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Preventing emerging zoonoses

This POSTnote summarises approaches to preventing zoonoses with pandemic potential by targeting animal-environment-human interactions. It reviews current biosecurity measures in the UK and globally, notes lessons from COVID-19 and identifies future prevention strategies.

Overview

- Zoonoses are diseases that can be transmitted between animals and humans.
- Most diseases emerging in recent decades are zoonoses, including HIV, Ebola, Zika, Swine flu (H1N1), and COVID-19.
- Approaches to prevent emerging zoonoses include ensuring safe human-animal interactions through good hygiene and improving global surveillance systems.
- During the G7 and the G20 summits, world leaders agreed to apply holistic approaches in future pandemic prevention and preparedness policies.
- In the UK, lessons from the COVID-19 pandemic include development of adaptable responses and scalable capacity in public health systems.

Background

Zoonoses are diseases caused by pathogens (such as bacteria or viruses) that can spread between animals and humans. In the last three decades, 75% of new diseases in humans have originated in animals.[1] These include all recent pandemics such as the H1N1 ('swine') Influenza, and COVID-19 (caused by SARS-CoV-2).[2,3] Zoonoses are said to be 'emerging' when they have recently spilled over into humans or have expanded into to new geographic regions.[4]

Zoonoses circulate within animal populations until 'spillover events' (when a pathogen jumps from an animal into a human) lead to human infections.[5] Zoonoses become pandemics if localised outbreaks escalate into sustained global human-to-human transmission.[6] Animal-to-human transmission can happen by direct contact, consumption of contaminated animal products and through contaminated surfaces, water or air.[7] PN 597 covers zoonoses transmitted indirectly through insect vectors such as mosquitos (e.g., Zika and West Nile viruses).

Humans can also pass diseases to animals ('reverse zoonoses'). Reverse zoonoses can impact domestic and wild animal health or create new sources (reservoirs) of human infection.[8] For example, the human seasonal influenza virus has spilled over into pigs multiple times, and is subsequently circulating globally within pig populations. [9–11] Similarly, in 2020 and 2021 SARS-CoV-2 was detected in North American and European captive mink and in North American populations of wild white-tailed deer. These species could be a new source of infection for humans or animals.[12–18]

Biosecurity is defined as a series of precautions applied together to prevent pathogen introduction and spread. [19] It is part of a broad set of international sanitary and phytosanitary measures set out by the World Trade Organisation (the SPS Agreement) to protect humans, animals, and plants from diseases, pests, or contaminants.[20] Measures to prevent the emergence and spread of zoonoses include hygiene and sanitation, disease surveillance and reducing risky human-animal contact.[21–23]

Drivers of zoonotic disease emergence

Most animal pathogens do not directly infect people, but the number of spillover events is increasing. [24,25] This is largely due to human-driven factors such as increasing population size, land use change and increases in wildlife trade of pets, meat and other products (PN 236).[26] A greater number of human-animal interactions increases the risk of zoonoses emergence.[27]

Land use change and biodiversity loss

Land use change, such as land clearance for agriculture, can affect the types of animals and plants (biodiversity) that live in an area. By removing predators, small animals such as rodents and bats can thrive.[28] These animals act as reservoirs and have

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adapted to tolerate several types of pathogens that can easily be transmitted into humans.[29,30] Experts are debating the role of biodiversity in zoonoses emergence, with the greatest risk likely from partially converted land where people and wildlife share space.[31–33]

Wildlife use: trade and farming

The trade in animals and their products has cultural, social and economic significance in many regions around the world.[31–33,41] However, taking animals from the wild for their meat or other products is a known major source of zoonotic diseases such as Ebola and HIV.[42–44] The transport and sale of wildlife involves keeping different species in close proximity, increasing the risk that diseases will spread between species, including people.[45,26]

The demand for wild animal products has increased in recent decades, arising from cultural preferences.[46] Wildlife farms are now used extensively in some areas of the world. They are often used as a substitute for hunting or poaching, especially where wildlife sources are low.[47] Several species of non-traditional animals such as mink or wild game species are farmed worldwide.[26,47] Intensive farming of wild animals in countries where regulations are poor and veterinary interventions are scarce may increase the risk of zoonoses emergence. This risk increases if farmed animals become stressed, as they become more susceptible to diseases.[48,49]

A One Health approach to zoonoses

'One Health' is the concept that the health of animals, humans and the environment are interdependent.[50] The One Health approach is collaborative, where multiple sectors work together to design and implement programmes and policies for better animal and public health outcomes (Box 1).[50,51,34–36] To increase international coordination, the UN specialised agencies for agriculture (FAO) and health (WHO), together with the World Organisation for Animal Health (OIE, responsible for the animal aspects of the SPS Agreement) established a collaboration (the 'Tripartite') in 2010. The UN Environment Programme (UNEP) joins the Tripartite to form the 'Tripartite Plus'.[52]

In 2021 both the G7 and the G20 declared they would integrate One Health approaches in future pandemic prevention and preparedness policies.[53,54] Global health experts emphasise that any One Health intervention requires analysis of co-benefits and trade-offs for the animal, human and environmental sectors.[50,55]

Box 1: One Health and science advice

To implement a One Health approach multi-disciplinary expert panels have been established.[34–36] UK-based governmental expert panels include the:

- **Human Animal Infections and Risk Surveillance** group**.** It assesses the risk of emerging diseases (including zoonoses) that may pose a threat to UK public health.[28]
- **UK Zoonoses, Animal Disease and Infections** group. Re-established in 2021, it advises on zoonotic trends that impact public and animal health.[38]
- **Advisory Committee on Dangerous Pathogens**. It provides scientific advice on hazards and risks from exposure to pathogens, including zoonoses.[39]

Internationally, the **One Health High Level Expert Panel** set up by the Tripartite and the UN Environment Programme (UNEP) in 2021 provides scientific assessments of emerging zoonoses from human-animal-environment interactions.[40]

Targeting the drivers of zoonotic spillover

Climate change and global food systems are large scale drivers of zoonoses emergence as they are linked to land use change, biodiversity loss, and increases in animal farming.[56–58] More details can be found in PN 617, PN 589, PN 600.

Reducing domestic-wild animal interactions

Zoonotic infections sometimes spill over into people from the natural animal host via an intermediary. This could be a pet, working animal, or livestock. Interactions between wildlife and livestock are a major risk factor for zoonosis emergence, as pathogens can adapt, spread and amplify when infecting hosts that live in large populations, such as farmed animals.[32,59,60] This happens, for instance, with avian influenza viruses , that can be transmitted to domestic poultry populations through contact with infected wild birds or through contaminated water or food (Box 2).[61,62]

Sustainable wildlife trade

In response to the COVID-19 pandemic, the Tripartite Plus recommended governments suspend trade in live-caught wild mammals.[63] Some stakeholders say that imposing total bans without local enforcement support or compensation would negatively affect food security and livelihoods, and could lead to an increase in unregulated illegal trade.[64] They suggest that supporting sustainable and responsible wildlife use, such as improving sanitation and animal welfare practises, could reduce the risk of zoonoses and protect biodiversity and species conservation. [65–68] The sustainable use of biodiversity is one of the four goals of the draft Global Biodiversity Framework to be agreed by UN Convention on Biological Diversity's COP-15.[69]

Safer domestic animal and human interactions

Many interactions between animals and humans occur with domesticated animals. Zoonotic infections such as avian or swine influenzas, and coronavirus diseases such as MERS have been reported in animal workers globally, although widespread human-to-human transmission is usually rare.[70–74] In low- and middle-income countries (LMICs), limited resources mean that disease prevention and control measures may not be implemented.[75] Proposed improvements need to be cost effective for those who rely on these systems for their livelihoods whilst respecting cultural farming practises. These include enhancing hygiene and other biosecurity practices and tracking animal movements between keepers.[76,77]

Immunisation of animals

Preventing infections in animals can improve their welfare and reduce the risk of zoonoses transmission.[78] Livestock populations can be made resistant to diseases by selectively breeding naturally immune animals or through vaccination.[79,80] For instance a MERS vaccine for camels is currently under development.[81,82] Veterinary experts agree that there are challenges in developing and manufacturing vaccines quickly and in their long-term effectiveness.[83,84] Not all vaccines are permitted for use in the UK as vaccinations may interfere with monitoring of diseases such as bovine tuberculosis and may affect international trade where disease exposure and vaccination cannot be distinguished (Box 2).[85–87]

Box 2: Controlling avian influenza

Humans can become infected with avian influenza viruses through contact with infected birds such as poultry. If avian influenza is detected in wild birds in the UK, an Avian Influenza Prevention Zone (AIPZ) may be declared. Within the AIPZ, mandatory biosecurity measures for poultry and domestic bird keepers are required.[103] These include keeping farmed bird species separate (i.e. ducks and geese) and restricting contact with wild birds.[103] These measures are often business as usual for commercial farms and part of the requirements for food assurance schemes.[104] According to farming stakeholders, small and hobby farmers are not always aware of when an AIPZ is declared and face additional financial or resource barriers to meet the required standards.[105]

Vaccination of poultry workers

It is not permitted to vaccinate poultry against avian influenza in the UK.[85] Some scientists suggest that vaccinating animal workers against seasonal influenza reduces the risk of animal and human influenza strains co-infecting people and creating new versions of the virus (recombine).[106] This policy is implemented routinely in countries such as Australia,[107]and the USA.[108] In the UK, the Joint Committee on Vaccination and Immunisation (JCVI) recommends this policy only in the event of an avian influenza outbreak in poultry.[109]

Vaccinating wild animals is an effective method of controlling some zoonoses, such as rabies. [88,89] For emerging zoonoses, challenges include development of suitable vaccines, identification of the reservoir species to vaccinate and adequate vaccine coverage to prevent trasmission.[90]

Surveillance systems

Surveillance systems rely on reporting to monitor pathogens in animals and humans. The possibility of economic consequences such as restrictions in trade, free movement of people, or the lack of compensation for destruction of livestock are barriers to reporting.[91–93] Previously, disagreements over intellectual property rights of a pathogen's genetic information have prevented details of zoonoses being reported (PN630).[94] The WHO Pandemic Influenza Preparedness Framework was established in 2011 to ensure sharing of influenza genetic information, specimens and vaccines, however this does not cover other zoonotic pathogens (PN630).[95]

Detecting pathogens in animals

Surveillance of wild or domestic animals can detect pathogens before they spread to humans. In the UK, veterinary surveillance of animals including livestock is overseen by the UK Surveillance Forum (UKSF).[96] International livestock surveillance projects have been part of the UKRI Zoonoses and Emerging Livestock Systems program.[97] Some researchers support investment in surveillance projects that aim to identify and sequence all animal viruses with potential for spillover to humans.[98,99] There is a global debate among academics on whether this is the best allocation of limited resources, as knowing the genetic sequence of a virus is currently not enough to predict its ability to infect humans or cause pandemics.[100,101] Some current methods for directly sampling animals are time consuming, risky, expensive and in the case of wild animals, often unsuccessful.[102] Developing scalable non-invasive sampling techniques, such as sampling bird droppings, could reduce the cost of surveillance and distress to animals.[102]

Surveillance for zoonotic diseases in humans

Most global disease surveillance networks collect and analyse data from cases of zoonoses in humans after they seek medical treatment. Reporting can happen at a local, national or international level but it requires medical professionals to recognise new or unusual symptoms, targeted diagnostic testing and a willingness from governments to report cases quickly to international authorities if required.[110,111]

Surveillance can be targeted proactively to people who are most at risk of exposure to zoonoses. In the UK, following the detection of a zoonosis in animals, blood samples from farm workers may be tested for current infections or previous exposure .[112] Similarly, special attention can be focused on returning travellers, especially those coming from areas of known emerging disease activity.[113,114]

Modelling of disease risk and spread

Policymakers can use models to target early response measures, especially in resource-poor regions.[115,116]

Risk mapping

Risk mapping combines the knowledge of historical spillover events, changes in the local landscape and biodiversity with population density, trade hubs and other social, political and cultural factors of a region.[117] Risk maps are used by policymakers to better target public health interventions such as surveillance or vaccination to prevent disease emergence.[118]

Modelling disease spread

Mathematical modelling can be used to understand how a disease can spread in a population and how its spread is affected by disease control interventions.[119] To make accurate forecasts, modellers need high quality data, such as routes of transmission, how long people or animals are infectious for, how long immunity lasts and the population size to determine the rate of spread.[120,121] Scarcity of good data and uncertainties in the model's parameters can limit a model's accuracy in predicting outbreaks.[122]

Biosecurity approaches in the UK

The UK Government carries out a risk-based, early warning, surveillance approach for animal and human health.[96]

Measures to monitor animal health

The Animal and Plant Health Agency (APHA) is an executive agency of Defra responsible for responding to biosecurity threats in the UK, including zoonotic diseases, and hosts many disease reference laboratories.[123] Biosecurity, One Health and innovation are key focus areas of the 2021–2026 APHA Science Strategy.[124] APHA's responsibilities include:

- **Inspecting imports of animals and animal products.** Depending on the type, use and origin of animal products, APHA requires documentation such as import licences and veterinary health certificates for UK imports.[125] Live animals receive veterinary checks, and may require vaccinations (such as against rabies) or quarantine before importation.[126] For pets, privately funded surveillance networks such as the

Small Animal Veterinary Surveillance Network and VetCompass™ collate data from participating veterinary practises and diagnostic laboratories.[127,128] These data are used to monitor changes in clinical signs in pets, which could be associated with emerging diseases in the UK.

- **Coordinating the GB wildlife Diseases Surveillance Partnership.**[129] The Partnership mainly focuses on detecting known and emerging diseases in wild animals. Notifiable disease such as rabies-like viruses in bats, the fox tapeworm and bovine tuberculosis in badgers (PN307) are monitored by the APHA wildlife team working with stakeholders.[130,131] If cases are confirmed, disease control methods may be implemented.[112,132] Veterinary experts call for broader surveillance in the UK to identify pathogens naturally found in wild and domestic species.[133] Currently there is no funding for broad surveillance of non-notifiable pathogens in UK wildlife.[134]

Measures to control zoonotic diseases in humans.

In 2021 the UK Health Security Agency (UKHSA) was established as a new public health body merging elements of Public Health England, the Joint Biosecurity Centre and NHS Test and Trace.[135] UKHSA is responsible for preventing, detecting and responding to UK public health threats. This includes providing public health advice, development of guidance and investigating and responding to incidents of zoonotic infections.[136] Additionally, following the detection of a known zoonotic disease in livestock, as part of investigation and control, UKHSA may undertake surveillance or preventative treatment of exposed workers.[137]

Global biosecurity approaches

The 2005 International Health Regulations (IHR) require that emerging and re-emerging diseases of international concern are reported to the WHO.[138] To improve implementation of the IHR, in 2014 a group of 44 interested countries and parties including WHO created the Global Health Security Agenda.[139] This public-private international partnership has grown to over 70 countries and aims to strengthen mechanisms to detect and respond to emerging health threats, including zoonoses, by improving detection, data sharing and testing.[139,140] Many stakeholders argue that investing in surveillance and response to tackle zoonoses endemic in LMICs, such as plague or Lassa fever, will build the capacity and capabilities for monitoring emerging global threats.[141–143]

Identifying zoonotic disease threats

Global surveillance initiatives such as the animal influenza network OFFLU[144] and the Tripartite's Global Early Warning System (GLEWS+)[145] among others rely on reporting to monitor potential threats to human and animal health.[146,147] However some initiatives are often disease- or host-specific, or only cover defined countries or regions.[148] International surveillance hubs such as the WHO Hub for Pandemic and Epidemic Intelligence, and the UK's proposed International Pathogen Surveillance Network (IPSN), aim to improve data sharing and to link local, national and global initiatives.[149,150] In 2021, the G7 requested a scoping study from the 'Tripartite Plus' to identify opportunities for further harmonisation of surveillance systems to strengthen One Health intelligence.[151,152]

Responding to threats

Robust surveillance systems allow for a prompt response.[148] Every six months, OFFLU reports to WHO details of zoonotic influenza viruses detected in humans that have potential to cause outbreaks.[144,153] Industry stakeholders can use these data to proactively develop vaccines against zoonotic influenza viruses, but this is not a requirement. The Tripartite Zoonoses Guide (2019) aims to assist countries in implementing One Health approaches in low-resource settings.[50] Strategies include coordinated investigations between government departments, strategic planning and joint risk assessments.

Lessons from COVID-19

Recent international reports, including from the WHO Independent Panel for Pandemic Preparedness and Response, analysed the global response to the COVID-19 pandemic and identified priorities for improvement. [154–157] These include:

- **Improving global coordination and leadership** to learn from international experiences and coordinate responses.
- **Strengthening a One Health approach,** as set out in the UK's Integrated Review and requested by the World Health Assembly Resolution on COVID-19. [158,159]
- **Increasing global financing** to increase healthcare capacity, data sharing infrastructure, and to establish and maintain disease surveillance, as recommended by the G20 High Level Independent Panel.[155,157,160]

A number of Select Committee reports have recommended actions for the UK Government, including:

- **Developing adaptable responses and scalable capacity** in public health systems to quickly respond to emerging threats when they are detected.[161]
- **Expanding the capability of emergency responses** to cover more than just pandemic influenzas.[161,162] This approach is key for unknown future emerging diseases ('Disease X') where the spillover location, symptoms, and means of spread are unknown.[163,164]
- **Setting up a dedicated national centre for biosecurity** to address biological threats including zoonoses.[162]
- **Establishing an independent public inquiry**.[165]

Future approaches to zoonoses prevention

The UK continues to support research and innovation in zoonoses prevention, as recognised by recent UK Government strategies. [166–169] Future government-funded projects include:

- The **UK animal vaccine manufacturing and innovation centre**, aiming to accelerate the delivery of vaccines for livestock diseases.[170]
- The **UK International Coronavirus Network,** bringing together animal and human coronavirus researchers.[171]
- **Further development of available technologies**, such as rapid genome sequencing to test imported animal products and rapid diagnostic tests (similar to the lateral flow tests for COVID-19) to detect diseases in animals.[172–174]

A series of international initiatives such as PREZODE and the International Zoonoses Community of Experts among others have been announced.[175–178] These initiatives aim to improve early detection, risk assessments and the sharing of technical data on emerging health threats among governments.

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