PREZODE

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Break out room 2: Reduction of zoonosis emergence

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Introduction

The group felt that PREZODE should work broadly across pathogens to understand how to reduce risks from zoonoses, including endemic and newly emerging zoonotic pathogens. It was noted that the links between humans, domestic animals, wildlife and the environment will vary locally and regionally. Thus processes of zoonotic disease emergence will need to be studied across multiple scales and ecosystem contexts through inter-disciplinary Systems approaches to allow locally relevant risk reduction measures to be specified. European ecosystems are diverse, have low biodiversity and endemicity and are impacted by climate change. This may mean that new zoonotic disease risks may originate in Africa and Asia, highlighting the importance of understanding and mitigating the processes of arrival by trade, tourism and travel and natural spread. Since climate, biodiversity and pandemics are intricate challenges that are not specific to Europe, involving processes and science needs beyond Europe's borders, international cooperation is vital to mitigating the risk of zoonotic disease emergence.

1. **Main stock take of research related to Reduction of zoonosis emergence**

Much of the discussion focussed on the need to understand the process of emergence and spill-over better through inter-disciplinary research and Systems approaches, especially the following key aspects:

a. Understand links between *human activities within ecosystems and spill-over and vulnerability to zoonotic diseases* to help us identify the most vulnerable populations as well as adaptation measures
b. Understand *Impacts of climate change and its interactions with food systems on risk of emergence* - to reduce climate change impacts from food systems
c. Understand whether *impacts of livestock factors on spill-over* can be reduced by understanding and changing farming practices for example by:
    i. Reducing fur farming of mammalian hosts that can act as a source of new variants for zoonoses

ii. Understanding hotspots of emergence better and how they link to densities, diversity, stress, diet and connectivity of livestock populations and types, determining whether extensive or less specialised farming practices may reduce these hotspots and be acceptable to local communities
iii. Understanding how biodiversity within/surrounding farms affects pathogen transmission
iv. Identifying preventative measures in the livestock sector to avoid spill-over such as human and avian influenza control measures

d. One Health approaches to antibiotic resistance should be fostered, including research on alternatives
    i. Impact of different agricultural farming practices (pig slurry from intensive meat production, biogas digestives) on AMR genes (antimicrobial resistance genes) along the tropic chain should form part of OneHealth considerations

e. In terms of links between biodiversity, policy and spill-over, the following needs were identified:
    i. To leverage ecosystem management to promote pathogen dilution, once scientific benefits are established
    ii. To develop forest policies for preventing zoonoses, encompassing conservation and reforestation practices and include emerging zoonotic disease risks in the EU forest strategy.
    iii. To move to One Health in all policies to reduce the likelihood of disease emergence
    iv. To explore mitigation measures regarding biodiversity loss (including microbiome diversity) and conservation
    v. To ensure that results of risk assessments and surveillance feed into risk reduction across sectors

f. In terms of links between emergence and European policy on trade and international development, the following needs were identified:
    i. Better understand and manage trade (legal and illegal) in zoo species, wildlife and livestock.
    ii. Prevent introduction and spread of disease by international travellers, tourists and companion animals
    iii. Better understand the role of natural migration in transporting diseases such as the role of bird migration in transporting ticks and tick-borne diseases
    iv. EU impact on global forests and risks of emergence should be quantified
    v. Develop more sustainable ecotourism business models that facilitate conservation of intact community-managed ecosystems at fringes of large reserves

Several areas of *capacity building* were highlighted as being needed including enhanced preparedness for pandemics and fostering rapid responses in terms of interventions, vaccine development, fast and multi-pathogen diagnostic tests, availability and inter-operability of data between countries. Basic research and epidemiological studies on zoonoses are needed to establish baseline data against which to measure change. We need to enhance the participation of indigenous and local communities in research and pandemic prevention and increase general public awareness of zoonotic disease emergence through outreach actions. We need to strengthening capacity across Lower Middle Income Countries, including fully funded partnerships with Africa, to mitigate risk of emerging pathogens from these areas and exchange expertise, especially on Systems approaches.

2. Knowledge gaps and cutting edge science related to Reduction of zoonosis emergence that should be addressed in PREZODE

Systems and eco-epidemiological approaches to understanding risk and spill-over

The need to predict and focus on the hotspots of highest risk of spill over to humans and domestic animals was highlighted. The ecological, environmental and social processes driving spillover should be jointly examined and quantified across environmental gradients, ideally within “living labs”. The Systems approaches should identify all interfaces where transmission can occur and develop integrative scenarios of emergence. For example, it is important to identify multiple pathogens (and contact rates) that hosts may encounter within extensive, landscape-driven farming systems, or given increased contact with biodiversity resulting from the movement to less controlled, greener farming practices. The impacts of climate change and extreme weather events on pathogen systems needs to be better understood and predicted. The role and impact of invasive vectors and hosts on zoonotic disease emergence should be evaluated as well as whether livestock genetic diversity reduces or enhances spillover on farms.

Vulnerability and adaptive capacity

We need to identify the wide ranging factors and processes that affect resilience, vulnerability and adaptive capacity to disease emergence such as co-circulation of endemic diseases, interaction with other environmental stressors, socio-political drivers, and socio-cultural practices. These include understanding the indirect impacts of policies on disease systems such as impact of wildlife management on livestock disease control using systems analysis. We need to better links between risk perceptions, disease information and adaptive behaviours including whether livelihoods can be altered or diversified to avoid risk and how peoples interaction with livestock and companion animals underpins risk. Ideally this knowledge would be linked to frameworks that provide evidence of the costs and benefits of adaptive actions, including prevention and rapid responses. We need to understand the role of Water, Sanitation and Hygiene (WASH) for humans, animals and wildlife in mitigating zoonotic disease impacts.

Ecology and evolution of pathogens

In order to understand which animal pathogens pose a risk to humans, molecular and evolutionary methods are needed to assess key pathogen traits such as likelihood of spill over to humans, tropism, virulence, pathogenicity (e.g. along the pathogen-symbiont continuum), transmissibility from genetic sequences and inform horizon scanning. Holobiont approaches, that examine whether the microbiota within a host or vector have consequences for the likelihood of transmission and spill-over, were also advocated. We also need to understand the pathogen communities out there in wildlife, through empirical eco-epidemiological studies such as those pioneered by the US Predict Consortium, and develop new ecological and evolutionary methods to predict where to look for zoonotic pathogens that we have not discovered yet, to help target surveillance and intervention. We also need to assess the “gene flow” of pathogens with different transmission pathways, including vector-borne diseases, to the relative roles of different host and vector species as well as environmental pathways in spread, to identify where this could be interrupted by interventions. The ecological concept of “refuges” developed in parasite control could be built on, to identify strategies to reduce build up of resistance to interventions in pathogen populations.

Science-policy interfaces

We need to develop a science-policy interface that favours inter-discipliniarity and inter-sectionality. The economics and social science of multi-sectoral responses to global change and pandemics needs to be better understood (e.g. coherent multi-level governance structures, collective inclusive solutions). We need to better understand the links between activities of different sectors and spill over (including biodiversity, agriculture, tourism, land use) and climate change (especially for hardwood forests and wetlands). We need to develop and evaluate solid business models that minimise ecosystem degradation and the associated spillover risks (e.g. carbon trade) and take account of the economic and societal value of (unfragmented, intact ecosystems) to the goverments and communities that own them. In terms of designing community interventions, we need to work on "pull effects" that allow behavioural change rather than "push measures". We need to understand how livestock breeding may evolve in the EU and the consequent impacts on spill over.

Capacity building

Observatories or "living labs" of links between biodiversity and one health are needed in which the interacting social, ecological and environmental processes underpinning spill-over can be studied, with multi-pathogen approaches being particularly valuable. Enhanced capacity is needed in integrating and interpreting data from different sources and sectors (livestock, environment, wildlife, humans), that are collected according to different systems and standards, to understand disease systems and interventions. Strengthening the veterinary sector (which can be less developed in many countries) was a key priority since this sector is at the forefront of reducing or detecting emergence events. Could vets become "ecosystem health managers" to reduce disease emergence?

3. How filling these research gaps would help our societies to reach lower risk of zoonotic emergence

The recent Eklipse workshop[1] concluded that "root causes of pandemics [should be addressed] through more coordination and coherence across policy sectors and with science". Aligning with this statement, the group considered that filling the above research gaps would help societies to reduce the risk of zoonotic emergence by improved *integration and translation of knowledge of links between biodiversity, health and zoonotic diseases into all policies* and fostering of ways to identify cross-sectoral policy evidence needs. We hope to ensure that climate, biodiversity and trade policy are coherent and aligned across sectors and locations drawing on the evidence-base from the science with appropriate multi-level governance structures and science-policy interfaces, extending down to local level to shape collective and inclusive resilient solutions. Paradigm shifts are expected, for example towards ecosystem management rather than livestock management (changing the role of primary farming stakeholders), and in the understanding of relationships between humans and animals and risks associated with practices involving use of farmed and wild animals. Broad, One health systems approaches are likely to allow consideration and mitigation of "wider determinants of health" and clarifying when biodiversity protects or amplifies zoonotic disease risks could help people to accept and mitigate spill-over risks linked to biodiversity conservation. It is hoped that local sustainable livestock production and ecosystem approaches to health would be promoted.

The improved public understanding of risks of emergence and changes in practices needed to reduce risk may foster c*ommunity level changes in behaviour* that reduce the risk of zoonotic disease emergence, These may include changes consumer behaviour, cooking and eating habitats through pricing, accreditation and subsidy models and education and higher uptake and knowledge of the

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[1] https://eklipse.eu/wp-content/uploads/website_db/Request/Covid/Workshop_report_Biodiversity-in-post-covid-cross-sectoral-challenges.pdf

personal protection measures that can be taken at the community level. Farmers could be incentivised to move to less risky farming practices through (economic) incentives.

Improvements in surveillance and capacity, including in tropical countries, may include standardised data collection protocols and improved information sharing across different sectors (humans, animals and environment); improved linkage between veterinary and medical practitioners and researchers and scientists; augmented evidence for global management risks; improved partnerships between Europe and tropical countries resulting in reciprocal improvement of their skills base and inclusive, practical experiences of life and economies in front line communities.

New tools and interventions to control transmission and spill over are likely to results from improved knowledge about human – farmed animal – wildlife – environment interactions. The evidence may allow the interventions to be targeted at the most cost-effective stage of the process to emergence, probably at prevention of initial spill-over from domestic or wild animals to humans. Economic frameworks will be developed that better assess the economic costs of emergence over the long term, fostering the acceptance that it is better to spend money now than pay the costs when it is too late i.e. in maintaining highest biodiversity in agriculture areas or spending or prevention measures. Frameworks quantifying the true economic costs of human activities, should capture all the costs of CO_2 removal or disease risk mitigation. One Health and Planetary Health indicators and indicators of the risk of emergence will be developed.