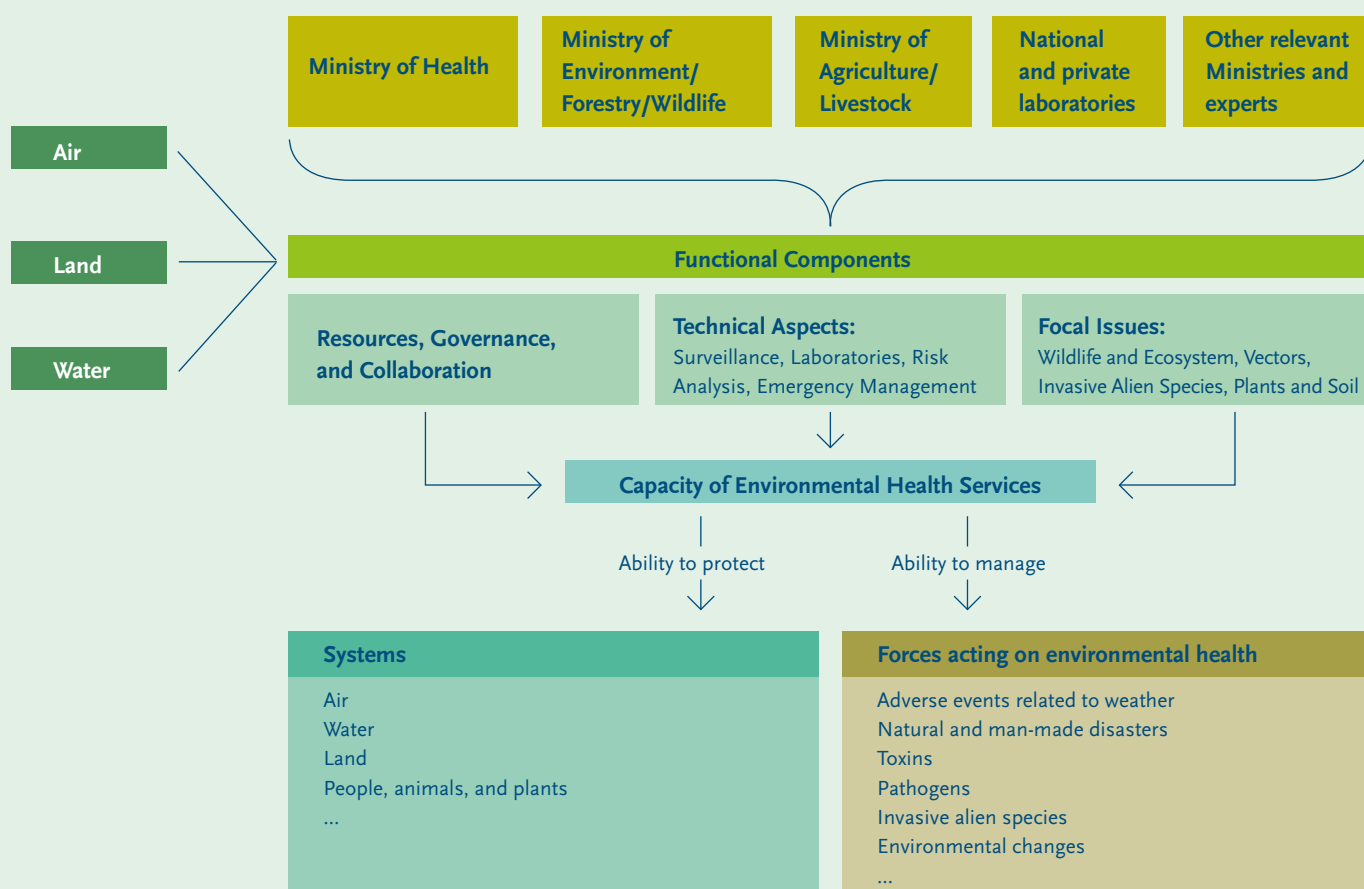


Figure A1.1 Environmental health services components and capacities targeted in draft Country Assessment for Environmental Health Services
 Source: EcoHealth Alliance and World Bank. Country Assessment of Environmental Health Services (draft), Version 2. 2018.

It is structured around the operational components needed for environmental health systems including governance, resources, and collaboration; technical aspects such as surveillance and risk analysis; and focal issues such as terrestrial wildlife and ecosystems, and vectors (Figure A1.1). It builds on existing initiatives promoting resilience, such as the World Bank’s Climate Change and Health Diagnostic and Country Environmental Analysis.

Needs Assessment for National Wildlife Health Centers

The United States Geological Survey National Wildlife Health Center has developed a needs assessment for national wildlife health systems. Applied with partners in the Republic of Korea and Thailand, the tool provides a pathway for assessing infrastructure and capabilities to identify key gaps and needs for transitioning from current to desired future states.

Intended Uses

The two assessment tools seek to assist countries in prioritizing and tracking capacity development, optimizing use of existing infrastructure, reinforcing progress in addressing other goals and action plans such as climate adaptation, biodiversity conservation, tackling antimicrobial resistance, disaster risk reduction, and health security. They are designed to be flexibly applied and country-owned. Ideally, the results of assessments will serve as an input to multi-sectoral National Action Plans for Health Security and preparedness initiatives to increase representation of wildlife and environment aspects and ensure delivery of needed capacity enhancements.

Annex 2. Spotlight on Wildlife Health and Policy: Example from China

Commercial use of wild animals in China

The wild animal industry in China has been developed for decades with major focus on wild animal farming, product processing, trade, pets, exhibiting and tourism. Wild animal farming for fur products, medicine, food, pets and research has generated more than 14 million jobs and USD 73.4 billion direct output as estimated in 2016 (Table A.2.1). It significantly contributed to the development of rural communities, and is seen as a way to prevent illegally hunted wild animals from entering the market. Recent incomplete statistics showed a few hundred wild animal species were farmed in China in 2016, including approximately 7.33 million individual reptiles and mammals for medicine, and 42 reptile, amphibian, birds, and mammal species for food.

The use of wild animals in China is regulated by the Wild Animal Protection Law and Fisheries Law, enforced by the State Forestry and Grassland Administration and the Ministry of Agriculture and Rural Affairs for terrestrial animals and aquatic wild animals, respectively. Hunting licenses are required to harvest protected wild animals from the wild; raising and breeding wild animals need permits or certificates in regard to the animal source, farm facilities and relevant techniques; an operating license and quarantine certificate are necessary in order to sell the animals to the market; as a vendor in a market, a business license should be obtained to run a business involving wild animals such as restaurants, meat stalls, processing, etc.).

Table A.2.1. Employment and direct output value of wild animal industry in China, 2016.

Industry	No. of Employment	Direct Output Value (million CNY)
Fur animals	7,600,000	398,483
Medicinal animals	210,800	5,027
Food animals	6,263,400	125,054
Exhibiting animals & pets	13,700	652
Experimental animals	2,000	400
Total	14,089,900	520,616

Source: Chinese Academy of Engineering Consulting Research Project. 2017. Report on Sustainable Development Strategy of China’s Wildlife Farming Industry (In Chinese)

Figure A.2.1 demonstrates a brief process for the management of wild terrestrial vertebrate animals from the wild to the market. Different departments are involved to enforce the regulation at value chain parts that requires a great deal of coordination; all wild animals can be brought into the industry with appropriate permits; and many species not listed as “protected” are outside of the scope of most regulations. These “unprotected” species include most bat species and many rodents that are widely distributed in China being hunted, and this number will increase if aquatic wild animals are counted.

Wild animal disease monitoring in China

The disease monitoring among wild animals in China is centered around the terrestrial wild animals under the supervision of the forestry department, while regular disease monitoring is implemented for domestic aquatic animals by the agriculture department. In 2005, a wild animal epidemics and epidemic sources monitoring center was founded at the State Forestry Administration. By 2015, the monitoring network included 350 national stations, 918 provincial stations, and a large number of monitoring stations at city and county level, covering 2,000 institutions in the online reporting system.

In 2013, the Administrative Measures for Monitoring and Control of Epidemics and Epidemic Sources for Terrestrial Wild Animal was enacted, in accordance with the provisions of the Wild Animal Protection Law and the Regulation on Handling Major Animal Epidemic Emergencies, to outline procedures and responsibilities for terrestrial wild animal disease monitoring, reporting, and response. A number of rules and normative documents were issued by the forestry department to detail the terrestrial wildlife-borne infectious diseases for monitoring, and set up standards for techniques, facilities, personnel qualifications, and preventative measures for humans in different circumstances (Figure A.2.2).

Monitoring the interactions and disease transmission between wild animals, domestic animals and humans requires an efficient communication mechanism between departments. It is also a challenge to clarify accountability streams between forestry and agriculture departments in the area of wild animal farming, and between terrestrial and aquatic animals. Some wild animals that have been farmed over a long period of time such as sika deer, racoon dogs, fox, and mink, are regulated as domestic animals; others are included in the National Catalogue of Livestock and Poultry Genetic Resource. Species that can be categorized as terrestrial and aquatic such as amphibians and some reptiles such as turtles can be easily overlooked by either department for disease monitoring. This example from one country, with regulations and strategies evolving in real time, demonstrates how responsibility for wildlife accountability can become fragmented across agencies and contexts. This challenge is common across the region and underlines the rationale for a systems approach to comprehensively assess and manage wildlife disease risks.

Annex 3. Case Studies: Wildlife and Environment Associations in Zoonotic Diseases

Depending on the pathogen, species, and situation, the factors driving spillover and spread may vary from country to country, or even outbreak to outbreak. In some cases, distinctions between endemic and emerging status, wild and domestic animal roles, and vector-borne and zoonotic may be complex. Understanding major risk factors, as well as impacts, can help identify entry points and target interventions. As the examples below demonstrate, disease prevention, detection and response may involve a mix of sectors depending on the disease, context, or objective. Improved monitoring and understanding of wildlife and environmental factors may inform more precise risk assessment and reduction based on seasonality, weather, ecological niche, migration patterns, feeding preferences, occupational practices, and other factors.

Hendra and Nipah (Henipaviruses): Pteropus fruit bats (flying foxes) are the reservoir for henipaviruses. Hendra virus (HeV) was first detected in Australia in 1994, with subsequent outbreaks along the coastal northeast, linked to bat-horse spillover likely via fruit contaminated by bat saliva or urine. The disease can spread horse-to-horse, and human infections can occur via handling of infectious materials, usually in veterinarians or handlers treating sick horses. Human-to-human transmission has not been detected. Outbreaks typically occur in the dry season, with proximity to a bat roost site a key determinant of risk (MacFarlane et al. 2011). HeV has also been detected in flying foxes in Papua New Guinea and

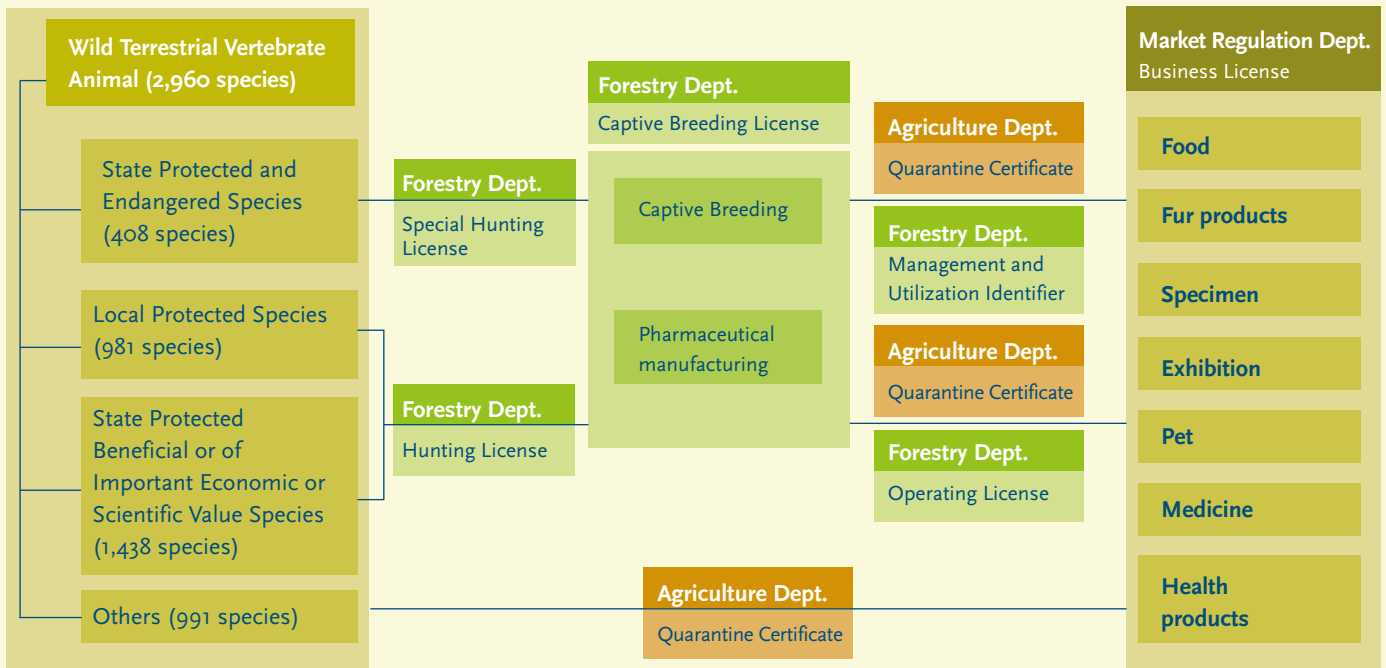
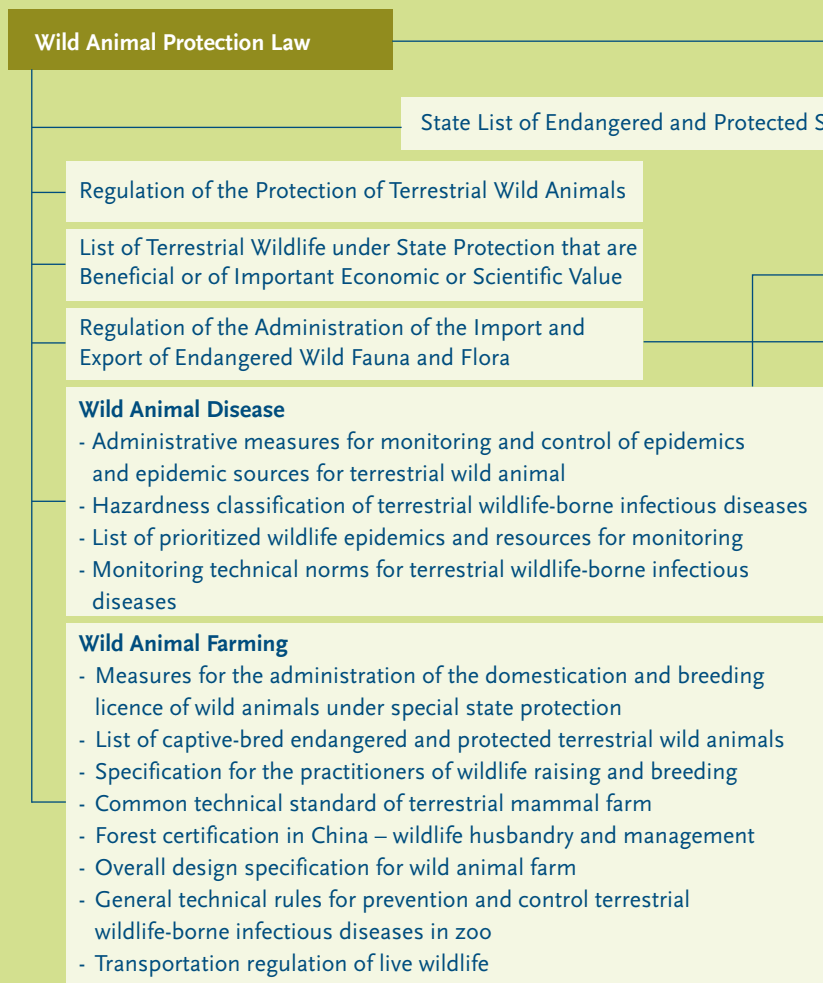


Figure A.2.1. Management of wild terrestrial vertebrate animals in China from the wild to the market. Source: Adapted from Li, et al., One Health (2021) <https://www.sciencedirect.com/science/article/pii/S2352771421000914?via%3Dihub>

Forestry Department



Agriculture Department (fisheries, veterinary, quarantine)



Human Health Department

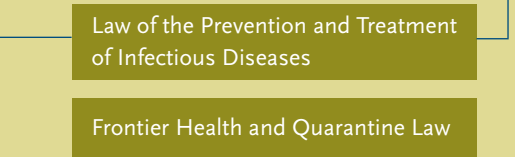


Figure A.2.2. Wildlife disease policies in China Source: Chinese Academy of Engineering Consulting Research Project. 2017. Report on Sustainable Development Strategy of China's Wildlife Farming Industry (In Chinese)

neighboring islands. Relevant control measures include zoning for horse farms; measures to prevent bat-to-horse contact (e.g. protecting feed via sheltering and away from fruiting trees); vaccination of horses to break the transmission chain; use of protective equipment while inspecting sick or dead horses; and quarantine of horses imported from risk areas. The related Nipah virus (NiV) was first detected in Malaysia in 1998 following bat-pig spillover via contaminated fruit. The spread of disease in pigs resulted in major losses for the industry, and spread to Singapore via live pig imports. Human infections occurred from transmission via pigs (likely via contact with secretions or infectious tissue). Subsequent human outbreaks have occurred elsewhere in the region, including in India and in Bangladesh through the consumption of raw date palm sap contaminated by bats during the sap collection process.

Highly pathogenic avian influenza (HPAI): Wild waterfowl are considered reservoirs for avian influenza (AI) viruses. While strains are typically low-pathogenic and wild birds pose little to no direct disease risk to humans, the genetic makeup of AI viruses (containing eight separate gene sections) makes these viruses prone to “re-assortment” and genetic drift that facilitates viral evolution and creates new strains when mixing with other individuals, populations or species. In particular, wild bird-domestic poultry mixing can drive generation of highly pathogenic viruses which may be able to spread efficiently in high-density poultry production, transport, or market settings. Circulation may drive major poultry product losses and potentially transmit to humans, as seen with H5N1 HPAI (2004-2013) and H7N9 (2013). The introduction of biosecurity measures to prevent wild-domestic bird contact is a priority for reducing risk, ideally by avoiding poultry rearing activities near important birding areas. Sentinel surveillance in wild birds can help identify circulating viruses and identify those with pathogenic potential to promote early warning and provide selection of priority strains for candidate human and poultry vaccines.

Plague: An ancient disease caused by the bacteria *Yersinia Pestis* and responsible for the bubonic plague pandemics in the 14th and later centuries, plague remains endemic in parts of the world but largely controlled with sanitation improvements. The basic ecology involves maintenance of the bacteria in a rodent or other small mammal-flea cycle, with differing local reservoir species (foci). Humans can be infected via the bite of infected flea or contact with infected animals. In China, the control of rat infestations effectively prevented transmission in Yunnan province, but in 2016 plague re-emerged from contact with a dead house rat. Inner Mongolia has also seen recent outbreaks. Cases in Mongolia have been linked to hunting or consumption of uncooked marmot. There are three forms (bubonic, septicemic, and pneumonic) based on exposure route and progression; while all can cause severe disease and death if untreated by antibiotics, only the pneumonic form can be spread person-to-person (via droplet transmission). Studies on plague suggest high correlation with humidity and other environmental factors.

Scrub typhus: Rodent hosts are carriers of the bacteria *Orientia tsutsugamushi* that causes the rickettsial disease scrub typhus. Chiggers (larval mites) that have fed on infected rodents can transmit the bacteria to humans via bites. The disease is environmentally-sensitive, seen with rainfall-associated rises in rodent and chigger populations. It is sometimes called bush typhus, reflecting that transmission commonly occurs in grassland areas where chiggers are present. It is estimated to cause over one million human cases annually; while considered endemic to parts of the Asia-Pacific region, it has seen recent re-emergence in India, the Republic of Korea, the Lao People’s Democratic Republic, and Maldives, plus expansion from southern China to all provinces, with changing recreation practices driving risk in urban populations (Li et al., 2020).

Glossary

Active surveillance: method by which special effort is expended to discover disease cases, for example through surveying and searches. Includes purposeful gathering of information. Cf. passive surveillance (World Bank)

Biosecurity: a set of management and physical measures designed to reduce the risk of introduction, establishment and spread of animal diseases, infections or infestations to, from and within an animal population (OIE)

Climate-sensitive disease: a disease whose incidence or transmission is affected, positively or negatively, by climate (World Bank)

Early warning system: comprehensive set of information and actions that alert decision makers of impending harm; inclusive of surveillance; aims to provide short- or mid-term disease forecasting so that appropriate interventions and mitigation efforts can reduce the impact of an epidemic (World Bank)

Ecosystem: dynamic complex of plant, animal, and microorganism communities and their non-living environment interacting as a functional unit (CBD)

Emerging infectious disease: infection appearing for the first time in a population, or rapidly increasing in incidence or geographic range (WHO and National Academies of Sciences, Engineering, and Medicine)

Endemic: a disease that is constantly present to a greater or lesser degree in people of a certain class, or in people living in a particular location (World Bank)

Epidemic: when new cases of a disease, in a given human population and during a given period, substantially exceed what is expected based on recent experience (World Bank)

Health security: global health security indicates the prevention of avoidable epidemics, detection of threats early, and responding rapidly and effectively (World Bank)

One Health: One Health is a collaborative, multi-sectoral, and transdisciplinary approach — working at the local, regional, national, and global levels — with the goal of achieving optimal health outcomes recognizing the interconnection between people, animals, plants, and their shared environment. The One Health approach aims to strengthen systems to prevent, prepare, detect, respond to, and recover from threats to human health, animal health and environmental health.

Pandemic: an epidemic of infectious disease that is spreading through human populations across a large region such as a continent, or even worldwide (World Bank)

Passive surveillance: method by which disease cases are uncovered through routine report. No special effort is extended to discover cases. Cf. active surveillance (World Bank)

Pathogen: any disease-producing agent (especially a virus, bacterium, or other microorganism) (World Bank)

Risk map: application of data to a visual media that facilitates the communication of disease threats (World Bank)

Transmission: passing of an infectious disease from one infected individual or group to another (World Bank)

Vector-borne disease: infectious disease transmitted from one host to another by an insect or any other living carrier (World Bank)

Wild [animal]: an animal that has a phenotype unaffected by human selection and lives independent of direct human supervision or control (OIE)

Wildlife: means feral animals, captive wild animals and wild animals (OIE)

Zoonosis: infectious disease transmissible from animals to humans (i.e., “zoonotic disease”) (World Bank)

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Emerging infectious diseases (EIDs) are infections associated with new or significantly-expanded geographic scope or spread of zoonotic, vector-borne, and drug-resistant pathogens. The majority of EIDs have animal origins, and of those, the most recent EIDs are tied to wildlife. They are also increasing in frequency, with reoccurring outbreaks causing epidemics and pandemics exacting tremendous health and economic costs on individuals, nations, and the global economy. Strategies to reduce EID risks and better prevent future events from happening, need to comprehensively include wildlife - and the multiple interactions between wildlife, domestic animals, and humans - in a holistic way. 'One Health' addresses this, with the goal of achieving optimal health outcomes while recognizing the interconnections between people, animals, plants, and their shared environments. In this report, we explore the root causes of pathogen spillover and disease emergence from wildlife to humans in East and South Asia, we review existing strengths and gaps of One Health systems, and provide recommendations to improve their performance by better including wildlife considerations. We describe human practices that increase exposure to pathogens, and specific, tangible actions to reduce risks along the chain, prioritizing the wildlife trade, food systems, and the environment. The report argues that investing in prevention of wildlife-originated human EIDs at source is extremely cost-effective, and is thus to be viewed as a public good, with benefits within and across national boundaries. The cost of inaction, by contrast, is very high.

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