PREZODE
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Break out room 1: Assessment of the risk of zoonotic disease emergence

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The risk assessment of emergence aims at integrating all available knowledge to evaluate the probability and consequences of an emergence of a disease in a population and the occurrence and impact of an emergence can vary from local to global (Meurens et al, 2021). Formal risk assessment follows a methodology recognized and shared by different authors and institutions and consists in estimating the probability of the different events that contribute to the emergence of a hazard in this case the emergence or re-emergence of a zoonotic disease.

To perform risk assessment, either qualitative or quantitative, the availability of data is key. Indeed, **collecting and sharing data** need a commitment of different stakeholders and institutions from different disciplines adopting a One Health approach. Finally, several knowledge gaps may exist on the main factors influencing the emergence of zoonotic diseases at human/domestic/wildlife interfaces, to fill these gaps collaborative research efforts will be needed.

Objective of BR1 (Breakout Room 1)
With regard to the specific European context, the aim of breakout room 1 (BR1) was **to identify and discuss the main knowledge gaps (and research needs) regarding the risk of emerging and reemerging zoonotic diseases in Europe.** Finally it was attempted **to indicate what are the main expected transformations and benefits that filling the identified knowledge gaps will bring to society**.

1. Main stock take research on the risk of zoonotic emergence within EU specificities

The BG1 (Breakout Group 1) recognized the contribution of globalization, habitat fragmentation and destruction and climate change as main drivers of zoonotic emergence in Europe as in other parts of the world. In particular:
Globalisation enhancing the trade of live animals (livestock, pet, exotic animals), animal food products (including bushmeat through unofficial import) migrating animals (due to climate change) international travel (traveling of people, medical tourism, food animal trade) have enhanced exotic pathogens spread and highly contributed to AMR.

Climate change was particularly mentioned as a main driver of vector borne diseases, but not limited to them, since it affects reservoir/vector distribution and dynamics and persistence in EU.

Biodiversity/wildlife
Together with climate change, it was acknowledged that biodiversity loss and dilution plays a crucial role in the emergence and re-emergence of zoonotic disease. Urbanization is one of the main causes of biodiversity loss with declines in species richness from rural areas towards the urban core. This is

documented across multiple taxonomic groups. At the same time loss of predators and habitat fragmentation increases the number of invasive species in urban settings with enhanced risk of encroachment with human habitat. As an example, in Europe the unbalanced wildlife ecosystems with few predators lead to large numbers of deer, boars, rodents. As for Meurens et al 2021, participants agreed on the roles of wildlife, livestock and their interactions in emission, amplification of the pathogen sources and exposure of humans.
This may be due to re-wilding of areas with high human population without defined boundaries to livestock farming.

Farming practices
Intensive agriculture one of the biggest driver of species extinction and creates 15 percent of Europe's climate emissions (https://eeb.org/major-new-eu-farm-policy-will-worsen-environmental-crises/). Intensive farming is still widespread in EU having an impact on habitat clearance for cropping and grazing resulting in alteration of biodiversity. Food safety is a basic individual right. This is specifically recognized in the United Nations Sustainable Developments Goals, of which goal 2.1. In the WHO European Region, it was estimated that more than 23 million people fall ill from eating contaminated food every year (https://www.euro.who.int/__data/assets/pdf_file/0005/402989/50607-WHO-Food-Safety-publicationV4_Web.pdf). The BG1 recognized that intensive farming may amplify the release of "high" load of foodborne pathogen in the food chain and the environment. BG1 pointed out that, besides wildlife, intensive Livestock husbandry may act as a source of zoonotic disease emergence as they are in close contact with humans. With regard to pathogen emergence, a further risk associated with intensive farming is related to waste management (potential dissemination in environment). On farm biosecurity measures are in place in many Member States but proper training of farmers in risk assessment will be needed.
On the other hand, livestock raised under semi-intensive/extensive production systems are typically raised outside (pastures) or with outdoor access (free-range farms), which increase the chances of contact with wildlife. Backyard farming, although mainly of relevance for developing countries, might also be considered under certain circumstances due to the generally lower levels of biosecurity measures applied.

Land use
Concerns were expressed about the ecological consequences of the usage of land for food and feed purposes as well as to widen urban settings In Europe. Change in land use may lead to Increased exposure (interface) between humans and animals, due to changes in anthropic activities impact of land use on reservoir species and pathogens
Conflict between current EU driven climate change mitigation/adaptation actions (eg. land use fragmentation through the establishment of large windfarm/solar parks even in N2000 regions) and biodiversity conservation actions.

Pathogens (AMR)
BG1 particularly focused on AMR as this is becoming more frequent and increasingly difficult to treat in the EU as well as in other parts of the world. Antimicrobials should be seen as a non-renewable resource. The rapid emergence and spread of antimicrobial-resistant infections is exacerbated by the widespread use of antimicrobials in humans, in veterinary medicine (not only in livestock) and in the agriculture industry.

There is a need to enhance pathogen identification and characterization (including knowledge about infection biology and a wider use of NGS) to allow early detection of newly emergent pathogens.

Socio-political factors

Health determines social, cultural, economic and political outcomes of societies. COVID-19 pandemics highlighted that (Human) health systems not being prepared or not having the capacity to absorb emergent diseases. Before COVID-19 European countries were not used anymore to major infectious disease occurrence in humans with communities unwilling to change their behaviours.
Unequal societies and poverty leading to unequal response and provision of healthcare thereby leading to unequal risk distribution. For example, in UK, ethnic minority groups disproportionately affected by COVID19. In addition, lack of trust of national authority and the pressure of surveillance (accurate information) are important parameter regarding the efficience of health policy.
Covid-19 vaccination campaign showed that control programmes need to be adequate and acceptable in different socio-cultural contexts. As an example, different sectors of society perceive differently risks and management options leading to conflict and wrong management. Therefore both health promotion and education activities regarding (also) emerging infectious diseases should consider potential social gradients underlying both their prevention as well as timely eradication and/or management.

Monitoring and data collection
Continuous monitoring, even at the scale of individual communities and considering the main human, domestic animal, wildlife and environment, produces an impressive volume of data on a daily basis. Even if it is not just a European priority, collecting high quality data that should be subsequently available and accessible to the relevant stakeholders, is crucial. There is extreme fragmentation in the health sector due to the numerous standards, systems, methods and coding used in data generation and storage, The effectiveness of zoonotic disease surveillance plans would be greatly enhanced if we systematically integrated and harmonized all these sources of information exchanging between EU member states and third countries. In this sense cost-benefit case studies at a local level would be of interest and would form the basis for the integration/harmonisation of data and resources at a European level.

2. Knowledge gaps cutting the edge of science

Data monitoring and surveillance (OH approach in surveillance, quality of data)
Zoonotic disease surveillance should be enhanced and improved to collect the necessary data for assessing the risk of emergence and re-emergence of zoonotic diseases.

To improve surveillance, data monitoring and Risk assessment the followings will be needed:

- Overcome the current lack of coordination in animal and human zoonotic disease research and surveillance to effectively share the human and animal surveillance data using a One Health perspective
- Risk monitoring should be harmonized and improved at human/domestic animal (livestock and pets)/wildlife/environmental interfaces at european level. More precisely, improvement should be targeted in data management/ data mining strategies/data accessibility and sharing, which should be promoted through OneHealth platforms @local, national and EU levels.
- The strategy should enhanced surveillance of occupationally on exposed groups
- International observatory needed to integrate the monitoring of pathogens (including AMR), vectors, hosts (diff. taxa and regions), environment, ect.

To better monitor and predict spillover risks within EU these will be the main needs:

- More investments in wildlife/vector surveillance
- improve and standardize field data collection on vectors and wildlife
- Adopt a prioritization methodology to define which wildlife must be surveyed

Hosts - livestock, wildlife and vectors (evolution and biodiversity, role of different farming practices)

The intensification of farming practices, habitat clearance for cropping and grazing can result in alteration of **biodiversity**. These factors were identified as drivers of (re)emergence of infectious diseases by several authors. A**gricultural drivers** have a number of effects, including **mixing diverse wildlife species together and pushing wildlife and livestock into overlapping environments**, thus facilitating the transfer of novel agents into naive and susceptible species.

Regarding farming practices, the following priorities in research have been indicated:

- To establish a European framework of livestock distribution / production systems (e.g. outdoor, backyards). Abundance data with sufficient spatial resolution.
- Need to investigate emergence, circulation and dissemination of zoonotic pathogens in already existing extensive farming
- Assessing the Impact of intensive / organic farming practices on animals microbiota and susceptibility to pathogens and impact of farming practices on mutation, gene transfers (antibioresistance, virulence, ...)

Environmental drivers, such as climate and weather changes, affect vectors and wildlife host biology and concentration. Europe has specificities in term of biodiversity and human footprint (agricultural landscape) the following actions were found necessary to improve prevention and control of zoonotic diseases:

- Regarding vectors : Assess vector competence of european arthropod species and vector host selection and preference under different scenarios (urban, rural, natural settings)
- Regarding wildlife: Assess European wildlife biodiversity loss (host community and habitats preservation) and evaluation of the relationship between level of biodiversity and risk of pathogen transmission to humans. To do so, we need to better assess wildlife biodiversity (eg, using molecular approaches) and pathogen identification in wildlife species, changes in wildlife use of space and the impact of human activities on wildlife immunity (through stress, due to pollution, habitat and community disturbance...) and better understand the multiscale trophic interaction from pathogens, to predators.

Human activities such as: global trade and illegal trade may contribute to the emergence of zoonotic diseases, but it is crucial to determine the real figures of:

- illegal trade of wildlife including food (bush meat)
- "wildlife" and exotic pet markets in Europe.

Modelling

Data analysis through modeling is one of the ways to study the human/domestic animals/wildlife/ environment interfaces. Models can help inform policy and disease control interventions.

To increase the predictive performances of modeling studies the following will be needed:

- Identify, classify, prioritize key drivers for emergence and spread
- Include scenario analysis in a world of uncertainty
- Improve epidemiological studies using a One Health approach :e.g understanding disease transmission processes at the animal–human–environment interface, multihosts and environmental persistence of pathogens that can lead to complex disease dynamics
- Integrate scales (from local to global) to understand the contribution of the different drivers
- Regarding risk assessment: establish common framework to assess emerging risks, integrate multiple risks in the same pathway, connect EU Risk assessments with those of other continents (especially for emerging risks)
- Involve stakeholders in the approach (participative and inclusive approach)

Improve the reliability of wildlife & vectors distribution/abundance spatial models for risk assessment

- consider the effect of environmental change and global heating for climate sensitive diseases and environmental pathogens.
- Improve zoonotic disease monitoring in animal reservoirs
- better knowledge of the emergence drivers for the various microbial candidates in current and future hotspots and cold spots where there is little surveillance

Pathogens (interaction with microbiota and evolution detection)

To predict which zoonotic pathogens will be likely to emerge or re-emerge at the interface of wildlife-livestock-, and human-systems in the future and mitigate the associated risks, the current knowledge on host, pathogens and drivers of emergence will need to be updated with the following data:

- mutation rate & host adaptation of viruses (modeling, Artificial Intelligence)
- Molecular basis for host adaptation, pathogenicity of zoonotic infections (behaviour of mutation) and infectious doses
- viral (pathogen) determinants of pathogenesis and vector transmission
- Impact of animal microbiota on pathogen emergence, growth & immunogenicity
- pathogens - insect vectors interaction
- better understand the genetic basis to host specificity and ability to jump host species
- Increase knowledge of wildlife pathogens and associated risks associated with wildlife
- Enhance research on non invasive diagnostic techniques

Society (education and politics, exploring actions)

BG1 recognized the importance of engaging with different stakeholders (Eg. policy makers, society as whole), adopting a multidisciplinary (including social sciences and humanities) and transdisciplinary approach to improve the surveillance and control of zoonotic diseases.
In particular, BG1 acknowledges the importance of an active dialogue between science and public health sector. These three main pillars have been identified:

(i) Project education programs targeted to different categories and risk groups

- Promote higher education program on full risk assessment and health promotion programs for the communities
- Include One Health courses in veterinary/medical and ecology curricula @EU University and promote electives on One Health related issues to create multidisciplinary classes (address quality assurance constraints linked to the innovative character of these programs that may arise thus involve EU education stakeholders)

(ii) Engage with policy makers with a stronger representation of scientists in political decisions will be needed to:

- Enhance science-based policies.
- Prioritize zoonotic diseases in terms of their impact and consequences on the communities
- Plan Natural habitat restoration to minimize zoonotic disease emergence or re-emergence
- Improve risk management strategies of pathogens with high individual consequence / impact which are of low population probability / risk

(iii) Involve social sciences and humanities in zoonotic disease research to:

- Develop science communication strategies
- Social science research on impact of prevention measures on human-animal interactions

- Perform studies on the perception of zoonotic risks by people, depending on their socio-economic conditions ? depending on the activities considered (eg, hunting, hiking, ...)
- Collect data on human behavior and zoonotic disease risk?
- Collect data on the impact of conservation plans in decreasing or increasing ZD risks
- Perform risk/benefit analysis on behavioural, societal and land use change to "fixing" the problems of climate change

3. How answering scientific gaps would contribute to changes in the society to reach low level of zoonotic emergence?

To reduce zoonotic disease emergence and re-emergence at human/domestic animals/wildlife/environment a participative approach will be necessary, BG1 identified the following actions and their respective contributes in reducing zoonotic disease emergence and promoting health and welfare:

Improving education and communication to society. These actions will positively impact on:

- increase of scientists legitimacy toward stakeholders and people
- the awareness and knowledge on zoonotic disease impacts and risks
- the acceptance and co-design toward prevention control programs and strategies and actions to reduce risk (improve farming practices, to undertake climate adaptations solutions etc)
- better capacity to discern scientific results from "fakes", better confidence in scientific results in more engaged communities
- Better decisions of consumers, civil society, politics, etc
- Sustainable food choices through improve citizen education on food consumption to promote

Establishing collaborations with different stakeholders will positively impact on:

- Communication of science, which is essential to get different stakeholders engaged and reduce human-human conflicts that may arise when managing emergencies.
- better confident in scientific results, and better willing to be engaged in the issues addressed, solutions proposed, ...
- Promoting science based policies to address decision/policy makers and impulse the change European political interventions toward sustainability
- Adopting a multidisciplinary approach through involving stakeholders from humanities and social sciences : to better understand the different points of view from inside and increase the social acceptance and estimate the impact of different risk management measures options

Adopt diverse solutions based on:

- Scenario approach including all stakeholders to stimulate novel ideas and participation (more chance to be useful). Preparing for a crisis or a threat would involve distinguishing different types of infectious disease threats, distinguishing different types of response to infectious disease threats and finally, which type of response is most effective for which type of response (Kenis et al., 2019)
- Improved knowledge about pathogens --> to develop of effective countermeasures (pharmaceuticals, equipment etc.)

This will:

- Open the way for a diversity of solutions to prevent zoonosis emergence (e.g. not only biosecurity), eg

- Find ways to make farm animals more robust and resistant to infection of asymptomatic carriage
- Implement farm management regulations that specifically target reducing the risk of zoonotic pathogen emergence & dissemination (via microbiota, wildlife management, waste management...)
- Improve our understanding of how events in animals influence public health
- motivate action to protect or restore land & biodiversity
- Finding new ways to manage extensive farming considering the risk of zoonosis emergence
- Stimulate the cost/benefit risk analysis including options of management

Further, with more scientific evidences, risk mitigation strategies may be better funded and thus better supported at individual as well as societal level

In addition, it appears important to stimulate twinning with South countries in terms of RA.

Multidisciplinary approach to optimize surveillance of zoonotic disease: enabling technologies and strategies

- Integrate artificial intelligence in risk assessment will improve prediction of ZD emergence using a One Health approach
- Use digital tool will allow real time risk assessment; improve risk priorisation using a system approach
- Putting in place a real one health approach, in surveillance of zoonotic diseases, will improve our understanding of ZD emergence drivers
- Better coordination in collecting and sharing data (reservoirs, infectious agents, ...) will improve risk assessment
- Up-to-date knowledge about wildlife populations and their microorganisms will allow a better preparation toward emergencies that may arise and promote evidence-based behavior changes
- Improving knowledge on emerging pathogens occurrence/circulation and drivers of disease emergence would allow cost/effective interventions enhancing their sustainability.

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