Outbreaks and Spillovers

Policy Exchange

How the UK and international community can lower the risks of zoonotic disease

Benedict McAleenan and Will Nicolle

Foreword by Rt Hon Lord Hague of Richmond

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Contents

Foreword

By The Rt Hon the Lord Hague of Richmond

It would be easy to see Covid-19 as fundamentally a health crisis. Future studies of the pandemic will no doubt compare the healthcare systems of the world and draw conclusions about how they coped, rewriting league tables and even drawing out new electoral battle lines.

It could also be seen as a crisis of globalisation. It has proven too easy for a virus from the other side of the world to travel here, to spread and to kill. Our dependence on trade with China and others, whose notions of transparency and cooperation differ wildly from our own, has exposed us, our livelihoods and our economies.

Yet this is also a detective story, an etiological question that gets to the heart of our relationship with the natural world. Before this became a debate over epidemiological models and Chinese cover-ups, it was a question about nature. How did a novel virus – a zoonotic disease – spill unnoticed from animals into the human world?

The IPBES, a UN panel on biodiversity, has warned that increasing ecological disruption is distinct from climate change but as grave in its implications. Such disruption includes a host of human activities that have eroded biodiversity and exposed us to a Pandora's Box of pathogens. From wildlife trading to climate change, humans have long been creating risks that put everything on the line. We increasingly understand these processes and the consequences are now writ large. It would be criminally negligent if we did not learn and act from the Covid-19 crisis before the world's attention moves on.

We have certainly gathered pace in recent decades, but our destruction of natural habitats is not new. Humans were burning down forests around the world tens of thousands of years ago. Around 45,000 years ago, we arrived in Australia and promptly set fire to it, creating grasslands more suited to hunting than the woods that preceded them. The same happened in North America at the end of the last ice age 12,000 years ago, where we wiped out 34 of the continent's 47 genera of megafauna. A similar process happened in what was to become the British Isles, reducing perhaps 70% tree cover after the ice age to the 13% we have now.

What is different today is twofold. Firstly, we now know better. Scientists, public figures such as Sir David Attenborough and a global health crisis that started in bats all tell us that something has gone badly wrong in our relationship with nature. Secondly, we have the tools to change our ways. We have satellite systems that can track deforestation and genetic mapping that shows us which animals are present in a given habitat. Even more powerfully, we have global communication systems that allow us to discuss and to co-ordinate our response. We have these

tools; it is time we put them to good use.

One area where we apply these systems effectively is in defence and security. At an international level, we have created systems to monitor, analyse and inspect risky behaviours at an early stage to prevent the proliferation of weapons of mass destruction, whether nuclear, chemical or biological. The coronavirus crisis has taught us that other high-risk behaviours are commonplace around the world – and that we need to apply the same urgency to zoonotic disease as we do to preventing the proliferation of WMDs.

Trade in wildlife, whether at a wet market in South China or in a shipment from West Africa, is raising our exposure to novel pathogens that could spread globally. Deforestation is displacing species that spill into suburbs and rural communities, causing viral outbreaks like Nipah and Zika. Industrial farming is creating the perfect conditions for new flu strains in birds and pigs, only a splash away from their handlers and the human population. Our most frightening scourges, from HIV to Ebola, have started in animals. US scientists have estimated that 1.6 million undiscovered viruses exist in wild animals, nearly half of which could infect people.

If we know these threats are out there, why are we not applying every human ingenuity to stopping them?

Part of the answer is that we have not joined the dots at the global level enough to take the most appropriate action. Scientists and even Hollywood have known that those East Asian countries with experience of SARS have designed systems (albeit clearly insufficient ones) for halting further outbreaks. In the West and the international institutions that we designed, that connection has been missed.

This important paper from Policy Exchange seeks to remedy that. By placing its focus on prevention of spillovers from animals to humans, rather than the usual emphasis on containment using healthcare, it radically shifts the spotlight. It is, as the authors point out, like fixing the Chernobyl reactor before it blows, rather than waiting until afterwards to limit the damage. Just as we have regimes to monitor nuclear facilities and ban WMD proliferation, so we need a system to study, monitor and inspect the zoonotic threats that pose the greatest danger to human health and the global economy – and then to act to shut them down.

It is particularly important that the UK's leadership hears and amplifies this message – something that I have full faith will happen. Britain is currently well-placed to create the new mechanisms the world needs. It is due to host COP26 in the coming year, making it a global focus for environmental debate. In 2021 it will also host the G7, giving it a second chance to set the world's agenda. In the longer term, we are in the process of re-establishing trade relationships around the world, creating new contexts for discussions about sustainable commodities and standards. For the sake of world safety, we must not miss these chances to champion the ecological cause.

Executive Summary

- Zoonotic pathogens (those that originate in animals) are a growing risk to human populations. There were three times as many outbreaks in the 1990s as in the 1940s, and cases continue to rise. The majority of new infectious diseases originate in animals, including well-known diseases such as SARS, avian flu, Ebola and HIV. Whilst too early to say for sure, it is likely that SARS-CoV2 (the virus that causes COVID-19) originated in bats. This has led to almost three million infections and over 200,000 deaths worldwide,[1] as well as fiscal costs in the trillions of pounds and a likely long-term impact of trillions more on economic stability, jobs, investments, companies and personal savings.
- This rise is caused by three key trends:
  - A rise in ecological disruption, such as wildlife trading, land use change (e.g. deforestation to create farmland), habitat fragmentation and climate change. This increases human exposure to viruses and bacteria that are ordinarily only found in animals.
  - Ever larger industrial agriculture, without appropriate sanitary and veterinary systems, which increases the possibilities of pathogen mutation and spread.
  - A rise in international connectedness, which allows such pathogens to spread around the globe quickly.
- Zoonotic pathogens are more likely to 'spill over' into human populations when natural ecosystems are disrupted. These mechanisms are relatively well understood but need significant further research (which the UK should support through funding of UK and international organisations). One example is when agricultural expansion causes deforestation, leading to the displacement of species such as bats. These species seek new habitats, often in agricultural or suburban settings, in closer proximity to livestock and/or humans. This proximity makes a spillover event far more likely.
- Another way in which spillovers may occur is in wildlife trade. Pathogens from the wild are unnaturally introduced to humans via the sale of wildlife products, such as bush meat.
- It seems probable, based on current available evidence, that 'wet markets' played a role in the current pandemic. Wet markets sell a range of fresh foods and form a key part of food systems in much of South East Asia, Africa and South America. They are comparable

1. As of 27th April 2020. Source: Johns Hopkins University.

to fresh food markets around the world. However, some sell 'bush meat', or meat from animals caught in the wild, as well as wildlife-based products for traditional medicines. Live animals are often kept in cages at such markets, in close proximity to other species and to people, and frequently involve slaughter on site. These practices raise the risks of a 'spillover'.

- It is important not to focus on wet markets alone, which have a valid role in many cultures and societies. Wider ecological disruption, of which wildlife markets are just one subset, is the overarching trend in need of better regulation and enforcement to control zoonotic spillovers. Wildlife trade at wet markets is a subset of much more widespread wildlife trading (for restaurants, traditional medicines and other purposes), which itself is one form of multifarious ecological disruptive practices, such as deforestation and habitat loss. Despite these mechanisms being relatively well understood, human activities are demonstrably driving greater ecological disruption. Agricultural expansion, urbanisation and climate change are the key drivers. Addressing this is the ecological equivalent to fixing Chernobyl power station before it explodes. However, we must also invest in research and capacity building so that dynamic strategies for managing human-wildlife interactions whilst lowering risks.
- The international community does not have a well-structured and co-ordinated system for managing these risks. Data collection is very poor, with under-reporting or misreporting of outbreaks still commonplace. The system is also toothless in preventing high-risk activities.

Summary of recommendations

- **A new international convention and agency:** We recommend treating activities that increase the risk of zoonotic disease outbreaks in the same way as we treat other threats to global security such as WMD proliferation. This can be done through:
  - A new international convention on zoonotic disease emergence;
  - A new or strengthened co-ordinating body at the international level, ideally UN-based, to lead the monitoring, research and inspection of high-risk activities;
  - Trade restrictions on those who indulge in high-risk activities;
  - Financial support and capacity-building for countries with fewer resources.
- **For the international community:**
  - **Two inquiries:** There should be two inquiries at the international level. The first should investigate COVID-19 specifically, its origins and its spread so as to prevent a repeat.

The second should investigate the broader risks of zoonotic disease and how they can be minimised.

- **Free media, civil society and scientific communities:** The international community must refresh its drive for free and independent media, NGOs and scientists as a necessary corollary to any formal regulatory regime. These help to circumvent cover-ups caused by crime, corruption and/or politicised reporting systems.
- **Wildlife markets:** The world should acknowledge China's current ban on wildlife trading, but insist that it goes much further. The ban should be extended to high-risk elements of traditional medicine and it should be implemented and enforced consistently in every province and across every border. It should then be turned into permanent law, rather than short-term diktat. Compensation and re-training should be given to those whose livelihoods have depended on the wildlife trade, as part of a clear strategy to end it. If China or others refuse this ban, the international community should refuse trade in agri-goods from those countries.
- **Convention on Biological Diversity:** The CBD's COP15 in China should include proposals for the new convention on zoonotic disease risks (see above) and should amend the CBD to take account of zoonotic disease and the indirect risks of farmed endangered species.

- **For the UK:**
  - **Dedicated Minister and scaled-up agency:** Appoint a single Minister, ideally sitting across the FCO and DEFRA, to co-ordinate UK activities in lowering zoonotic disease risk, overseeing a scaled-up Animal and Plant Health Agency (APHA). APHA should become the UK's key point of contact with the new international body (see above) and should also administer a fund for supporting research by UK universities and companies into this area of risk.
  - **Diplomatic agenda:** The UK should use its role as co-host of COP26 and an attendee at COP15 to drive this agenda for a new convention on zoonotic disease and ecological disruption.
  - **Sustainable commodities:** Integrate sustainable procurement and trade through a sustainable commodities strategy, governing all trade in which the UK partakes (including via the City of London's commodities trading operations, with an approach similar to the PRA's Senior Manager's Regime on climate change risks).
  - **International aid:** A greater portion of the UK's aid budget should focus on sustainable and productive agriculture and related practices.

Introduction: A growing risk

The COVID-19 pandemic was predicted by a number of academic and institutional researchers. Several research papers,[2] [3] [4] [5] as well as intelligence reports for national governments,[6] have predicted a global outbreak caused by a virus or bacterium jumping from animals to humans and then spreading globally via air travel. These warnings have often been treated by the general population and their representatives as outlier events – the stuff of Hollywood films such as 'Contagion'. However, they are not outliers, but a growing and significant problem.

This paper argues that the conditions and activities that lead to such outbreaks should be treated with the same severity and attention as other security concerns, such as terrorism and the proliferation of weapons of mass destruction. Just as extremist hotspots can be identified and monitored, or uranium enrichment programmes can be inspected, so should the behaviours and policies that increase the risk of zoonotic pandemics. We argue that an international system to monitor, inspect and penalise contraventions should be instated, under a new international agreement that commits parties to take actions to minimise the risks of these outbreaks happening in the first place.

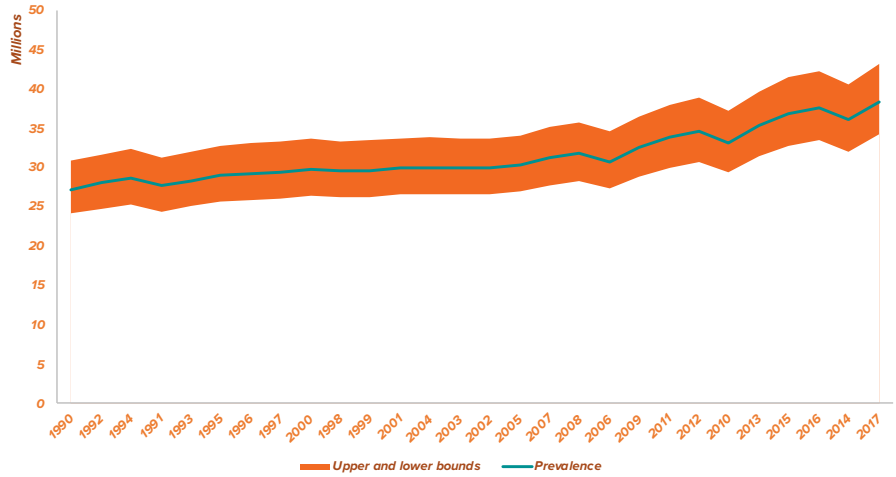
Risk analysts increasingly talk about 'fat tail' events. A standard distribution of possible events forms a bell curve, with thin 'tails' on either side representing the range of less likely events. However, public figures such as Nassim Nicholas Taleb have warned that these events are more likely than society assumes – the thin tail is not as thin as we believe.

This logic applies to pandemic risks, which historically have seemed highly unlikely, but which actually occur at an alarming frequency. More alarmingly, they appear to be occurring at an *increasing* frequency than before. There were more than three times as many zoonotic outbreaks in the 1990s compared to the 1940s (Figure 2). Since 1990, the number of cases of zoonotic disease has steadily risen. The 'fat tail' of zoonotic pandemics is getting fatter. This is in part due to better detection, but this should not mean we discount the risk – a Bayesian approach suggests we should adjust the risk profile and commit resources accordingly.

This appears to be due to two megatrends. On the one hand, globalisation has made it far easier for disease to spread. *Yersinia pestis*, the bacteria that is suspected to have caused the Black Death in the mid-14th century, took more than a decade to travel the length of Eurasia, following the path of the Mongol Conquests and medieval Silk Roads. SARS-CoV2 (the virus that causes COVID-19), in contrast, took a few weeks to reach every continent on Earth except Antarctica.

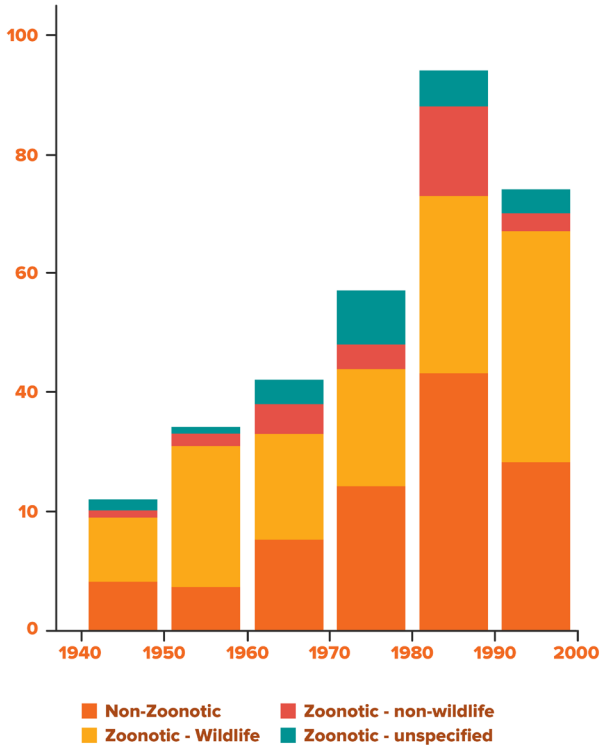
2. E.g. Cheng et al. (2007), "Severe Acute Respiratory Syndrome Coronavirus as an Agent of Emerging and Reemerging Infection", *Clinical Microbiology Reviews*.
3. Fan et al. (2019), "Bat Coronaviruses in China", *University of Chinese Academy of Sciences*.
4. Cui et al. (2018), "Origin and evolution of pathogenic coronaviruses", *Nature Reviews Microbiology*.
5. Inglesby and Adalja (2019), "Characteristics of Microbes Most Likely to Cause Pandemics and Global Catastrophes", *Global Catastrophic Biological Risks*.
6. E.g. National Intelligence Council (2008), "Global Trends 2025: A World Transformed", https://www.files.ethz.ch/isn/94769/2008_11_Global_Trends_2025.pdf.

Figure 1: Global prevalence of zoonotic disease cases in humans from animal contact, 1990-2017.[7]



Such increased connectivity might explain the rise in the number of individuals infected by such diseases (Figure 1) if it applied to just a small number of outbreaks. However, there has also been a rise in the number of discrete emergence or reemergence events (Figure 2). That is, outbreaks are not only having more widespread effects – they are also happening more often. Of these, a rising number have been zoonotic; that is, they originated in animals.

Figure 2: Rising number of emerging infectious disease events, 1940-2004.[8]



7. Institute for Health Metrics and Evaluation (2020), "Global Burden of Disease 2017: GBD results tool", http://ghdx.healthdata.org/gbd-results-tool; Year, 1990 – 2017; Context, Cause, Animal Contact; Metric, Prevalence; The IHME collate this data from a number of different sources.

8. Jones et al (2008), "Global trends in emerging infectious diseases", *Nature*.

The zoonotic origin of new disease outbreaks has been closely linked to the increasingly disruptive pressures applied to ecosystems around the world. HIV, Ebola, Lyme Disease, some forms of flu, Nipah, Zika, SARS and MERS have all been traced with a high level of confidence to human or livestock interactions with wildlife.[9] It is too early to say with similar confidence that SARS-CoV2 had such origins, but it bears many of the hallmarks.

When these factors are combined – increased connectivity with increased zoonotic outbreaks – the risk is amplified. China is not the only country with zoonotic outbreaks, but its desire to play an active role on the world stage has meant a massive increase in its connectedness. This means that China has a greater responsibility to the international community for lowering risks at every stage of an outbreak, including limiting risks through better regulation of wildlife trade. Despite this, China made disturbing attempts to suppress those who sought to raise the alarm at the outset of COVID-19. Li Wenliang, the 33-year-old doctor who first raised the alarm about a possible SARS outbreak around Huanan seafood market via a private WeChat group, was summoned by police and given a formal warning for doing so.[9] China has condemned calls for an inquiry into the pandemic's origins and it continues with misinformation about those origins. The Global Health Security Index 2019 puts China below the global average for zoonotic disease prevention (101 out of 185 countries). China has therefore played a central role in the current crisis and its response in coming months, both domestic and international, will be important for limiting future zoonotic outbreaks.

Some honourable figures within the Chinese system did seek to raise the alarm, including medics and journalists, risking their own livelihoods to defy local state apparatus. These efforts were censored at an early stage. There was also a medical reporting system instated in 2004, which played a role in controlling avian flu in 2013 but which failed this time, apparently owing to local political interference. This paper makes recommendations for an international system designed to circumvent such local mechanisms. However, it will also depend on the less formal scrutiny applied by free and independent media, civil society and scientific communities. Such actors must have the freedom to identify and report high-risk issues, feeding such reports into an international system. Open economies and trade, with the free movement of goods and people between countries must come with the corollary of transparency and independent ways to find information.

The mechanisms by which pathogens escape from their normal host populations (known as animal reservoirs) and into humans are reasonably well understood in general terms. Deforestation or habitat fragmentation often disrupts existing populations. [10] For example, bats lose their normal nesting sites and seek new ones. Such sites normally host millions of genetically similar animals in close proximity, which provides an excellent context for viral spread and mutation – a pandora's box that should not be opened. Disruption of such colonies is often driven by demand for

9. The Economist (2020), "Obituary: The Man Who Knew", https://www.economist.com/obituary/2020/02/13/li-wenliang-died-on-february-7th.
10. e.g. Wilkinson et al (2018), "Habitat fragmentation, biodiversity loss and the risk of novel infectious disease emergence.", *J R Soc Interface*.

agricultural land or urbanisation. The displaced species try to find new homes amid newly built farms or suburbs, bringing them into closer contact with livestock or humans. It is then a short step for pathogens to pass from their original hosts and into livestock. These are often kept in large, genetically homogenous groups that are ideal places for further mutations, which may include a new ability to infect local human populations. From there, international travel amplifies the spread.

A closely related factor, which has attracted significant attention amidst the SARS-CoV2 outbreak, is the deliberate trade in wildlife. This has not yet been proven, but it is notable that previous outbreaks (e.g. SARS[11], H5N1[12]) were traced back to food markets (sometimes called 'wet markets') and the first occurrences of COVID-19 were among workers at the Huanan Seafood Wholesale Market. Trade in wildlife often occurs in poorer regions, where other foods are unaffordable, sanitary practices are not followed and regulatory oversight is weak. Certain species are also seen as delicacies and served for special occasions. However, it is notable that wildlife, including endangered species, often feature in 'traditional' medicines and such traditions have been actively promoted at the international level by China as a cultural element in its Belt and Road Initiative, thereby increasing the channels by which zoonotic diseases might enter human populations and cross borders.

However, a narrow focus on Chinese markets, whilst relevant to the current pandemic, risks missing the greater trend towards zoonotic disease emergence.[13] Novel diseases are increasing not simply because of more connectivity with China and its poorly regulated markets where bush meat is on offer, nor China's promotion of Traditional Chinese Medicine (TCM) though both of these are factors, but rather a global trend towards ecological disruption and the resultant human contact with wild animals. HIV, for example, appears to have originated in Africa as a set of viruses in primates, which spilled over to humans in the 1920s.[14] In 2019, the IPBES, a UN body which advises on biodiversity issues, noted significant long-term losses of biodiversity and other markers of ecological health. The leading drivers of such loss were listed in order as land-use change (towards agriculture and urbanisation), pollution and climate change.[15] Land-use change and agricultural industry have been noted as the two leading drivers behind notable zoonotic outbreaks.[16]

We therefore understand that ecological disruption increases the risk of new diseases emerging, that humans are causing a significant rise in such disruption and that we have seen a rise in novel diseases. There is strong evidence to suggest that this is not merely correlation, but a causal chain. There will therefore be no permanent solution to such threats unless such disruption is limited, regulated and closely watched, wherever it occurs. Doing so is comparable to fixing Chernobyl power station *before* it explodes, rather than acting after the meltdown.

Fortunately, the international community appears to be waking up to these risks in the wake of COVID-19. The Intergovernmental Science-Policy Platform Biodiversity and Ecosystem Services (IPBES), for instance,

11. Bell et al (2004), "Animal origins of SARS coronavirus: possible links with the international trade in small carnivores", *Philo. Trans. of the Royal Society B.*
12. Hayden and Croisier (2005), "Transmission of avian influenza viruses to and between humans", *Journal of Infectious Diseases*.
13. Jones, K. et al (2008), "Global trends in emerging infectious diseases", *Nature*; Allen, T et al (2017), "Global hotspots and correlates of emerging zoonotic diseases", *Nature Communications.*
14. Sharp & Hahn (2011), "Origins of HIV and the AIDS Pandemic", *Cold Spring Harbor Perspectives in Medicine*.
15. IPBES (2019), "IPBES global assessment report summary for policymakers", https://ipbes.net/sites/default/files/2020-02/ipbes_global_assessment_report_summary_for_policymakers_en.pdf.
16. Han et al (2016), "Global patterns of zoonotic disease in mammals", *Trends Parasitol.* ; Grace, D. et al (2012), "Mapping of poverty and likely zoonoses hotspots", *ILRI Kenya*, https://www.gov.uk/dfid-research-outputs/mapping-of-poverty-and-likely-zoonoses-hotspots; Redding et al (2016), "Environmental-mechanistic modelling of the impact of global change on human zoonotic disease emergence: a case study of Lassa fever", *Methods in Ecology and Evolution.*

recently launched a call for experts to contribute to a workshop on the relationship between biodiversity and pandemics.[17]

This paper examines the factors involved in this chain and how UK and international public policy can help to manage the risks of another pandemic caused by wildlife trading and ecological disruption.

17. IPBES (2020), "Call for nominations: IPBES workshop on biodiversity and pandemics", https://mailchi.mp/ipbes.net/call-for-nominations-ipbes-workshop-on-biodiversity-and-pandemics?e=9ff13ba424.

How do zoonotic diseases emerge?

Making the jump: the 'spillover'

How diseases emerge and the significance of ecological factors within this process is complicated. The drivers of zoonotic disease emergence never act in isolation. Rather, different drivers – both ecological and non-ecological – interact to create a situation where an infectious pathogen, existing within an animal host, can be transmitted to humans.

At a high-level, the spillover from animals to humans can be thought of through three key stages:

- **Reservoirs.** Initially, pathogens exist within 'animal reservoirs'. These animals often harbour pathogens while suffering minimal or no health impacts, due to a long history of years of co-evolution with the pathogen, similar to the common cold in humans. Alternatively, animal reservoirs might be intermediary hosts, which act as a bridge between normal hosts and humans. For example, measles appears to have jumped from cattle to humans around 1,000 years ago.[18] The IPBES, an international scientific advisory body, estimates that 17% of infectious diseases are spread via such animal contact.[19] Reservoirs can lead to infection either directly through various forms of contamination, or via 'vectors', usually biting invertebrates that carry the pathogen from the animal to the human bloodstream. A well-understood case is that of malaria, caused by parasites whose vector is primarily the female *Anopheles* mosquitos. There has been a suggestion that the SARS-COV2 virus emerged from bats via pangolins, which are commonly farmed for supply to the Traditional Chinese Medicine trade despite their endangered status.[20]
- **Increased human-animal contact.** Owing to various possible reasons, humans increasingly come into contact with animal reservoirs of pathogens. This can range from directly human-driven processes, such as farmers expanding agricultural land into previously wild areas, or more indirect processes, such as food chains being disrupted, causing fluctuations in ecosystems. For example, urbanisation and farm abandonment in the USA's East Coast region caused changes to owl, hawk, deer, wolf and rodent populations that led to higher numbers of white-footed mice carrying the bacteria that causes Lyme Disease (see Box 1).[21]

18. Furuse et al. (2010), "Origin of measles virus: divergence from rinderpest virus between the 11th and 12th centuries", *Virology Journal*.
19. IPBES (2019), "IPBES global assessment report summary for policymakers", https://ipbes.net/sites/default/files/2020-02/ipbes_global_assessment_report_summary_for_policymakers_en.pdf.
20. Andersen, K. et al (2020), "The proximal origin of SARS-CoV-2", *Nature Medicine*.
21. Robbins (2012), "The Ecology of Disease", https://www.nytimes.com/2012/07/15/sunday-review/the-ecology-of-disease.html.

- **Localised transmission.** The pathogen 'jumps' the species barrier from an animal reservoir to humans. Whereas human immune systems can resist most novel pathogens, occasionally such unfamiliar pathogens can evade these defences. The specific way in which a pathogen 'spills over' varies, but often includes direct contact with infected wildlife, contact with a domesticated species, or the consumption of wildlife for meat or pseudo-medicinal purposes. Local, clustered outbreaks can occur at this stage, and the pathogen and the disease it causes begins to be identifiable by researchers and authorities. For example, localised clusters of COVID-19 were identified among workers at the Wuhan wildlife market in early December 2019.[22]

A central concept is that of the 'human-wildlife-environment interface'. This refers to how often humans and animals interact, in what ways they interact, and under what conditions. In this context, biosecurity policy focuses on trying to influence how humans and wildlife interact in order to minimise the risk of zoonotic spillover, most obviously through minimising any interaction where possible and, in circumstances where this interaction will occur regardless (such as in forestry), trying to control *how* this interaction takes place. The WHO's 'One Health' agenda is an international work programme to encourage countries to base health policy on the notion that animal, plant and human health are interconnected.[23]

22. Andersen, K. et al (2020), "The proximal origin of SARS-CoV-2", Nature Medicine.
23. World Health Organization (2020), "Zoonoses and the environment: FAO/OIE/WHO Collaboration (Tripartite)", https://www.who.int/foodsafety/areas_work/zoonose/concept-note/en/.

Box 1: Endemic risk in the UK

Advanced economies with robust regulations, situated in temperate regions, have a different risk profile when it comes to zoonotic disease. Risks are twofold:

- On the one hand, there is an external threat of spread through the arrival of infected people or goods from overseas.
- On the other hand, there are growing risks from endemic zoonotic diseases, mostly through climate change.

Endemic threats (i.e. those originating within a country) tend to be well managed in advanced economies, where risks are well-researched, regulated and monitored. For example, Public Health England operates a list of statutory 'notifiable' zoonotic diseases that must be reported to the agency if they are found, supported by regular monitoring of both agricultural animals and wildlife. Risks tend to be food-based, the most common being *Campylobacteriosis* and *Salmonellosis*. Domestic cases of zoonotic diseases have been stable for a decade. The most notable outbreak in modern times was the UK's BSE/vCJD crisis, which is estimated to have cost the UK around £9 billion, not including lost export value.

The Intergovernmental Panel on Climate Change (IPCC), a UN body, notes that infectious diseases will likely increase as a result of a warmer climate. In particular, vector-borne diseases (those that spread via unaffected third-party species, especially parasites) are likely to spread to new regions. One study of 150 pathogens found in Europe concluded that two-thirds have at least one climate-affected variable. I.e. changes in climate will affect their spread.

The two most common instances of vector-borne diseases in temperate developed countries are ticks and mosquitoes.

Tick-borne Lyme disease, which can be debilitating or deadly, is rising in the UK, with a 612% increase between 2001 and 2019 in England and Wales. Higher temperatures and precipitation are thought to increase tick abundance, making climate change a credible culprit.

The Asian Tiger Mosquito, which carries diseases including yellow fever, dengue fever and chikungunya, has been found in the South East of England in recent years. The mosquito's range is increased by ecological disruption and climate change.

The UK's exposure to such risks is therefore inherently international: it is raised by air travel, ecological disruption around the world, unsanitary livestock and wildlife handling and climate change.

Biodiversity, dilution and amplification

Currently, most ecological protections appear to be focused on protecting and improving biodiversity. This emphasis rests on the importance of biological diversity to various human systems (known as environmental services), as well as a certain *a priori* respect for nature. However, the issue of human health in ecological regulation and treaties has been a relatively low priority. For example, the Convention on Biological Diversity does not mention zoonotic disease risks.

There are nuances in the role of biodiversity – that is, the range in species within an ecosystem – as it pertains to zoonotic spillovers. There is no clear scientific consensus on the influence of biological diversity on the risk of zoonotic disease emergence.[24] It is tempting to assume that higher biodiversity reduces the risk of zoonotic diseases spilling over into human populations, based on the long-term trend of biodiversity decline[25] and

24. Angela (2018), "Species diversity concurrently dilutes and amplifies transmission in a zoonotic host-pathogen system through competing mechanisms", *Proceedings of the National Academy of Sciences*; Jones et al (2020), "FAQs – relationship between infectious disease and habitat loss, biodiversity, bats and wildlife markets".
25. IPBES (2019), "IPBES global assessment report summary for policymakers", https://ipbes.net/sites/default/files/2020-02/ipbes_global_assessment_report_summary_for_policymakers_en.pdf.

an increased zoonotic disease emergence.[26] However, two apparently contradictory hypotheses have been put forward, known as the Dilution Effect and the Amplification Effect.

- **Dilution effect:** This theory posits that greater biodiversity lowers the number of interactions between competent hosts (i.e. species able to carry the pathogen) because there is a greater number of species interactions. Like a combination wheel lock with more wheels, dilution makes it harder for a virus to find the right combination to spread. Multiple studies have shown that zoonotic risks increase with higher vertebrate diversity at larger spatial scales.[27]
- **Amplification effect:** Conversely, amplification effect theory argues that biodiversity increases the risks of zoonotic disease spillover because it raises the number of possible vectors for transmission. This theory seems to be most relevant where humans are an active element in the model i.e. if humans only ever interacted with pets or livestock, there would be lower chances of zoonotic spillover, whereas exposure to many species raises the number of opportunities for novel infections. One study constructed a theoretical model reflecting the role of intermediate land use change (i.e. where elements of wildlife remain as well as many humans), showing this higher risk in action.[28]

Whilst these theories appear contradictory, there is good reason to believe that they both operate but in different scenarios and at different scales. For example, it has been shown that biodiversity levels can have both diluting and amplifying effects on the transmission of the zoonotic disease *hantavirus pulmonary syndrome* depending on the driver of transmission in question.[29] More research is needed to understand both dilution and amplification effects.

What is clear is that the key drivers of biodiversity decline – agricultural expansion, urbanisation, climate change, overexploitation of ecosystems and the hunting or harvesting of endangered species – also drive zoonotic spillovers. However, it is important for public policy not to treat the two as one; doing so may miss important contributors to spillover risk. For example, the Convention on Biological Diversity does not reference zoonotic disease and as such cannot be relied upon to target the most relevant factors. We recommend amendments that refer to the potential health risks of ecological disruption, including wildlife trading and trade in endangered species.

Wet markets and the wildlife trade

The coronavirus causing the 2002-2004 outbreak of Severe Acute Respiratory Syndrome (SARS), was genetically traced to horseshoe bats in China's Yunnan province.[30] Later research found the SARS coronavirus in masked palm and asian palm civets being sold in markets in Guangdong

26. Jones et al (2008), "Global trends in emerging infectious diseases", *Nature*; Allen et al (2017), "Global hotspots and correlates of emerging zoonotic diseases", *Nature Communications*.
27. Wood et al (2016), "Does biodiversity protect humans against infectious disease? Reply", *Ecology*.
28. Faust et al (2018), "Pathogen spillover during land conversion", Ecology Letters.
29. Luis. et al (2018), "Species diversity concurrently dilutes and amplifies transmission in a zoonotic host-pathogen system through competing mechanisms", *PNAS*.
30. McKie (2017), "Scientists trace 2002 SARS virus to colony of cave-dwelling bats in China", https://www.theguardian.com/world/2017/dec/10/sars-virus-bats-china-severe-acute-respiratory-syndrome.

province, where 10,000 civets were butchered for meat in one year.[31] In the wake of the first SARS outbreak, China closed its wildlife markets. Yet it later re-opened them once the epidemic had passed. This approach must be extended beyond food markets to other trading such as traditional medicine, enshrined in law and enforced. Where countries will struggle to alter practices, the international community must use aid budgets to support a transition to more sustainable and lower-risk systems without undermining food supply.

"Wet markets" are neither unique to China nor are they necessarily unsanitary places. They typically involve an open area (covered or uncovered), vending stalls and "wet" items such as poultry, meat, seafood, vegetables and fruits. Wet markets' primary appeal appears to be a cultural prioritisation of fresh produce. They often supplement supermarket shopping, not dissimilar to Western temporary or outdoors markets, albeit with wet markets having a more significant role in their respective food systems.[32] [33] However, as in the West, this is a cultural and marketing narrative that can respond to the realities of the COVID-19 pandemic. That is, behaviour and culture can change; cultural tradition or established practice is no excuse if it endangers life at a global scale. Many parts of the world have banned unsanitary conditions and practices for the sake of human health without compromising on freshness, quality or cultural uniqueness. However, new standards must be developed for parts of the world with higher biodiversity and therefore a greater range of risks. Transposing westernised standards onto places with very different ecosystems will not work.

Unsurprisingly in a country of 1.2 billion people, there is a broad spectrum of market practices, from respectable to highly dubious. Most wet markets do not sell wildlife or keep live animals on site, but some do. Policy should recognise that there are safe and unsafe practices, and no justification for wet markets to indulge in the latter. Doing so would likely keep public sentiment onside in the relevant countries; a survey of 5,000 people in Hong Kong, Japan, Myanmar, Thailand and Vietnam found that 79% of respondents supported the closure of unregulated wildlife markets to prevent future outbreaks.[34] The closure of all wildlife markets is also likely to drive a black market, which happened after the post-SARS and avian flu outbreaks in 2003 and 2013 respectively.

As outlined above, short-term bans on wildlife markets have been implemented in response to past and current crises. In February 2020, The National People's Congress Standing Committee instated a ban on wildlife breeding and trading for most terrestrial species being used for food, somewhat oddly announcing that it was banning "illegal wildlife trade". This ban should be extended to include non-food uses, since there is nothing to suggest that only food systems increase risks of zoonotic spillovers. Traditional Chinese Medicine, for example, includes farming and over-hunting. The ban does not include TCM products, such as bear bile. Once extended, it should be turned into permanent legislation as part of the Wildlife Protection Law, which is expected later this year.[35]

31. Li et al. (2005), "Bats are natural reservoirs of SARS-like coronaviruses", Science.
32. Zhong et al. (2020), "Constructing freshness: the vitality of wet markets in urban China", *Agriculture and Human Values*.
33. Maruyama et al. (2016), "The modernization of fresh food retailing in China: The role of consumers", *Journal of Retailing and Consumer Services*.
34. GlobeScan and WWF (2020), "Opinion Survey on COVID-19 and Wildlife Trade in 5 Asian Markets", https://c402277.ssl.cf1.rackcdn.com/publications/1327/files/original/GlobeScan_WWF_Coronavirus_Public_Opinion_Survey_Report_20200402.pdf?1585859424.
35. Xinhuanet (2020), "Prohibition of illegal wildlife trading in an all-round way to eliminate the abuse of wild animals-The head of the relevant department of the Legal Work Committee of the NPC Standing Committee answers questions from reporters", http://www.xinhuanet.com/2020-02/24/c_1125620750.htm.

It must then be implemented consistently and enforced properly and the international community should monitor this closely. These measures should apply not only to China, but to a number of regions where wet markets and bush meat are routine, including South East Asia more generally, Africa and South America.

A paper from Hong Kong University in 2007, which warned of the zoonotic pandemic risk, highlighted the combination of factors as a risk, not one or another alone: "The presence of a large reservoir of SARS-CoV-like viruses in horseshoe bats, together with the culture of eating exotic mammals in southern China, is a time bomb."[36] China and other countries must recognise this and implement immediate and long-term strategies to remove the risk.

Enforcement of the ban should go hand-in-hand with support for those who have legally invested in the wildlife trade, to compensate them for stranded assets and re-train them. This will help to dismantle the supply chain, avoiding an expansion of the black market. Whilst China can afford to do this, other countries must be supported by the international community to do so, through direct funding of compensation and training schemes, microfinance and funding for rural infrastructure to make it easier to replace bush meat food chains.

This system will require a long-term funding and institutional arrangement. Given the integrated and complex nature of wildlife trading within the wider, international, legitimate wet market culture, an enforcement approach is likely to be risk-based. Multiple countries with wide-ranging regulatory capacities cannot be expected to act at the same rate and with the same efficacy. Instead, as outlined in a later section, we recommend a mapping, monitoring and inspection regime, together with incentives at local levels to promote more sustainable practices.

This regime should form part of a broader strategy of incentives and sanctions, which we lay out in more detail below.

Cross-border trade in wildlife

Too much focus on provincial wet markets as the culprit in the COVID-19 pandemic also risks overlooking the international trade in wildlife products, which is far more extensive, varied and complex. This adds to the risks of locally sourced bush meat, since it causes greater ecological disruption (e.g. industrial-scale hunting) and it risks exporting pathogens across borders.

An important driver within this trade is the 'traditional medicines' industry. This sells supposed remedies without scientific backing. China's promotion of Traditional Chinese Medicine (TCM) is included as part of its cultural pillar within the 'One Belt, One Road' strategy, also known as the 'Belt and Road Initiative' (BRI). This international push reverses and dwarfs any beneficial effects of the current ban on local-level wildlife markets. The Belt and Road is an amorphous but vast attempt by China to export excess domestic capacity by creating new demand in emerging markets, while at the same time boosting infrastructure capacity to meet

36. Cheng et al (2007), "Severe Acute Respiratory Syndrome Coronavirus as an Agent of Emerging and Reemerging Infection", *Clinical Microbiology Reviews.*

such demand. It is a strategic play by China at the global level. Within this, TCM is marketed and exported at increasing levels – exports of TCM products from China are just under $4 billion per year, but growing rapidly through the BRI strategy. There are widespread concerns surrounding its sustainability, albeit with opportunities to create a far more sustainable industry with Chinese cooperation.[37] Astonishingly, TCM is recognised by the World Health Organisation, which helps to legitimise practices that are, by definition, reliant on tradition rather than science.[38] Such legitimation creates demand for a range of products that can add to wildlife trading without necessarily providing any actual benefits. The international community should redress this by drawing very clear boundaries and insisting that the WHO recognise only peer-reviewed, clinically proven treatments.

TCM and other forms of traditional medicine include a number of wildlife-based 'treatments' and products that come from farmed animals including tigers, pangolins and bears. Farming of many of these animals is used to circumvent bans on the wildlife trade. However, leaving aside additional concerns over animal welfare and the illegitimacy of many of the industry's medicinal claims[39], such farming increases the risk of a black market in wildlife products. It is extremely difficult to distinguish the farmed from the illegally caught and consumer tastes sometimes favour wild species, despite their illegality. There is a lack of transparency and consistency in regulatory regimes, which also suffer from corruption. Therefore the existence of a legal trade simply feeds the illegal market. However, wildlife products form a minority of 'treatments' under TCM, suggesting it should be possible to phase them out. China's ban on the ivory trade, which underwent very similar regulatory oversight to the current wildlife trade, shows that progress can be made.

To address this, international policy must build a more coherent body of knowledge about zoonotic disease emergence and which animals pose the greatest risks. A multilateral convention is needed to establish an institutional, scientific and diplomatic framework that will focus on key areas in this trade, especially:

1. A ban on wildlife trading, except for specific exempted food groups (such as fish);
2. A ban on high-risk species associated with novel zoonotic disease outbreaks based on scientific understanding, whether they are farmed or not;
3. A ban on trade in all endangered species, whether farmed or not.

The question for China and other countries engaged in this trade should be whether their promotion of TCM, with the risks it carries of ecological disruption and zoonotic outbreaks, is worth the international opprobrium and sanctions that will follow. China's TCM industry is valued at around $50 billion in total,[40] with exports valued at around $3.9 billion in 2018,[41] whereas its agricultural exports are worth $64.8 billion per annum.[42] It

37. Hinsley et al (2019), "Building sustainability into the Belt and Road Initiative's Traditional Chinese Medicine trade", *Nature Sustainability*.
38. WHO (2019), "International Statistical Classification of Diseases and Related Health Problems, Vol. 11", https://www.who.int/classifications/icd/en/.
39. Whilst some treatments may prove effective, the binding ethos of TCM is not scientific, peer-reviewed, pharmaceutical efficacy. It is 'tradition'. Claims of cultural or religious significance are one thing, but labelling them as 'medicine' is misleading, at least outside the relevant cultural envelope.
40. Ovais et al (2019), "Traditional Chinese Medicine Going Global Opportunities for Belt and Road Countries", Proceedings of the Pakistan Academy of Sciences
41. Zhihua, Liu (2019), "Exports up, imports down in medical products",

http://www.chinadaily.com.cn/a/201903/19/WS5c90b5e1a3106c65c34ef7d5.html.
42. Brozicki (2020), "Agri-food exports of China", IHS Markit.

would not be unreasonable for international trade policy to consider the two industries to be closely entwined and refuse to accept either, unless TCM and similar tradition-based industries around the world undergo systemic and fundamental reforms.

Agricultural and urban expansion

According to the IPBES, a scientific advisory body to the UN, land use change (LUC) is the leading disruptor of ecosystems around the world. This LUC-related disruption takes many forms such as deforestation and other habitat loss, but the two key drivers are agricultural expansion and urbanisation.[43]

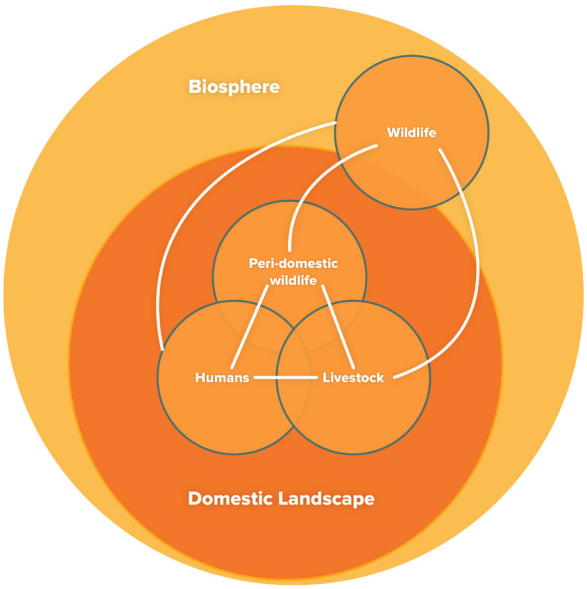
Between 2007 and 2012, 290,000 km^2 of land was cleared for agriculture, which equates to a net increase of 29% compared with 2000-2006, driven by higher demand for agricultural products.[44] Large-scale agriculture such as cattle ranching and monoculture plantations account for an estimated 40% of deforestation globally, and local subsistence agriculture 33%.[45] Further, agricultural land that is classed as 'degraded' is estimated to be 15% to 80%, driving further expansion of new agricultural land to make up for productivity losses, although such figures have a notably high uncertainty.[46]

Urbanisation is also a prevailing challenge. The world's increasingly urban population does not necessarily harm ecosystems, as it signifies a shift from rural areas to a more concentrated human population. However, suburban sprawl can and does encroach on wildlife. Resisting such pressure is the main reason for peri-urban green belts becoming common around the world during the 20th century. Between 2005 and 2015, the total extent of urban areas globally grew by 19% from 49.1 million Ha to 58.5 million Ha.[47] Urbanisation does not always encroach on natural habitats, of course. Loss of agricultural land is also a known problem, as it can cause indirect pressure for agricultural expansion elsewhere, a process known as indirect land-use change. Another indirect pressure it creates via lost agriculture is the need to source food from wild habitats, meaning the hunting of wildlife for economic use. This creates some of the supply seen in wildlife markets. To control the impact of urbanisation, environmental protections (such as national parks, green belts and nature reserves) are needed and should be integrated into planning systems.

Where expansionism encroaches on ecosystems, there is an increased risk of livestock and wildlife mixing, leading to disease spillover between domestic and wild species, as conceptually illustrated in Fig. 3 below. For example, the increasing ranching of cattle amongst fragmented forests has led to vampire bats switching from 'natural' prey to livestock, increasing the chances of rabies spill over in which livestock can act as an intermediary species. This has led to outbreaks of rabies in South American populations despite the availability of vaccines.[48] Other examples where this encroachment has likely led to spillover include Brucellosis, Rift Valley Fever and Q Fever.

43. IPBES (2019), "IPBES global assessment report summary for policymakers", https://ipbes.net/sites/default/files/2020-02/ipbes_global_assessment_report_summary_for_policymakers_en.pdf.
44. IPBES (2019), "Global assessment report on Biodiversity and Ecosystem Services: Chapter 3", P33.
45. Hosonuma et al (2012), "An assessment of deforestation and forest degradation drivers in developing countries", Environmental Research Letters, 7(4): 44009; FAO (2016), "State of the World's Forests. Forests and agriculture: land-use challenges and opportunities", http://www.fao.org/publications/sofo/2016/en/.
46. Gomiero, (2016), "Soil Degradation, Land Scarcity and Food Security: Reviewing a Complex Challenge", Sustainability.
47. Ritchie and Roser (2019), "Land use: How has global land-use changed over the long term?", https://ourworldindata.org/land-use.
48. Streicher and Allgeier (2016), "Foraging choices of vampire bats in diverse landscapes: potential implications for land-use change and disease transmission", *Journal of Applied Ecology*; Stoner-Duncan, Streicker and Tedeschi (2014), "Vampire bats and rabies: toward an ecological solution to a public health problem", *PLoS Negl. Trop. Dis.*

Figure 3: Pathogen flows between wildlife, livestock and humans[49]



Agricultural expansion and urbanisation also increase the 'surface area' of natural habitats through fragmentation, i.e. the extent of the interface between the human world and the wilderness. Fragmentation can lead to a proliferation of smaller bodied species as larger fauna are driven away.[50] This means parasitic vectors, such as ticks, blackflies and midges, come into increasing contact with livestock and agricultural communities.[51] Vector-borne diseases account for around 700,000 deaths annually, equating to over 17% of infectious diseases.[52] The most harmful vector of this type throughout human history has been the mosquito, which has spread a range of zoonotic pathogens including malaria, dengue fever, chikungunya, Zika virus, yellow fever and West Nile virus. Some species of mosquito tend to stick to the edge of habitats, not venturing more than 10m from the edge of certain habitats.[53] Where this edge is increased through habitat fragmentation, the mosquito's preferred habitat increases. For this and other reasons (particularly climate change, outlined below), all three mosquito genera have expanded their geographic ranges, in turn expanding where the zoonotic diseases they carry are found.[54]

Addressing agricultural expansionism

There is a very large range of potential policy responses to ecological decline. However, in the case of preventing zoonotic pathogen spillover, we can identify some key approaches.

First, an international risk-based monitoring system should be in place to inform procurement and trade policies. Consumers and policymakers in importing countries should be aware of the risks created by their purchasing power. This should help to improve supply chains through regulatory and reputational pressures. It should also require suppliers to take action where deforestation is detected in the supply chain.

The UK's Global Resource Initiative Taskforce (a government advisory

49. Jones, B. et al (2012), "Zoonosis emergence linked to agricultural intensification and environmental change", *PNAS*.
50. White et al (2018), "Disease outbreak thresholds emerge from interactions between movement behavior, landscape structure, and epidemiology", *PNAS*.
51. Bartlow, A. et al (2019), "Forecasting zoonotic infectious disease response to climate change: Mosquito vectors and a changing climate", *Vet Sci*.
52. WHO (2014), "A global brief on vector-borne diseases", https://apps.who.int/iris/bitstream/handle/10665/111008/WHO_DCO_WHD_2014.1_eng.pdf;jsessionid=C3CBCB4046B7F55FF267AAC3DFF11C38?sequence=1.
53. Reiskind et al (2016), "Mosquitos of field and forest: the scale of habitat segregation in a diverse mosquito assemblage", *Med Vet Entomol*.
54. Leta et al (2018), "Global risk mapping for major diseases transmitted by Aedes aegypti and Aedes albopictus", *Int. J. Infect. Dis.*; For detailed discussion, see Bartlowet al (2019), "Forecasting zoonotic infectious disease response to climate change: Mosquito vectors and a changing climate", *Vet Sci*.

group) has identified seven key commodities whose supply chains have notably high impacts on ecosystems: beef and leather, cocoa, soya, palm oil, pulp and paper, rubber, soya and timber. As a large economy and a net consumer, the UK's responsibilities regarding these commodities tend to lie beyond its borders, in supply chains that are increasingly long and complicated. The Taskforce called for a Strategic Sustainable Commodity Action Plan and for the UK to convene a global call for action during COP26.[55] Such an approach has renewed urgency in the context of zoonotic pandemics.

Regulation should be applied not only to imports, but also to the City of London, which is a global centre of commodities trading. Regulation should ensure that investors and traders are not enabling activities that raise zoonotic disease risks through high-risk ecological disruption. This would be neither unprecedented nor impractical. Many natural resource commodity supply chains are or can be highly regulated or certificated, from fuels to paper. Governance-level regulation can also be applied to ecological risks in the financial sector, mirroring the Prudential Regulation Authority's Senior Managers Regime regarding climate change. This requires banks and insurers to assign named managers who will address climate change risks. The PRA also expects boards to address and oversee risks, assign adequate expertise and report on their actions in this area.[56] A similar regime can and should be applied to ecological risks in the financial sector.

Importantly, sustainable management of resources is distinct from simplistic bans on resource use. It would be morally unjust and diplomatically counterproductive to insist that developing countries end all access to their natural capital. Indeed, sustainable and profitable use of natural resources is a highly effective long-term and decentralised protection against depletion. Forest owners are less likely to sell their land for conversion if they can harvest timber and other wood products as a profitable, long-term revenue stream. Where resource managers, such as foresters and fishing communities, recognise the economic value of stewardship, it leads to equilibrium. This also creates sanitary norms in terms of zoonotic disease, which improve the manageability of spillover risk as well as post-spillover monitoring in higher-risk areas. One virologist said: "It's not about keeping forest pristine and free of people. It's learning how to do things sustainably. If you can get a handle on what it is that drives the emergence of a disease, then you can learn to modify environments sustainably."[57]

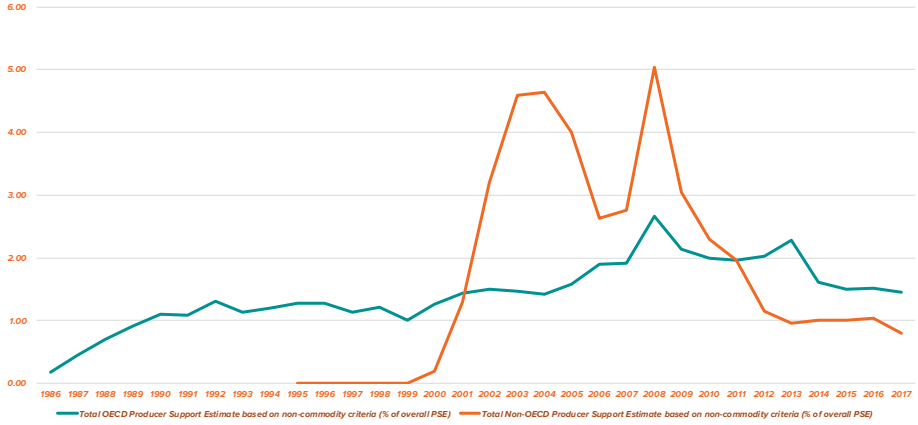
Second, there should be greater research into the roles of agricultural subsidy systems in ecological degradation. Where subsidies are based on production or area-based payments, farmers can effectively be incentivised to expand their working land rather than seek other ways to improve income. This unintended consequence can be remedied by subsidies that focus on productivity improvements, as well as environmental outcomes. More productive and sensitive use of a smaller amount of land is possible through precision-application of fertiliser and crop protection, data,

55. Global Resource Initiative Taskforce (2020), "Final recommendations report 2020", https://www.gov.uk/government/publications/global-resource-initiative-taskforce.
56. Bank of England/Prudential Regulation Authority (2019), "Policy Statement 11/19: Enhancing banks' and insurers' approaches to managing the financial risks from climate change".
57. Robbins (2012), "The Ecology of Disease", https://www.nytimes.com/2012/07/15/sunday-review/the-ecology-of-disease.html.

agritech automation and genetically modified crops. Rhetoric against 'intensive' agriculture is often misplaced in arable farming; it is extensive, expansionist farming that arguably causes more damage. Intensive arable farming can be combined with ecologically protected zones, which create a barrier between human-driven land-use change and wildlife. That is less the case for livestock rearing, where intensive methods often do pose greater risks of zoonotic diseases.

The UK has chosen to move away from the area-based payments of the EU's Common Agricultural Policy and towards an Environmental Land Management System (ELMS), with the principle of 'public money for public goods' at its heart, alongside measures to incentivise productivity. This approach was proposed in a 2018 paper by Policy Exchange as a way to improve agricultural outcomes for consumers, farmers and the environment.[58] The UK is currently in the process of passing its Agriculture Bill to implement the new system over the coming years. However, available data from the OECD suggest that this type of non-commodity-based system is actually in decline (Figure 4), though the data are somewhat opaque. In promoting its own approach, the UK should conduct research on the prevalence of such systems around the world and form an alliance of countries with similar regimes to promote environmental land management. Such an alliance would help agricultural systems around the world to move into greater harmony with ecosystems and lower the risks of zoonotic pathogen spillover. It could also champion the reduction of production-based agricultural subsidies at the WTO in the name of greater free trade.

Figure 4. Total support for agricultural producers for non-commodity reasons as a % of total agricultural producer support grouped as OECD and non-OECD countries, 1986 – 2017.[59]



In addition to more sustainable subsidies, the UK should pursue greater monitoring of agricultural practices and impacts. Policy Exchange has previously argued for the UK to use its leadership in satellite technologies for earth observation, ideally through its own version of the EU's Copernicus satellite system.[60] This can be expanded to other high-tech methods. A UK-based company, Nature Metrics, uses DNA found in water

58. Lightfoot et al. (2018), "Farming Tomorrow", *Policy Exchange*.
59. OECD (2020), "Agricultural support", https://data.oecd.org/agrpolicy/agricultural-support.htm.
60. Elefteriu (2019), "What do we want from the next Prime Minister?", *Policy Exchange*.

samples (environmental DNA, or eDNA), which can identify different species present in an ecosystem by its genetic footprint. This can already be used for bacteria and could be mobilised to monitor known pathogens in at-risk regions. The company is already building a network of laboratory partnerships to enable localised testing, though its sample collection can be performed by non-experts, making it highly distributable. Such capacities should be built into a global system, with significant advantages to the UK's leadership in this sector and a verifiable return on investment from its overseas development aid (ODA) funding.

The UK's spending on ODA is world-leading, meeting its legally-binding target of 0.7% of GDP. This places the UK amongst the most important ODA players in the world, alongside the US Government and organisations such as the Bill and Melinda Gates Foundation. The UK's spending on international aid to support livestock, biodiversity and monitoring was over £230 million in 2018-19.[61] This accounts for just 0.8% of DfID's overseas development aid spending. This should not only be increased in light of the obvious impact of ecological disruption, but could also be increasingly targeted with a more structured approach to preventing zoonotic disease outbreaks. Such an approach would not only target the pandemic risks to the UK, but also wider socioeconomic risks in less economically developed nations. The UK should also push allies, particularly in the EU, to match this level of funding as a minimum.

Factory farming

Large-scale farm systems often act as incubators of novel diseases. They often house thousands or millions of genetically similar individuals in close proximity, not unlike the bat colonies that harbour coronaviruses in South China. However, such farms are in contact with humans on a far more frequent and more intimate basis.

The Influenza Risk Assessment Tool (IRAT) was developed by the Centers for Disease Control and Prevention (CDC) to monitor novel flu viruses of special concern due to their potential for causing a pandemic. Of the 16 strains monitored, eight were found in commercial flocks and several more in wild or domestic birds. One is a swine flu. Notably, these are not limited to emerging economies – they are found in farms around the world, including America (though detection bias is likely significant here, given that the USA's CDC clearly has better access to American farms).[62] Indeed, high-income countries accounted for the majority of 39 avian flu spillovers recorded since 1959 in one study, and the majority of these spillovers came from commercial poultry farms. However, the 127 genetic reassortments and mutations (which lead to novel viruses emerging) in those cases predominantly occurred in countries that were in transition from 'backyard'-style poultry systems to intensive ones.[63] That is, as more of the world's economies intensify their meat production, there is a growing risk that animal viruses will mutate.

Any policies to address this should not amount simply to greater use of veterinary drugs. Farming has had a close relationship with antimicrobial

61. This figure uses an OECD methodology to estimate government-wide (i.e. not limited to DfID) spending on international development aid for the purpose of ecological sustainability, including agricultural support.
62. Centers for Disease Control and Prevention (2019), "Summary of Influenza Risk Assessment Tool (IRAT) Results", https://www.cdc.gov/flu/pandemic-resources/monitoring/irat-virus-summaries.htm.
63. Dhingra et al (2018), "Geographical and Historical Patterns in the Emergences of Novel Highly Pathogenic Avian Influenza (HPAI) H5 and H7 Viruses in Poultry", *Veterinary Epidemiology and Economics.*

resistance, also known as antibiotic resistance, which is at least as serious a threat to global health as the COVID-19 pandemic. Overuse of antibiotics (including to promote growth rather than combat disease), coupled with high-stress conditions that suppress animal immune systems, is a significant risk multiplier. It chronically undermines the first and second lines of defence in zoonotic disease emergence – animal immunity and effective antibiotics.

Acting on industrial farming is not straightforward. Larger and increasingly richer populations around the world are raising demand for cheap animal protein. Global food supply will need to nearly double in the next thirty years.[64] In almost all cultures, meat is seen as synonymous with celebration and ceremony. However, a number of measures are possible:

- **Lower demand for meat and increase access to alternatives**
  A key recommendation of the Intergovernmental Panel on Climate Change is for meat consumption to fall as a portion of global diets, saving up to 8 gigatonnes of CO_2 equivalent by 2050.[65] Such a reduction would also reduce the demand for meat at industrial scales as well as land use change. However, it need not lead to hunger nor denying meat's cultural importance. Indeed, industrial meat is arguably undermining global food supply by consuming more calories in grain than it creates in meat.[66] This is not an argument against meat and animal products, but for high-quality and sustainably, safely produced agrifoods.

  In vitro (lab-grown) meat is already possible, albeit prohibitively expensive. Like many emerging technologies, its development should be supported by governments as a potential way to deliver far more high-quality meat efficiently and at scale. Similarly, plant-based meat alternatives that are almost indistinguishable from meat are entering the mass market. Companies such as Beyond Meat and Vivera are creating viable alternatives which remove the zoonotic disease risk. These alternatives support, rather than reduce, consumer freedom.

- **Livestock rotation and division**
  As pathogens spread and mutate in large, crowded populations of genetically similar individuals, these conditions should be regulated out. Safer systems can use rotation of living areas between species to minimise diseases spreading via contaminated environments (e.g. through dung left on the floor of a living space). Similarly, smaller numbers of animals kept in separate groups without crossovers during transit processes creates barriers to transmission. Keeping animals on pastureland rather than sheds during the day lowers transmission risks and improves animal immunity, raising two barriers to pathogen spread and/or mutation. There may also be an argument for restricting transport of live animals.

64. Lymbery and Oakeshott (2012), "Farmaged-don", *Bloomsbury Publishing*.
65. Intergovernmental Panel on Climate Change (2020), "Climate change and land: An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems Summary for Policymakers", https://www.ipcc.ch/site/assets/uploads/sites/4/2020/02/SPM_Updated-Jan20.pdf, 23.
66. UN FAO (2011), "World Livestock 2011: Livestock in Food Security", *FAO*.

All such standards should undergo review with a focus on zoonotic diseases and the UK should examine its supply chain regulations to ensure unsafe industrial farming is not part of its supply chain. Such health-based principles should be maintained as 'red lines' throughout any future trade talks.

- **Better veterinary capacity**
  An assessment of the first funding phase of the USA's Emerging Pandemic Threats programme revealed an unexpectedly high level of demand for veterinarians. The developed world should invest in greater capacity building, training and exchange with developing economies to enable this. Developing economies, whose agricultural sectors are in transition from 'backyard' to more commercialised systems, should be a key focus. However, more advanced economies must also play a part in addressing disease risks. Veterinary inspections should be part of the international inspection regime we outline later in this paper.

All of these measures bring cost implications for food. The poorest parts of the world will be most sensitive to this, where transitions to more commercial farming help to deliver economies of scale and therefore cheaper food. Policy and trade measures must therefore be taken carefully to avoid unfairly disadvantaging such groups. Trade agreements with poorer nations, for example, could include agreements for veterinary capacity-building to support high standards (which would also have a multiplier effect by helping the trading partner to meet requisite standards for export to other nations too).

Current policy frameworks

The international approach

The international community employs a number of initiatives for promoting health security (Table 1). A tripartite arrangement exists between the World Health Organisation (WHO), the UN's Food and Agriculture Organisation (FAO) and the World Organisation for Animal Health (known by its French former acronym, OIE). The tripartite organisations create the clearest focus for combatting zoonotic diseases. The WHO also runs a programme known as 'One Health', which promotes a united approach to human, animal and environmental health.

Table 1: International systems for zoonotic disease control (Policy Exchange analysis)

Core theme	Name	Details
Health	Global Health Security Agenda	- Framework for rapid detection and response to infectious disease threats - Countries make commitments to implement IHR regulations
	International Health Regulations (IHR) 2005	- International legal instrument to manage the response to outbreaks of global diseases while avoiding disruptions to international trade and traffic
Health / zoonotic disease threats	International agreements on anti-microbial resistance	- Series of international agreements and actions targeting the misuse of anti-biotics in humans and animals that encourages anti-microbial resistance - E.g. WHO Global Action Plan on AMR
	WHO-OIE-FAO Tripartite Collaboration	- Agreement to work collaboratively to reduce threats at the animal-human-environment interface

Trade *Conservation of nature*	Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	- Treaty to ensure trade in endangered animals and plants does not endanger their survival - Protects 35,000 species in some way
	Convention on Biological Diversity	- Framework for international conservation goals and cooperation - Specifically, the Cartagena Protocol on Biosafety deals with the safe handling, transport and use of Living Modified Organisms

Whilst these programmes have laudable aims, Policy Exchange's conversations with specialists in the field of zoonotic disease have identified a number of failings. In particular:

- **Emphasis on managing outbreaks rather than preventing them**
  As outlined in earlier sections of this paper, there is a range of human activity that raises the risks of zoonotic disease spillovers, including but not limited to:
  - Hunting and selling of wildlife in markets;
  - Keeping livestock in unsanitary conditions close to food preparation;
  - Co-location of multiple species in unnatural, captive conditions for sale;
  - Broader trading in wildlife or endangered species (even when farmed);
  - Indiscriminate land use change in high-risk regions;
  - Indiscriminate use of antibiotics in agriculture.

  Despite this list being relatively well understood, there is more emphasis on cure than prevention. That is, international systems wait for outbreaks to occur before treating them as health hazards. Most systems are designed and managed by human health specialists, not ecologists or veterinarians. Such an anthropocentric approach needs updating. Some approaches, such as the WHO's One Health, are correct but too weak. The international community must place much greater focus on addressing the pre-spillover conditions that increase the risks.
- **Lack of a single treaty, institution or forum for focusing world resources on zoonotic disease risks**
  Zoonotic disease covers a number of areas, especially health, ecology, veterinary sciences and agriculture. As such, it tends to fall between the respective agencies covering these issues. At both a national and international level, there tends to be a disparate spread of organisations with some reference to the issue, but no single legislative or institutional focus. According to the Global Health Security Index, "fewer than 8% of countries demonstrate a

cross-ministerial department, agency, or similar unit dedicated to zoonotic disease."[67] This leads to the issue 'falling into the cracks' between respective organisations. A new institutional framework is needed to address this lack of focus.

- **Under-reporting, absence of reporting and misreporting of zoonotic outbreaks**
  During the course of our research, we found several cases of seemingly inaccurate reporting of zoonotic outbreaks. Under the World Trade Organisation's (WTO) Sanitary and Phytosanitary Agreement, member nations must report zoonotic outbreaks that may affect trade to the World Organisation for Animal Health (known as OIE). The OIE published these data in what is the most comprehensive database available (albeit still inadequate). However, 62% of countries had not submitted a report to the OIE last year. The database shows suspiciously few reported outbreaks in India, where under-reporting appears to be a problem due to a weaker healthcare system in rural areas. Many countries, on the other hand, seem to have misreported by massively overstating the number of outbreaks, seemingly reporting each case (i.e. each individual infected) rather than discrete outbreak events, which makes it extremely difficult to make sense of the data. Reporting requirements and standards must be improved.
- **Lack of a central database for mapping risk areas**
  When discussing the risks of potential zoonotic disease outbreaks, there are conditions that should be tracked, but this is a more complicated challenge than mapping past or current outbreaks. Instead, it must create a map of areas where ecological factors, agricultural systems and food supply chains, human economics, climatic conditions and trends, cultural factors, health systems and past outbreaks combine to create higher risks. Whilst individual institutions and researchers have attempted this, a more comprehensive methodology on which policy decisions can be made requires complex modelling as well as concerted scientific and political efforts. Such co-ordination does not currently exist and it was a point of frustration expressed by several academics in this field during our research. There is an obvious role for open data here, with a requirement that researchers who collect disease data should submit it to an open platform for public access.
- **Over-reliance on untrustworthy, impermanent and/or ineffective national regimes and inability of global mechanisms to monitor and inspect**
  After previous outbreaks, countries have taken measures to address identified causes. For example, China banned wildlife markets after the 2003-4 outbreak, only to re-open them a short time later with little identifiable change in practices around wildlife trading and sanitary conditions at the markets. Closure of wildlife markets without a proper regulatory regime to police high-risk activities is

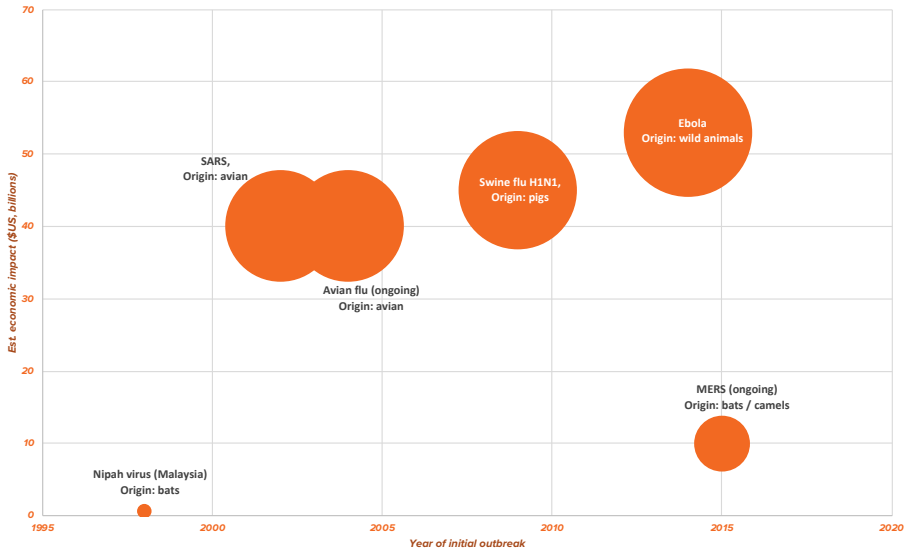
67. Global Health Security Index (2019), "GHS Index: Building collective action and accountability", https://www.ghsindex.org/wp-content/uploads/2019/10/2019-Global-Health-Security-Index.pdf.

only likely to increase risk, since closing legal markets can support black markets. China did implement a medical reporting system in 2004 after SARS, which helped to limit avian flu but which failed in 2019, apparently due to political interference. Early reports by Chinese journalists and medics were suppressed by state censors. The WHO's early response depended almost entirely on Chinese state systems, with highly questionable results. For example, the WHO repeated claims from China that there was no evidence of human-to-human infection some weeks after the initial outbreak. This claim was based on reporting rules that biased against finding human-to-human infections as it only focused on the Huanan Seafood Market.[68] This total dependence on untrustworthy national systems, without recourse to independent mechanisms, is deeply problematic. It also highlights the importance of multifarious information networks as a way to circumvent criminal, corrupt or politicised reporting. Journalists, scientists and NGOs must have the freedom to identify problems and report them publicly. This counts not just for post-spillover outbreaks, but also pre-spillover practices which are supposed to be illegal.

- **Lack of sanctions**

  None of the measures described above have direct sanctions that can be applied via trade or other means to force adherence. Human costs in terms of deaths now number in the hundreds of thousands in just the past 20 years. Figure 5 shows only a handful of high-profile events, with the total cost for this selection estimated at $167-177 billion. The cost for the COVID-19 pandemic (not included in the graph) is already in the trillions of dollars. There is a strong rationale to place such risks within trade and other frameworks in order to 'price in' their costs.

Figure 5: Global estimated economic impact of selected pandemics with zoonotic origins (multiple sources).[69]



68. Stephen Lee Myesr (17 April 2020), "China Created a Fail-Safe System to Track Contagions. It Failed." New York Times.
69. Lee, J-W. and McKibben, W. (2004), "Estimating the global economic costs of SARS" in Knobler S. et al, "Learning from SARS: preparing for the next disease outbreak: workshop summary", *Institute of Medicine (US) Forum on Microbial Threats*; Fan V. et al (2015), (2015), "The Inclusive Cost of Pandemic Influenza Risk", *NBER Working Paper Ser*; Huber, C. et al (2018), "The Economic and Social Burden of the 2014 Ebola Outbreak in West Africa", *Journal of Infectious Diseases*; International Working Group on Financing Preparedness (2017), "From panic and neglect to investing in health security: financing pandemic preparedness at a national level", http://documents.worldbank.org/curated/ en/979591495652724770/From-panic-and-neglect-to-investing-in-health-security-financing-pandemic-preparedness-at-anational-level; World Bank (2012), "People, pathogens, and our planet: Volume 2: The economics of One Health", https://openknowledge.worldbank.org/bitstream/handle/10986/11892/691450ESW0whit-0D0ESW120PPPvol120web.pdf?sequence=1&isAllowed=y, Annex 2, 39; World Economic Forum (2020), "A visual history of pandemics", https://www.weforum.org/agenda/2020/03/a-visual-history-of-pandemics.

Convention on Biological Diversity

One framework convention is worthy of mention in this context: The Convention on Biological Diversity (CBD). The CBD considers a very wide range of issues affecting biodiversity, but does not mention zoonotic diseases. As discussed above, there is some scientific disagreement regarding biodiversity and its effects on zoonotic pathogens, but there are considerable overlaps between the two issues. Perhaps more importantly, there is also a diplomatic angle to the CBD.

China was due to host the 15th Conference of the Parties (COP) to the CBD in Kunming in late 2020. This has now been postponed due to the pandemic, but will likely go ahead in 2021. The conference presents an opportunity and a challenge for addressing the various issues relating to zoonotic diseases. China has set the theme for the conference as "Ecological Civilisation: Building a Share Future for All Life on Earth."

The UN's 2030 Action Targets includes a list of 20 'Post-2020 Biodiversity Action Targets'. Two action targets (5 and 7) aims for the "sustainable" and "legal" use of wild species. This is understandable since fisheries and many other sustainable food systems rely on hunting of wild animals. Yet it is too vague, avoiding mention of endangered species. This allows countries to farm endangered species (e.g. pangolin or tigers), which enables the proliferation of a black market in such animals, mostly in the name of traditional medicine. Target 17 mentions "national cultural conditions"[70], which could too easily be used as a defence for TCM and other traditions. These traditions can be made sustainable, but they will require clear and forceful efforts to make them so.

There is no doubt that COVID-19 will be a major talking point for the CBD COP. However, it should not be allowed to take over the conference entirely, which would prevent good work on ecological disruption from being achieved. Instead, we recommend a strategy for the UK to follow:

1. Ensure zoonotic disease is featured on the conference's official agenda;
2. Push for amendments to the UN's post-2020 Biodiversity Action Plan to explicitly preclude the use of products from endangered species, farmed or not;
3. Call for a separate international conference, to be held in 2021, that will establish a treaty and framework for the prevention and control of zoonotic diseases in the future. The UK's presidency of both COP26 and the G7 gives it an excellent opportunity to lead this agenda.

70. The target's full text is: "People everywhere take measurable steps towards sustainable consumption and lifestyles, taking into account individual and national cultural and socioeconomic conditions, achieving by 2030 just and sustainable consumption levels"

Box 2: The USAid Emerging Pandemic Threat Programme (EPT): A model for the new international system

The US Aid Emerging Pandemic Threat Programme (EPT) is a US government programme designed to build capacity for preventing pandemics around the world. It has four pillars:

- Predict: Aims to detect zoonotic diseases that may pose a threat to humans, focusing on surveillance and monitoring of wildlife and people in contact with wildlife, identifying the types of behaviours and ecological drivers that can increase spillover risks and building information systems for modeling risk.
- Prevent: Identifies the ways in which higher human-wildlife interaction raises spillover risks and develops strategies and tools to prevent spillovers occurring.
- Identify: This pillar focuses on building laboratory capacities to diagnose and report animal and human pathogens.
- Respond: Builds capacity to respond to pathogen outbreaks when they occur, involving contingency planning and growing the capacity of local healthcare systems.

There are several aspects to note in the EPT approach:

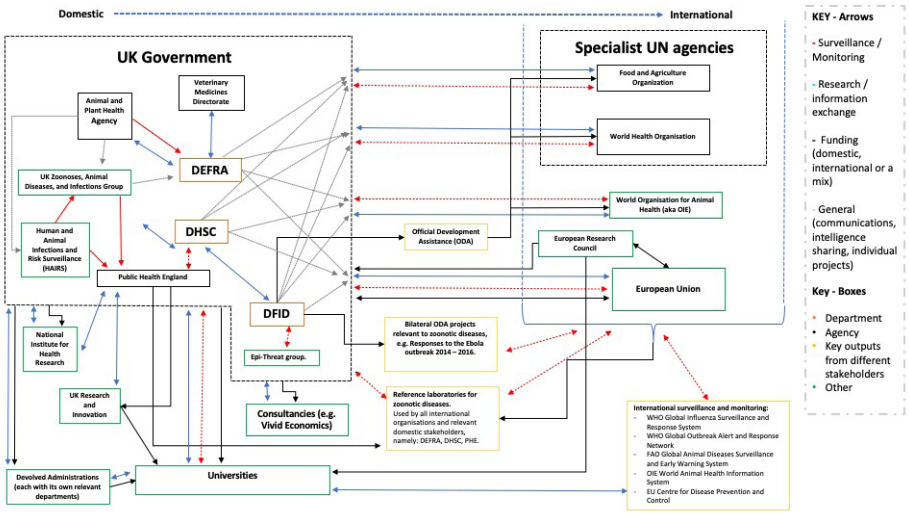
1. A clear structure. The international system is opaque and reliant on the WHO-OIE-FAO tripartite collaboration. This permits too much to fall into the gaps, whereas the EPT approach has a clear strategy for each phase in the outbreak chain.
2. A significant focus on early-stage, pre-spillover conditions. As noted above, most international systems dealing with zoonotic spillover risk are focused on post-spillover containment, not on spillover prevention. The EPT programme does not make this mistake.
3. Focus on capacity building. Each pillar is led by a specific group of US universities, companies and NGOs, but with the aim of creating local and regional capacities around the world. For example, an evaluation of the EPT's first funding phase noted that demand for veterinary capacity building was much higher than expected and recommended a greater emphasis in its second phase. The same evaluation also calls for regional networks to be able to operate independently. A renewed international system should seek to have a similar commitment to capacity building, with a continuing interaction once that capacity is developed (e.g. through open data and clear reporting standards).
4. A clear emphasis on data and reporting. As noted above, data exchange is poor in the international system and must be improved dramatically.

The EPT approach is not flawless (its evaluation process identifies areas to improve upon). We would also recommend that an international version run parallel with an inspection regime that carries trade-related sanctions for non-cooperation. However, the EPT programme does provide a world-leading model on which the world could base its future strategy.

The UK's approach

The UK's approach appears to be based on a philosophy of supporting international organisations and a diverse network of research and capacity-building partnerships. However, this lacks strategy and co-ordination. The UK has no central co-ordinating body on zoonotic outbreak risks, and it spreads responsibility for the issue across at least three Whitehall departments and multiple agencies. Figure 6 shows a high-level map of these responsibilities and their interactions with international bodies. The map may appear either overly complex or admirably comprehensive, depending on your point of view. However, it still suffers from the same problem described above, in that no individual minister or body holds a clear responsibility for the issue.

Figure 6: UK systems for limiting zoonotic disease risk and responding to outbreaks (Policy Exchange analysis).



Domestically, the UK does well on overall disease control and the Global Health Security Index places it second for its systemic preparedness. It ranks 19 out of 185 countries in terms of zoonotic diseases specifically.[71] The UK Government has a strategy for biological security, published in 2018. The strategy is based on four pillars: *Understand*, *protect*, *respond*, and *detect*. This offers a good framework through which to approach biosecurity issues, but the strategy focuses on the security aspects of biological threats from deliberate human actors (such as biological weapons and harmful substances that could be maliciously used), as opposed to the ecological drivers of biosecurity threats. This is an oversight, since security threats do not only originate with intentional actors. The Security Minister is responsible for delivering the *Biological Security Strategy* 2018, with the role of other departments like DEFRA and DFID only being incorporated on the governance board for the strategy.[72]

Cross-departmental funding for zoonotic disease prevention via support for ecological protections and sustainable agriculture (inter alia) is around

71. GHS Index (2020), "2019 GHS Index Country Profile for United Kingdom", https://www.ghsindex.org/country/united-kingdom/.
72. HM Government (2018), "Biological Security Strategy 2018", https://www.gov.uk/government/publications/biological-security-strategy.

£230 million per year, which is equivalent to just 0.8% of the DfID ODA budget.

There are several opportunities for the UK to improve its approach to this issue:

- Appoint a single Minister, preferably sitting across DEFRA and the FCO, to co-ordinate prevention and early-spillover control of zoonotic diseases;
- Create a single body, most likely within DEFRA or the FCO, to co-ordinate UK action on this issue;
- Commit a greater portion of overseas development aid to sustainable and more productive agriculture, sanitary animal husbandry, CITES enforcement,[73] research into zoonotic disease outbreak risks and surveillance of high- and medium-risk regions;
- Commit military and intelligence resources to this issue where appropriate.

73. Convention on International Trade in Endangered Species; CITES (2020), "What is CITES?", https://www.cites.org/eng/disc/what.php.

Policy Recommendations

An anti-proliferation approach

Zoonotic disease emergence and re-emergence is a growing threat to human health and economies. It should be treated with the same severity as other threats to global security, such as terrorism or weapons of mass destruction.

In other such security areas, international systems have been developed for the prohibition of dangerous practices, including close monitoring of early-stage risks such as uranium enrichment. Prohibition, mapping and monitoring of high-risk practices and regions are in place, supported by international inspection regimes.

The regimes governing anti-proliferation of weapons of mass destruction (WMDs) provide a model for risk-based governance. For nuclear risks, the IAEA, reporting to the UN General Assembly, has the ability to perform *ad hoc* inspections based on its assessments of risk. These are based on a range of criteria, but use accounting of nuclear processes and tamper-proof cameras to monitor activities *in situ*. It recognises that nuclear power generation is a legitimate civilian activity, but that there are ways in which this can spill over into higher risk categories. Under the Biological Weapons Convention 1975 and the Chemical Weapons Convention 1997, there are bans on stockpiling and usage of certain weapons. Refusal by countries to allow inspections under the terms of the respective treaties attracts suspicion and opprobrium on the world stage.

The same should be applied to the risks of zoonotic disease emergence. There are identifiable, high-risk activities and policies that must be phased out. Where they cannot be phased out, they should be monitored and inspected. Contravention should attract attention and penalties, such as trade sanctions. Governments must be forced to choose between valuable trading relationships and risky domestic practices.

An important reason for an international inspection regime is that it helps to circumvent local, regional and national reporting mechanisms. The actions of Chinese officials in Wuhan during the earliest stages of the COVID-19 outbreak were disturbing. A doctor who attempted to draw attention to the possibility of a SARS-like pneumonia outbreak was temporarily locked up for doing so and others were admonished for causing 'social panic', whilst Chinese authorities censored the social media hashtag #WuhanSARS. It took over two weeks for the Wuhan Health Commission to publish details of the outbreak on its website and inform the WHO, during which time an epidemic could have been averted through greater

transparency.[74] Even once the outbreak had become a global pandemic, case-reporting rules in China are reported to have incentivised officials to report zero new cases.[75]

A pre-spillover, risk-based, international inspection regime would help the international community to keep a closer eye on risky behaviours rather than relying on national systems that have been shown to disincentivise honest and open reporting. It would also apply external pressure, as mentioned above: when a country denies access to IAEA inspectors, for example, it draws attention and raises more questions.

On the flipside, countries with genuine willingness to act but with limited resources should be enabled through aid funding, easily accessible finance and shared scientific resources from laboratories and satellites to agricultural and veterinary expertise.[76] Rich nations should take financial responsibility for the fact that globalisation is a two-way street and their lengthening supply chains come with obligations to support poorer trading partners.

The current international framework contains important gaps, such as a central repository for zoonotic outbreak data, sufficient funding for reference laboratories in high-risk areas (both permanent and field) and a coherent map of such risk regions. Better understanding of spillover mechanisms is also needed, such as how biodiversity affects pathogens.

Two good models for thinking about a new international regime are the USA's Emerging Pandemic Threats (EPT) programme and the IAEA inspection regime.

EPT is a well-structured programme with clear strands focusing on prediction, prevention and preparedness (among others). Scientific research, local capacity building and better understanding of how human behaviour affects outbreak risk all feature highly in the programme. A global version of the programme would be a significant improvement on current systems.

On the monitoring and enforcement side, a multilateral framework convention should establish the institutions needed to minimise risk. Like the WMD control regimes, signatories would be required to enforce ecological and other standards relating to risk management in zoonotic disease. They would also submit to inspections where the inspectorate identifies elevated risks (e.g. forestry). Finally, signatories would commit to trading standards that effectively allow trade sanctions against countries where high-risk activities take place, banning imports related to such activities, such as timber linked to deforestation, palm oil linked to habitat loss or agri-foods from countries which trade in endangered species.

74. WHO (2020), "Pneumonia of unknown cause – China", https://www.who.int/csr/don/05-january-2020-pneumonia-of-unkown-cause-china/en/.
75. Kynge et al (2020), "Coronavirus: the cost of China's public health cover-up", https://www.ft.com/content/fa83463a-4737-11ea-aeb3-955839e06441/.
76. An assessment of the USA's Emerging Pandemic Threats programme found that vet training was in higher demand than expected where the programme was in operation, suggesting a key role for local capacity building.

A zoonotic anti-proliferation action plan

The UK government should:

1. Appoint a single Minister, ideally sitting across FCO and DEFRA, to co-ordinate the UK's activities around zoonotic disease risks. The Minister should sit on appropriate committees and advisory bodies that relate to biosecurity.
2. Scale up the Animal and Plant Health Agency (APHA) to co-ordinate UK activities on zoonotic disease risks. APHA should work with research labs, the FCO, intelligence and military personnel and the private sector to support international monitoring of zoonotic disease risks. Its analyses should be integrated into threat monitoring under the UK's Biosecurity Strategy, with appropriate responses by public health authorities when risks rise.
3. Create a fund, administered by APHA, to support UK universities and companies in research to develop a better understanding of this area of risk and methods for reducing it.
4. Implement the Global Resource Initiative Taskforce's recommendation for a Sustainable Commodities Strategy. This should include commodities traded in the City of London, even where physical goods do not come to, or originate in, the UK. The Bank of England's PRA should develop regulations to this effect under the Senior Managers Regime.
5. Commit a greater portion of the DfID budget to prevention of zoonotic disease emergence through sustainable and productive agriculture, veterinary capacity building and monitoring of zoonotic disease risks. This should include the use of new technologies, such as eDNA sampling and satellite monitoring of habitat loss.
6. Use its hosting of COP26 of the UNFCCC and its attendance at COP 15 of the CBD to make the case for a new convention on zoonotic disease prevention.
7. Form a 'club' of countries with agricultural subsidy systems like its new ELM system, which aim to enhance eco-friendly land management rather than incentivising agricultural expansion. This alliance should work to promote such systems globally, including at COP26 of the UNFCCC and COP 15 of the CBD.
8. Place environmentally-friendly agricultural subsidies and sustainable commodity supply chains on the agenda during the UK's presidency of the G7.

The international community, led by the G7 and close allies, should:

1. Conduct an in-depth inquiry into the origins of the current COVID-19 pandemic.
2. Conduct a separate inquiry into the wider risks of zoonotic disease spillover and its causes.
3. Acknowledge China's current ban on wildlife trading, but insist that it goes much further. The ban should be extended beyond food to traditional medicine and it should be implemented and enforced consistently in every province and across every border. It should then be turned into permanent law, rather than short-term diktat. Compensation and re-training should be given to those whose livelihoods have depended on the wildlife trade, as part of a clear strategy to end it. These measures should apply wherever needed, not just in China. If China or others refuse this ban, the international community should refuse trade in agri-goods from those countries.
4. Apply all means available to encourage China and other countries to support free and independent media, civil society and scientific communities, as an indispensable corollary to the more formal regulatory and monitoring systems recommended in this report.
5. Amend the Convention on Biological Diversity to specifically address the prevention of zoonotic diseases, including trade in endangered species and high-risk wildlife. Use the CBD COP15 to call for a new framework convention on zoonotic disease.
6. Sign a new framework convention to establish a new regime for preventing zoonotic disease outbreaks. It should include the following:
    a. Create a new, single body to co-ordinate global efforts to limit zoonotic disease risk. Alternatively, a well-resourced secretariat should be created for the FAO-OIE-WHO tripartite arrangement for zoonotic diseases. This should include a central database of zoonotic outbreaks, research funding, local capacity building and an independent inspectorate.
    b. A commitment by all signatories to ban practices within their jurisdictions that raise the risk of zoonotic diseases, such as high-risk wildlife markets and trade, trade in endangered species, deforestation, unsanitary livestock management and agricultural subsidies with perverse incentives.
    c. A commitment to procurement and trade frameworks that prevent ecological disruption. Signatories should commit to separate agreements on the production of key commodities.
    d. A commitment by rich signatories to fund a more co-ordinated network of permanent laboratories, field stations, data collection schemes, veterinary capacity and ecological crime enforcement.
    e. A commitment by all signatories to permit an international

inspection regime, similar to those used to control WMDs. Such a regime would not focus only on actual viral outbreaks, but on areas where local practices are disrupting ecosystems in a way that raises the zoonotic disease risk.

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