Expert Report for the UK Covid-19 Public Inquiry

Module 1: Surveillance and infectious disease control

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Author statement

I confirm that this is my own work and that the facts stated in the report are within my own knowledge.

I understand my duty to provide independent evidence and have complied with that duty.

I confirm that I have made clear which facts and matters referred to in this report are within my own knowledge and which are not. Those that are within my own knowledge I confirm to be true. The opinions I have expressed represent my true and complete professional opinions on the matters to which they refer.

Professor J Whitworth	Dr Charlotte Hammer
5th June 2023	2nd June 2023

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Professor ….. *Dr…*

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Q1: BIOSECURITY ISSUES RELEVANT TO PANDEMIC RISKS

1.1. Introduction

1. We view biosecurity as the preparation, policies and actions taken to protect human, animal and environmental health against biological threats. Pandemics essentially mean a widespread epidemic, which is caused by an infection that is increasing in incidence (Lederberg, Shope et al., 1992, Morse, 1995).

2. It is not only since the emergence of nCOV-2019, later re-named SARS-COV-2, in late 2019 and early 2020, that epidemics and pandemics have been high on the list of priorities in terms of their potentially devastating impact on societies and economies. The 2018 UK Biological Security Strategy acknowledges the international nature of biological threats and, drawing on the 2015 National Security Risk Assessment, classifies a major human health crisis as a Tier One risk ("one of the most significant civil emergency risks facing the UK") (HM Government, 2015, HM Government, 2018).

3. In today's interconnected world, with massive levels of international travel and trade, increasing population density and migration, and expanding and changing human-animal-environment interfaces, the potential for infectious disease risks has increased substantially. Experience shows that epidemics can emerge at any time at any place in the world. A wide range of pathogens have the capacity to cause epidemics including apparently new micro-organisms not previously recognised, known but re-emerging pathogens and adapted micro-organisms (including drug-resistant variants) responsible for established infectious diseases (UK Health Security Agency, 2023).

4. Biosecurity threats relevant to pandemic risk fall broadly into three categories of risk: Zoonotic spillover (section 1.2.1.), anti-microbial resistance (section 1.2.2.) and human-origin biosecurity risks (section 1.2.3.) including both the deliberate and accidental release of pathogens. These three risk areas are neither identical in their likelihood nor their potential impact.

5. Major drivers for the emergence of infections are wide-ranging and often interconnected. They include:

    - microbial adaptation and change
    - ecological changes favouring the multiplication of a specific microorganism
    - human land use and development bringing humans or animals into contact with microbes
    - climate and climate change can favour the flourishing of microorganisms or their vectors (Carlson, Albery et al., 2022)

- increasing international travel and commerce allows unfamiliar organisms to infect populations with no previous exposure or immunity and allows outbreaks to rapidly spread around the world
- direct human influences including technology such as the building of dams, or agriculture such as intensive farming of livestock
- increasing human population with crowding, urbanisation, poverty can facilitate the rapid spread of infections
- human behaviour such as encroachment into uncultivated spaces and forests, unsafe sexual practices, avoidance of vaccinations or social distancing measures
- immunosuppression in a substantial group of individuals can allow an epidemic to spread in a core group and later spread into the general population
- breakdown of public health measures such as safe water and sewage systems, isolation measures, vaccinations
- humanitarian crises and conflict may cause crowding, population movements, breakdown in public health measures, poverty and malnutrition accelerating the spread of infectious disease.

1.2. Biosecurity threats

1.2.1. Zoonotic spillover

6. The World Health Organization describes a zoonosis as "any disease or infection that is naturally transmissible from vertebrate animals to humans" (World Health Organization, 2020b). As of 2020, there were over 200 known zoonotic pathogens including viruses such as *Rabies lyssavirus* (causing rabies), bacteria such as *Yersinia pestis* (causing plague) or parasites such as *Cryptosporidium* (causing cryptosporidiosis). Zoonotic pathogens and the diseases they cause range from those with limited or no risk for onward human-to-human transmission like the above-mentioned example of rabies to those with pandemic potential such as SARS-CoV-1, the causative agent of Severe Acute Respiratory Syndrome (SARS), as well as pandemic influenza strains. After circulation within an animal host population, such pathogens can make the jump to humans. This process is called zoonotic spillover.

7. In a zoonotic spillover event pathogens are transferred from animals to humans. Thus, leading to the emergence of new infectious diseases in the human population. The contexts of zoonotic spillover vary but generally, the process occurs when humans come into close contact with infected animals or animal products, such as through consumption, hunting, wet markets, handling, or co-habitation. Emerging infectious diseases are predominantly generated by spillover (Jones, Patel et al., 2008b). Key drivers of the emergence of zoonotic diseases and their spillover into human populations are the ecology and evolution of humans, animals, and pathogens. While broad host ranges and other pathogen-specific risk factors play a

role in the spillover potential for a pathogen or group of pathogens, contextual factors of the specific human-animal-environment interface in which a spillover can occur influence both the likelihood of spillover and the level of risk of further transmission, amplification, once a pathogen has jumped to humans. Particularly, land use changes, such as the conversion of rainforest to farmland, and the intensification of agricultural practices can increase the risk of zoonotic spillover by bringing humans into closer contact with infected animals and animal products. However, conversely, highly intensified agriculture leads to a reduced spillover risk due to the reduction of liminal zones between wildland and cultivated land (Bartlett, Holmes et al., 2022). Additionally, globalisation has increased the likelihood and speed of pathogens from one part of the world spreading to another. Coupled with growing and moving populations of humans and animals this increases the chance of contacts of pathogens with immune-naive populations and hence increases the potential for zoonotic spillover to occur as well as to lead to sustained outbreaks rather than individual cases. All these factors interact in creating risk. Spillover occurs when pathogen with zoonotic potential, occurs in an animal that has sufficient contact with humans, with or without an intermediate host such as a domestic animal, and if these humans are sufficiently immune naïve to contract the pathogen. Outbreaks then occur when the epidemic potential of the pathogen, i.e. the ability to replicate and transmit in humans meets the right contextual factors such as population density, mobility and factors of the healthcare system including health-seeking behaviour.

8. Among the biosecurity issues generated by zoonotic spillover, there are three that are of particular pandemic and epidemic concern: pandemic influenza virus strains, coronaviruses and Disease X – although strictly speaking, Disease X does not have to be a zoonotic pathogen. Both coronaviruses and pandemic influenza strains have caused pandemics in the past. Likely pandemic potential is marked by several pathogen characteristics such as high adaptability, meaning generally RNA viruses are more likely candidates than DNA viruses, high transmissibility, and becoming infectious rapidly when clinical disease is still absent or minimal. This applies particularly to influenza and coronaviruses, while Disease X has been specifically coined to describe a pathogen fulfilling those characteristics but not yet known. (King, 2020)

Pandemic influenza (Influenza A virus)

9. The original hosts of influenza pandemics are usually wild aquatic birds with intermediary hosts found among wild birds, domestic birds (including livestock) and mammals such as pigs (CDC, 2022a, Long, Mistry et al., 2019, World Health Organization, 2018a).

10. Overview of past influenza pandemics in the 20th and 21st centuries:

- 1918-1920: H1N1, estimated to have infected 500 million people worldwide, resulting in an estimated 50 million deaths (CDC, 2019a).
- 1957-1958: H2N2, estimated 1.1 million deaths worldwide (CDC, 2019b).
- 1968-1969: H3N2, estimated 1 million deaths worldwide (CDC, 2019c).

- 1977-1978: H1N1, estimated 700,000 deaths worldwide (Michaelis, Doerr et al., 2009).

- 2009-2010: H1N1, estimated over 200 million cases worldwide, resulting in approximately 18,500 laboratory-confirmed deaths, estimates of the true mortality go as high as 285,000 (Dawood, Iuliano et al., 2012)[1].

Coronaviruses

11. The original hosts of coronaviruses are most likely bats with intermediary hosts in previous outbreaks having been other mammals such as civet cats (SARS-CoV-1) and dromedary camels (MERS-CoV) (World Health Organization, n.d.-b, World Health Organization, 2022a, Wang and Eaton, 2007, Li, Shi et al., 2005, Cui, Li et al., 2019).

12. Overview of past coronavirus pandemics:

    - Severe Acute Respiratory Syndrome (SARS), 2002-2003: Causative agent: SARS-CoV-1; emergence in Southern China in 2002 and spread to several countries in Asia, North America, and Europe; containment in 2003; over 8,000 cases and 774 deaths globally (World Health Organization, 2015).

    - Middle East Respiratory Syndrome (MERS), 2012-present: Causative agent: MERS-CoV; identification in Saudi Arabia in 2012; spread to several countries in the Middle East, Africa, and Asia; as of 2021, over 2,500 confirmed cases and over 850 deaths (World Health Organization Regional Office for the Eastern Mediterranean, 2022, World Health Organization, n.d.-b).

    - Coronavirus disease 2019 (COVID-19), 2019-present: Causative agent: SARS-CoV-2; emergence in Wuhan, China in late 2019; global spread; as of 3 February 2023, the WHO has reported more than 754 million cases and 6.8 million deaths worldwide (World Health Organization, n.d.-f).

    - There have recently been suggestions that the 1889-1890 pandemic which was referred to as an influenza pandemic initially might have been caused by human coronavirus OC43 (Brüssow and Brüssow, 2021, Vijgen, Keyaerts et al., 2005).

Disease X

13. *Disease X* describes a hypothetical future disease with the potential to cause a global pandemic. The concept of *Disease X* was introduced in the WHO's Global Research and Innovation Forum in 2018 and has remained on the list of prioritised diseases for research and development in emergency contexts (World Health Organization, n.d.-c). This list otherwise spans diseases such as viral haemorrhagic fevers, SARS,

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[1] Estimates of true mortality are based on modelling with the usual limitations. However, it can be assumed that reported laboratory-confirmed deaths are a considerable underestimation due to lack of laboratory capacity and confirmation in many settings.

MERS and COVID-19 and other high-consequence diseases[2]. As a hypothetical addition, "Disease X represents the knowledge that a serious international epidemic could be caused by a pathogen currently unknown to cause human disease. The Research and Development (R&D) Blueprint explicitly seeks to enable early cross-cutting R&D preparedness that is also relevant for an unknown "Disease X". (World Health Organization, n.d.-c) The Blueprint is aimed primarily at researchers in academic, private sector and governmental institutions (including UKHSA and NIHR).

14. Thus, the addition emphasises the need for preparedness and research to respond to new and emerging diseases, even if the specific pathogen or disease is not yet known. *Disease X* represents the uncertainty and unpredictability of future disease outbreaks and serves as a reminder that diseases can emerge suddenly and spread rapidly, with devastating effects on global health and economies.

15. As such diseases and pathogens known to be of pandemic potential, are, by definition, not *Disease X*. Hence, *Disease X* is not a specific disease, but rather a hypothetical scenario meant to highlight the importance of preparedness and research in the face of uncertainty and unpredictability in the emergence of new diseases. While this means that *Disease X* is not specifically zoonotic, with the majority of emerging diseases being zoonotic (Olival, Hosseini et al., 2017, King, 2020, Woolhouse and Gowtage-Sequeria, 2005, Murphy, 1998, Madhav, Oppenheim et al., 2017) it seems most likely that a naturally occurring *Disease X* will have a zoonotic origin. Therefore, Disease X has been grouped with zoonotic diseases here.

1.2.2. Anti-microbial resistance

16. The second major biosecurity issue with pandemic relevance is anti-microbial resistance (AMR). AMR describes the evolutionary ability of microorganisms such as bacteria, viruses, fungi, and parasites to resist the effects of antimicrobial drugs such as antibiotics, antivirals, antifungals, and antiparasitics. This phenomenon occurs when microorganisms evolve and develop mechanisms that can neutralise the drugs designed to neutralise them. This has the potential to significantly reduce our ability to treat infections. The World Health Organization (WHO) has designated AMR as one of the top 10 threats to global health (World Health Organization, n.d.-e, World Health Organization, 2020a). Beyond the transmissibility of the individual pathogen, which varies widely across the pathogens capable of resistance, AMR poses the further issue of transmissibility of resistance genes between pathogens. AMR has complex drivers among the human-animal-environment interfaces and within a wide range of sectors including, among others, the use of antimicrobials in agriculture and human prescribing practices (Holmes, Moore et al., 2016, Vikesland, Garner et al., 2019, World Health Organization, 2021). AMR has gained the label "silent pandemic"

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[2] The UK government defines high consequence infectious diseases (HCID) according to the following criteria: acute infectious disease, typically has a high case-fatality rate, may not have effective prophylaxis or treatment, often difficult to recognise and detect rapidly, ability to spread in the community and within healthcare settings, requires an enhanced individual, population and system response to ensure it is managed effectively, efficiently and safely (UK Health Security Agency (2023)

as it occurs over time with less visibility than other pandemic threats. In 2016, AMR was predicted to kill about 10 million people per year by 2050 (The Review on Antimicrobial Resistance, 2016) and there were an estimated 5 million deaths associated with AMR worldwide in 2019 (Murray, Ikuta et al., 2022). However, while the precise future impact of AMR is uncertain, advancing AMR has the potential for catastrophic consequences as antimicrobials such as antibiotics are a cornerstone of modern medicine including particularly post-surgical care and with antimicrobials becoming less effective or even ineffective care would be significantly compromised (World Health Organization, 2021, Dixon and Duncan, 2014). In 2022, Dame Sally Davies, the UK special envoy on AMR warned that "Anti-microbial resistance could kill us before the climate crisis does" (Ferber, 2022).

17. Below are some of the key, current AMR risks:

- Methicillin-resistant Staphylococcus aureus (MRSA): a common bacterium resistant to members of the penicillin antibiotic class such as methicillin and several other antibiotics; MRSA is a key pathogen for outbreaks in healthcare settings.

- Multidrug-resistant tuberculosis (MDR-TB) and extreme-drug-resistant tuberculosis (XDR-TB): bacterium resistant to multiple antibiotics or most antibiotics. MDR-TB is a growing concern in many parts of the world, particularly in countries with high rates of TB and poor healthcare systems.

- Fluconazole-resistant Candida: fungus resistant to fluconazole, an antifungal drug used to treat Candida infections. Fluconazole-resistant Candida is particularly dangerous to individuals with weakened immune systems and can cause severe outbreaks in healthcare settings.

- Pan-resistance: resistance profiles of several microorganisms, particularly bacteria, are constantly evolving, and we are moving from situations of resistance to one or more key antimicrobials such as in the case of MRSA to multidrug- and extreme-drug-resistance as seen in the case of TB. The risk for the future is the occurrence of pan-resistant organisms that are resistant to all treatments including reserve antibiotics.

1.2.3. Human-origin biosecurity risks of pandemic potential

18. The two categories of biosecurity issues with relevance to pandemics explained previously focus predominantly on the natural occurrence of potentially pandemic diseases. There is, however, also a non-zero risk of a pandemic originating from either deliberate or accidental human behaviour. Three main issues fall within this category: laboratory accidents, malicious use of biological material by state actors and malicious use of biological materials by non-state actors. The latter includes both terrorist and criminal intent.

19. Laboratory accidents have happened in the past. In 2003 and 2004, four incidents involving SARS-CoV-1 occurred in Singapore, Taiwan, and mainland China. In only one of those incidents was onward transmission to a small group of people detected

at the time (Senior, 2003, CIDRAP, 2003, Walgate, 2004, Taiwan CDC, 2014). One of the largest outbreaks associated with a laboratory incident was the 2007 foot and mouth disease outbreak in the UK which led to the culling of 2,000 animals on nearby farms (Department for Environment Food and Rural Affairs, 2008). The only confirmed larger outbreak associated with a laboratory incident was the 2019 Brucella outbreak in Lanzhou, China, which was caused by a leak from a biopharmaceutical plant and led to approximately 10,000 non-fatal cases of brucellosis in the city (Pappas, 2022, Shim, 2020). However, no other large human outbreaks or pandemics, to date, have been traced back to a laboratory accident with certainty. This might be due to national secrecy with suppression of information, or the enhanced security and surveillance around high-containment laboratories which increase the likelihood of early detection. With the increasing numbers of such laboratories, there will be an increased risk of a laboratory leak as no containment system can be absolutely foolproof. However, the likelihood of laboratory derived outbreaks is far outweighed by that from the natural world.

20. Biological warfare by state actors dates to antiquity and has been subjected to international restriction in the 1925 Geneva Protocol and later in the 1972 Biological Weapons Convention (in force since 1975), which is still in effect today and bans biological warfare and offensive bioweapons research. As of February 2023, 184 states have become party to this treaty, including, since 1972, the United Kingdom (United Nations Office for Disarmament Affairs, 2021).

21. Non-state actors have in the past attempted to maliciously use biological material for both criminal and terrorist intent. The largest incidents include the 1984 Salmonella typhimurium outbreak in Oregon caused by a religious commune of followers of Rajneesh / Osho which led to 751 cases and the attacks by the Japanese cult Aum Shinrikyo in the 1980s and 1990s. Aum Shinrikyo experimented with sarin (a chemical agent), and two bacteria: *Bacillus anthracis* and *Clostridium botulinum,* both of which cannot be transmitted from human to human. They also tried unsuccessfully to acquire *Ebola zaire virus* in Zaire (now DR Congo) (Monterey Institute of International Studies, 2001). While there is public controversy about the origin of the Covid-19 pandemic, in our view, having reviewed the literature in the public domain, we feel that a zoonotic spillover associated with a wet market is the most likely source of the first human infections. However, other hypotheses, such as a laboratory leak cannot be dismissed at this point and risk mitigation should cover all plausible scenarios.

1.3. Biosecurity countermeasures

22. Some of the biosecurity considerations with emerging infections are:

- a small cluster of infections has variable potential to become widely established in the population and this is challenging to predict accurately in advance
- this means that in the early stages of an outbreak the likely public health burden is unpredictable and could range from trivial to devastating

- when more surveillance for emerging infections is conducted, there will be more 'false alarms' as an increasingly small proportion of the possible clusters of infection that are identified will lead to a widespread epidemic
- this means that there is a significant impact of the threat of an outbreak in terms of preparedness, whether an epidemic occurs or not
- the disruption to social and economic life and the cost, both in finance and opportunity, may be disproportionate to the morbidity burden of an epidemic
- Public communication and transparent risk assessment processes are essential to maximise social and scientific cohesion especially at times of uncertainty
- It is important to steer a course between complacency and overreaction for the general public and policy makers.

23. To appropriately prepare for and respond to the above-mentioned biosecurity challenges, a suite of countermeasures is essential in a spirit of One Health, interdisciplinary research and response, resilient and well-funded health systems and global health governance coordination (Traore, Shanks et al., Bedford, Farrar et al., 2019, Pan-European Commission on Health and Sustainable Development, 2021). One Health describes the collaborative, multisectoral, and transdisciplinary approach to health, including to infectious disease events, that recognises the interconnectedness of humans, animals and their environment and the impact this has on diseases they share. The concept of One Health goes back to the term One Medicine, coined in 1964 and has become a focus in the 2000s, with the UK Human Animal Infections and Risk Surveillance group (HAIRS) being established in 2004. See paragraph 46 for more details of HAIRS. The US CDC Office for One Health was established in 2009 and the following year, the FAO-OIE-WHO Tripartite Collaboration was first established. The High-Level Expert Panel which advises the Tripartite was established in 2021. In 2022, the Tripartite was extended to a Quadripartite with the inclusion of the United Nations Environment Programme. One Health becomes particularly relevant in the case of zoonotic diseases such as Covid-19, Ebola, Nipah and Mpox and their (re-)emergence (Kelly, Machalaba et al., 2020, Ghai, Wallace et al., 2022, World Health Organization, 2022b, CDC, 2022b, CDC, 2023). In the case of Covid-19, we have seen the importance of this, with "spillback" occurring from humans to mink and other animals and then spillover back into humans from some of these animals (Munnink, Sikkema et al, 2020). Another key area for One Health is antimicrobial resistance across humans, animals and the environment.

24. The specific technical measures listed below are examples of key biosecurity countermeasures, their order of appearance is not indicative of a judgement of their respective importance. Many of them are already parts of existing systems and mechanisms.

1.3.1. Surveillance and alert systems

25. Surveillance and early alert is a key element of the ability to respond in a timely manner. Surveillance describes the systematic collection of data on infectious diseases through mechanisms such as notification systems or event-based surveillance to generate data for action. Surveillance systems can be disease specific such as in the case of classical notification-based surveillance systems (see paragraphs 62-67) or broader, examples of the latter are event-based surveillance and syndromic surveillance as well as epidemic intelligence. In the context of outbreak detection, and thereby also pandemic detection, a system's ability to recognise changes in epidemiology early as well as an overall timely system (from first notification or other notice to an alert in the surveillance system) becomes a key indicator (The Independent Panel for Pandemic Preparedness & Response, 2021).

1.3.2. Global coordination and leadership

26. Currently, the International Health Regulations 2005 (World Health Organization, 2005) govern the global detection of and response to global health threats. They also set out the minimum standards countries need to adhere to and the mechanisms for assessing these standards in the form of Joint External Evaluations (JEEs). As the biosecurity threats and challenges with the highest pandemic relevance are by their nature international, such mechanisms for international standardisation and collaboration are key to counter them at the international level. The IHR are currently being rewritten and are expected to be integrated into the new Pandemic Treaty in the future which needs to give a strong basis for international coordination, including the relevant funding (The Independent Panel for Pandemic Preparedness & Response, 2021, Pan-European Commission on Health and Sustainable Development, 2021, G20 High Level Independent Panel on Financing the Global Commons for Pandemic Preparedness and Response, 2021).

1.3.3. Response capacity with scale-up capacity

27. It is also critical that there is sufficient capacity to respond to any alert generated by one or more surveillance systems (Pan-European Commission on Health and Sustainable Development, 2021, G20 High Level Independent Panel on Financing the Global Commons for Pandemic Preparedness and Response, 2021). This includes initially the verification of the alert, i.e. the investigation and subsequent determination of whether it is truly an outbreak of an infectious disease or not. In the case of a true alert, timely scalability of response capacity, including field epidemiological support, laboratory capacity and clinical response are needed locally and nationally. For field epidemiology, both the Global Health Security Agenda and the World Health Organization through the Joint External Evaluations (JEE) have adopted the metric of one trained field epidemiologist per 200,000 population as the global public health workforce target (World Health Organization, 2018b, Williams, Fontaine et al., 2020, Jones, Dicker et al., 2017, CDC, 2014). This metric is a scaled-down version of the US target of one field epidemiologist per 100,000 population to account for international variation, particularly in low- and middle-income countries (Williams, Fontaine et al., 2020). Graduates from intermediate and advanced field epidemiology training programmes (FETPs) are used as an international proxy, and

we note that the 2-year UKHSA FETP currently recruits 8-10 fellows annually. However, FETP graduates are not the only scientists who could potentially be counted as field epidemiologists for these calculations and are not the only ones counted in the original context of the US. In light of these uncertainties, increased response and scale-up capacity would also require an improved metric for calculation including a definition of (field) epidemiologists. Without such it is challenging to determine if enough suitably trained personnel are being recruited, trained, and retained.

1.3.4. Stockpiling and supply chains

28. While we cannot anticipate the exact details of the next pandemic threat, there are some elements that remain similar across the biosecurity challenges outlined above. Hence, it is not unreasonable to consider stockpiling and maintaining supply chains for some key items as an essential biosecurity countermeasure (G20 High Level Independent Panel on Financing the Global Commons for Pandemic Preparedness and Response, 2021). This refers mainly to personal protective equipment (PPE) such as high-quality masks (medical, FFP-2 and FFP-3 standards as a minimum), gowns, gloves, and similar equipment. These items are essential to maintain healthcare capacity, prevent the infection of healthcare workers (and other key workers if relevant in the specific circumstances) and reduce the likelihood of nosocomial infections.

1.3.5. R&D for scalable medical countermeasures in peacetime

29. Continuing research activities involving multiple scientific disciplines are essential to improve preparedness, prevention and response to outbreaks (The Academy of Medical Sciences, 2019). For example: environmental science to understand better the determinants of the emergence of infections; epidemiologists to understand who is getting infected, how this occurs and spreads; microbiologists to identify the organism and develop diagnostic tests; clinicians to describe the features of the disease and likely consequences; social scientists to explore community perceptions and responses to an infectious disease; animal health experts to investigate infections in non-human animals; experts to advise on means of infection prevention and control; experts who can develop and test therapeutic drugs and preventive agents such as vaccines. This requires co-ordinated multidisciplinary research ideally conducted in networks encompassing scientific groups in a variety of settings including low-resource countries.

30. The Covid-19 pandemic has demonstrated the importance of medical countermeasures such as vaccines, antivirals and similar pharmaceutical products (Pandemic Preparedness Partnership, 2021, The Independent Panel for Pandemic Preparedness & Response, 2021, G20 High Level Independent Panel on Financing the Global Commons for Pandemic Preparedness and Response, 2021). The speed of development and production during this pandemic has been unprecedented. To maintain the ability to respond speedily to emerging biosecurity threats, the continued development of medical countermeasures such as for example the development of diagnostic tests, especially those that can give rapid results and be administered as

close to the patient as possible, pan-coronavirus and pan-influenza vaccines, platform trials to test therapeutic agents and vaccines and other measures including those mentioned in paragraph 29 that can be instituted during peacetime or are quickly implementable during the early stages of an outbreak are essential.

1.4. Biosecurity:Summary and conclusion

31. Threats to biosecurity that have potential pandemic impact thus fall into three distinct categories: emerging and re-emerging zoonotic diseases, AMR and malicious or accidental release of biological materials. Past pandemics have shown the considerable potential of novel zoonotic diseases to pose pandemic threats, particularly under conditions of globalisation and increased human-animal interactions as well as increased density and mobility of human and animal populations worldwide. Because of this potential and the resulting risk as well as the possibility for the emergence of previously unknown pathogens, Disease X can also most likely be grouped in this category. Additionally, with the increase in AMR, we are facing a creeping, silent pandemic with potentially devastating effects on society, economy, and healthcare. Finally, while the malicious or accidental release of pathogens have so far not been proven to have caused harm on the scale of zoonotic pandemics, this cannot be ruled out in the future.

32. While the biosecurity threats outlined above are varied in their appearance, many of the suggested biosecurity countermeasures are appropriate across different biosecurity threat scenarios. The ability to detect threats early, respond decisively and at the appropriate scale and minimise morbidity, mortality and disruption are essential to all biosecurity challenges. This requires both technical countermeasures such as the ones outlined above as well as a broader response including health systems strengthening and financing and an interdisciplinary and One Health-focused preparedness, response, and research ecosystem.

Q2: THE EXTENT AND SIGNIFICANCE OF THE RISK OF ANY KNOWN VIRUSES OF CONCERN AND/OR ANY NEW VARIANTS OF SARS COV TYPE VIRUSES AND ASSOCIATED EMERGING INFECTIOUS DISEASES, INCLUDING THOSE INVOLVING VIRAL TRANSMISSION BETWEEN ANIMALS AND HUMANS

2.1. Introduction

33. Worldwide, the number of potential pathogens that could cause an epidemic is very large, while the resources for epidemic preparedness and response and for disease research and development (R&D) is limited. It is thought that over 1.5 million undescribed viruses exist in mammals and birds, of which about half are thought to have the potential to spill over into humans and cause epidemics (Grange, Goldstein et al., 2021). WHO declared on 30 January 2023 that COVID-19 remains a Public Health Emergency of International Concern (PHEIC), three years after the emergency was first declared. This decision was made on the basis of the continued high rates of infection and disease, the potential risks of transmission between animal species and the possibility of animal reservoirs of infection, and the likelihood of the emergence of new variants of concern (McVernon and Liberman, 2023). But

SARS-CoV-2 is just one of many potential viral threats to humans. The majority of new virus infections are zoonoses - infections that have spilled over from animals to humans and caused disease in people (Olival, Hosseini et al., 2017). It is estimated that of 586 known viruses in mammals: 55% are exclusive to other mammals; 13% are exclusive to humans; and 32% are shared, i.e. zoonoses. While these known zoonotic viruses are of ongoing concern to human health, the as-yet-unidentified viruses also pose a serious threat to humanity.

2.2. Priority diseases

34. Identifying all potential viral threats, quite apart from the risks from bacteria, fungi and parasites, is currently an insurmountable challenge, and so efforts have been made to try to predict the characteristics that make spillover from other animals into the

human population more likely. There are potential biosecurity risks of collecting specimens from wildlife, so this needs to be done in a targeted and responsible manner (Sandbrink, Ahuja et al., 2022). Scientists have examined host and viral traits, geographical hotspots, rodent reservoirs, the effect of climate change amongst other factors to gain some insights into the ranking of risk, but this is still at an early stage and remains a work in progress (Grange, Goldstein et al., 2021, Olival, Hosseini et al., 2017, Woolhouse, Brierley et al., 2016, Woolhouse, Haydon et al., 2005, Jones, Patel et al., 2008a, Han, Schmidt et al., 2015, Geoghegan, Senior et al., 2016, Mollentze and Streicker, 2020).

2.2.1. World Health Organization

35. WHO has established a R&D Blueprint to work on a priority list of diseases and pathogens that have the potential to cause public health emergencies around the globe (World Health Organization, n.d.-c, Mehand, Al-Shorbaji et al., 2018). To ensure efforts under WHO's R&D Blueprint are focused and productive, a list of diseases and pathogens are prioritised for R&D in public health emergency contexts. This identifies the diseases which pose the greatest public health risk due to their epidemic potential and whether there are no, or insufficient, countermeasures in terms of diagnostics, therapeutics and vaccines. The list is periodically reviewed and minor alterations have been made over time. At present, the priority diseases are:

    - COVID-19
    - Crimean-Congo haemorrhagic fever
    - Ebola virus disease and Marburg virus disease
    - Lassa fever
    - Middle East respiratory syndrome coronavirus (MERS-CoV) and Severe Acute Respiratory Syndrome (SARS)
    - Nipah and henipaviral diseases
    - Rift Valley fever
    - Zika
    - "Disease X" (a pathogen currently unknown to cause human disease).

36. This is not an exhaustive list, nor does it indicate the most likely causes of the next epidemic. WHO reviews and updates this list as the need arises. Based on the priority diseases, WHO then works to develop R&D roadmaps for each one.

2.2.2. United Kingdom

37. Pandemics and high-consequence infectious disease outbreaks are listed on the UK National Risk Register, but apart from the mentioning of pandemic influenza and COVID-19, there is no listing of priority diseases with epidemic potential for which the UK is prepared (HM Government, 2020). The closest to this is the list of high consequence infectious diseases that the Advisory Committee on Dangerous Pathogens considers (UK Health Security Agency, 2023). These are:

Contact transmission

- Argentine haemorrhagic fever
- Bolivian haemorrhagic fever
- Crimean Congo haemorrhagic fever
- Ebola virus disease
- Lassa fever
- Lujo virus disease
- Marburg virus disease
- Severe fever with thrombocytopaenia syndrome

Airborne transmission

- Andes virus infection
- Avian influenza A (H7N9, H5N1, H5N6 and H7N7)
- Middle East respiratory syndrome (MERS)
- Mpox (clade 1)
- Nipah virus infection
- Pneumonic plague
- Severe acute respiratory syndrome (SARS).

38. The UK Vaccines Network (UK Vaccine Network, n.d.) in 2016 identified a list of pathogens for which investment in vaccine development has been identified as a priority. These are:

- Chikungunya virus
- Crimean Congo Haemorrhagic Fever (CCHF) virus
- Ebola virus
- Hantavirus
- Lassa Fever virus

- Marburg virus
- Middle Eastern Respiratory Syndrome (MERS) virus
- Nipah virus
- Plague (Yersinia pestis)
- Q fever (Coxiella burnetii)
- Rift Valley Fever virus
- Zika virus

39. However, this does not mean these pathogens are thought to be of the highest risk of causing public health consequences in the UK, merely that in global terms these are diseases for which development of vaccines would be most beneficial (excluding influenza, which is addressed separately).

40. We are aware that the Department of Health and Social Care has been recently leading a working group on Emergency Preparedness Countermeasures. It may be that this group has drawn up a list of priority diseases.

2.2.3. United States of America

41. In the USA, the National Institute of Allergy and Infectious Diseases (National Institute of Allergy and Infectious Diseases, 2018) produces and updates a pathogen priority list of emerging infectious diseases. This is based on various criteria:

    - Can be easily disseminated or transmitted from person to person
    - Result in high mortality rates and have the potential for major public health impact
    - Might cause public panic and social disruption
    - Require special action for public health preparedness

The highest-risk pathogens (Category A) are:

- Bacillus anthracis (anthrax)
- Clostridium botulinum toxin (botulism)
- Yersinia pestis (plague)
- Variola major (smallpox) and other related pox viruses
- Francisella tularensis (tularemia)[3]

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[3] This refers to *F.tularensis.tularensis* subspecies and not *F.tularensis.holarctica*, which is present in Europe and is less pathogenic

- Viral haemorrhagic fevers:
    - Arenaviruses
    - Junin, Machupo, Guanarito, Chapare, Lassa, Lujo
    - Bunyaviruses
    - Hantaviruses causing Hanta Pulmonary syndrome, Rift Valley Fever, Crimean Congo Haemorrhagic Fever
    - Flaviviruses
    - Dengue
    - Filoviruses
    - Ebola and Marburg viruses

42. It should be noted that this list was drawn up before the COVID-19 pandemic. It is also worth noting that influenza viruses are in the third rank of priority pathogens, although it is recognised that they have potential for high morbidity and mortality rates and major health impact.

43. In addition, the National Center for Emerging and Zoonotic Infectious Diseases (NCEZID) at the US Centers for Disease Control and Prevention has developed a One Health Zoonotic Disease Prioritization (OHZDP) process that brings together representatives from human, animal, and environmental health sectors to prioritise zoonotic diseases of greatest concern and develop next steps and action plans to address the priority zoonotic diseases (CDC, 2022b).

2.3. Expert advisory groups in the UK

44. The UK government has or had a number of expert groups that help advise on aspects of emerging infections.

45. The New and Emerging Respiratory Viral Threats Advisory Group (NERVTAG) (New and Emerging Respiratory Virus Threats Advisory Group, n.d.) is an expert committee of the Department of Health and Social Care (DHSC), which advises the Chief Medical Officer (CMO) and, through the CMO, ministers, DHSC and other government departments. It provides scientific risk assessment and mitigation advice on the threat posed by new and emerging respiratory viruses and on options for their management. This is highly relevant to assessing risks and advising on countermeasures, but it considers only respiratory viruses (including influenza) and not the whole range of potential emerging infections.

46. The Human Animal Infections and Risk Surveillance (Human Animal Infections and Risk Surveillance group (HAIRS), 2022) group is a multi-agency cross-government horizon scanning and risk assessment group established in 2004. It includes representatives from the UK Health Security Agency, Department for Environment, Food and Rural Affairs, Department of Health and Social Care, Food Standards

Agency, Animal and Plant Health Agency and their counterparts in the devolved nations. It aims to identify and assess the risk of emerging and potentially zoonotic infections which may pose a threat to UK public health. This group is highly relevant to assessing risks and to some extent on advising on countermeasures, but it considers only zoonotic diseases and not the whole range of potential emerging infections.

47. The Advisory Committee on Dangerous Pathogens (ACDP) (Advisory Committee on Dangerous Pathogens, n.d.) is an expert committee of the Department of Health and Social Care (DHSC) which provides as requested independent scientific advice also to the Health and Safety Executive (HSE), UK Health Security Agency (UKHSA) and the Department for Environment, Food and Rural Affairs (DEFRA) on hazards and risks to workers and others from exposure to pathogens. However, its remit does not include horizon scanning or surveillance.

48. The National Expert Panel on New and Emerging Infections (NEPNEI) (Department for Health and Social Care, 2008) was established in 2003 to provide independent expert advice to the England Chief Medical Officer on the public health risk from new and emerging infections. NEPNEI assessed risks based upon scientific evidence and best available clinical and epidemiological expertise. This Panel was disbanded about 10 years ago, which seems unfortunate as it assessed risks and countermeasures for the whole range of potential emerging infections (apart from pandemic influenza).

49. The Scottish Government has established a Standing Committee on Pandemic Preparedness comprised of scientists and technical experts to advise the Scottish Government on the future risks from pandemics (https://www.gov.scot/groups/standing-committee-on-pandemic-preparedness/)

Q3: THE DIFFERENCES BETWEEN FORECASTING, MODELLING, HORIZON SCANNING AND EPIDEMIC INTELLIGENCE AND THE BENEFITS OR LIMITATIONS OF ASSISTANCE TO BE GAINED FROM EACH OF THESE PROCEDURES

These four terms all relate to activities that are used to predict or detect epidemics. They are all essential elements of a surveillance system.

3.1. Forecasting

50. Forecasting of infectious disease aims to predict characteristics of both seasonal epidemics and future epidemics and pandemics. If they are accurate and timely, infectious disease forecasts can inform preparation and mitigation public health responses. Forecasting can include: (1) routine surveillance of the targeted diseases; (2) modelling the disease risk based on historical surveillance and contemporary environmental data; and (3) forecasting future risk through the use of predictive models and continued epidemiological and environmental surveillance.

51. For predictable seasonal epidemics, it is challenging to predict the size and severity of the outbreak in advance. For other epidemics, it is rarely possible to predict in advance what infection will emerge to cause an epidemic, in what place and when. Inferences can be drawn for particular countries when outbreaks have occurred elsewhere. So, for example, it is reasonable to be concerned about the risk of vector-borne diseases such as dengue and malaria occurring in the UK because of their documented northward spread associated with global warming (CLIMATE-ADAPT, n.d.).

3.2. Modelling

52. Epidemic modelling uses mathematical, statistical, and computational approaches to study the spread of communicable pathogens in host populations. It uses data and hypotheses describing the demographic processes, environmental characteristics, transmission opportunities, and health consequences of diseases to construct forecasts and scenarios. These models provide a simplified representation of the real world, and their construction is the result of structural choices motivated by previous knowledge, data and observation and a set of assumptions based on understanding of the epidemic under study. Different models may therefore arrive at different

forecasts and conclusions depending on the choices on how they have been constructed and the assumptions used.

53. Models can be used to inform public health responses, especially in the short to medium term and can be used to test the hypothetical effect of different interventions.

3.3. Horizon Scanning

54. Horizon scanning is a technique for detecting early signs of potentially important developments through a systematic examination of potential emerging disease threats, by regular review of information available on the internet and reports from elsewhere. Choices can be made about how widely to trawl through information, as the more information that is gathered, the faster clusters of cases that might represent any early outbreak will be identified, but there will be more false alarms and more information to be sifted. So, for example, approximately 24,000 signals of potential events are screened annually by the Pan-American Health Organization, with 5,000 (21%) of these being further analysed and 160 (0.6%) followed up (3 per week on average).

55. Horizon scanning is relatively simple and cheap to set up and once the system and routine is in place reports can be provided as often as required. For example, UKHSA conducts daily horizon scanning and reporting of suspected and confirmed outbreaks affecting human populations around the world. The same team also produces a monthly summary of the most important outbreaks, with a risk assessment for each one.

56. However, the line between horizon scanning and epidemic intelligence (discussed below) is blurred, and the above examples can be seen as examples of both horizon scanning and epidemic intelligence. The best way to distinguish the two is probably one of focus. Horizon scanning in general looks towards a broader future threat with results that might or might not be directly actionable. Epidemic intelligence on the other hand seeks to find actionable signals that then undergo further verification (see below).

3.4. Epidemic Intelligence

57. Epidemic Intelligence is a cycle of organised and systematic collection, analysis and interpretation of information from all sources to detect, verify and investigate potential health risks. At a global level there are substantial epidemic intelligence networks to help us know when an outbreak may be starting.

58. The Program for Monitoring Emerging Diseases (ProMED) (The Program for Monitoring Emerging Diseases (ProMED), n.d.) is a program of the International Society for Infectious Diseases. ProMED was launched in 1994 as an Internet service to identify unusual health events related to emerging and re-emerging infectious diseases and toxins affecting humans, animals and plants. ProMED operates 24 hours a day, 7 days a week and has subscribers in almost every country in the world. ProMED is a decentralised but edited information-sharing mechanism

that allows for early signal detection by sharing early insights into acute and protracted health events and asking subscribers for further information. ProMED first informed about a cluster of pneumonia of unknown aetiology in Wuhan on December 30[4]. In the UK PHE also provided timely information about the early stages of the COVID-19 outbreak. It first reported the outbreak on 31 December 2019, and regularly reported updates in the following days and weeks. On 16 January 2020, it reported the first cases diagnosed outside China and on 21 January that sustained human-to-human transmission was occurring.

59. The Global Public Health Intelligence Network (Public Health Agency of Canada, 2022) was set up in the late 1990s as a global network of connected professionals working to rapidly detect, identify, assess, prevent and mitigate threats to human health. It tracks events including disease outbreaks using leading-edge communications technology and automated processes on a real-time 24/7 basis complemented by human analysis to monitor media sources worldwide and provide organised, relevant information to users allowing them to respond to potential health threats in a timely manner. GPHIN is headquartered at the Public Health Agency of Canada in Ottawa, Ontario, Canada, and managed by the Centre for Emergency Preparedness and Response.

60. WHO has established a Hub for Pandemic and Epidemic Intelligence in 2021 (Morgan and Pebody, 2022). Based in Berlin, Federal Republic of Germany, this hub conducts global surveillance of emerging public health threats, as part of the WHO Health Emergencies Programme and works with all member states including the UK.

61. The Epidemic Intelligence from Open Sources (EIOS) initiative sits within the Health Emergencies Division at WHO It is a multi-stakeholder initiative that aims to create a "unified all-hazards, One Health approach to early detection, verification, assessment and communication of public health threats using publicly available information" (World Health Organization, 2023). EIOS consists of three pillars, the global community of practice that brings together other epidemic intelligence stakeholders and initiatives such as GPHIN, Health Map and ProMED among others, the stakeholder collaboration, and the actual EIOS system. The IT system of the EIOS initiative was developed under the technical and scientific lead of the European Commission's Joint Research Centre and provides a range of dashboards based on webscraping that seek to collate public health signals based on publicly available information across all regions and languages and provides basic interpretation and extraction tools. As such it condenses and makes available large amounts of data in an analysable and thus actionable format. In January 2022, the EIOS initiative moved to the new WHO Hub in Berlin.

3.4.1. Surveillance

62. At national level surveillance is a form of epidemic intelligence. Surveillance can be described as ongoing, systematic collection, collation, analysis & interpretation of

[4] Due to the difference in time zone between Boston, where ProMED is based and the UK, the report dates to December 31 in the UK.

data with dissemination of information to those that need to know in order that action may be taken.

63. A surveillance system can be used for identifying epidemics early to enable rapid and tailored control measures.

64. The architecture of surveillance requires:

- A reporting network: this can be focused on healthcare facilities, laboratories, or communities, and may include active case finding teams and contact tracing during outbreaks
- Decisions about what priority diseases to include, what information needs to be reported and how frequently
- Decisions about case definitions: how specific[5] and sensitive[6] do they need to be, sensitivity and specificity can be weighted against one another based on the specific needs of the individual surveillance system (e.g. a system designed for monitoring the progress towards disease elimination will value sensitivity over specificity)
- Analysis and Interpretation of the information, up to and including data science-based analytics approaches (Polonsky, Baidjoe et al., 2019)
- Decision-making
- Alert for action
- Feedback

65. Choices need to be made about the type of surveillance to be used.

A. Surveillance may be indicator- or event-based:

  - Indicator-based surveillance:
    - Routine' surveillance from healthcare infrastructure (hospital, clinics, labs, etc)
    - Organised collection, monitoring, assessment and interpretation of defined health indicators (diseases, syndromes)
    - Outbreaks are then identified by case numbers exceeding predefined thresholds triggering active reporting
  - Event-based surveillance:

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[5] Specificity refers to a system's ability to detect the right disease/event/pathogen, i.e. not classifying something as for example Ebola if it is Marburg or Lassa.

[6] Sensitivity refers to a system's ability to detect (nearly) all cases/events, i.e. not missing cases or events.

        - From a variety of sources including media, public, communities, healthcare system
        - Rumours and other informal sources made be incorporated
        - Immediate reporting – no regular reporting mechanism
        - Media scanning using tools such as EIOS and GPHIN on the global scale

B. Surveillance can be active or passive:

    - Active:
        - Direct engagement with healthcare providers
        - Can be enhanced during outbreaks
        - Provides immediate information
    - Passive:
        - Routine case counts
        - At regular frequency (e.g. weekly)
        - Can use pre-defined thresholds to define departure from normality which may indicate an outbreak and thus trigger a report

C. Surveillance can be exhaustive or sentinel:

    - Exhaustive: where public health action is case-specific and no case can be missed (e.g. Ebola)
    - Sentinel: where public health action is driven by trends and specific features of cases. Not all cases necessarily need to be identified but case number trend information needs to be specific

For practical reasons most surveillance systems are passive and indicator (health facility/clinician) based. Whether they are sentinel or exhaustive depends on the specific pathogen.

66. It is important to ensure that surveillance systems are effective and do protect public health. Integrated Disease Surveillance & Response (CDC, 2021) is one strategy to make surveillance more effective by integrating all surveillance activities in a country into one system. This is often adopted by low- and middle-income countries. The US Centers for Disease Control has also published useful guidelines for evaluation of Public Health Information Systems (Guidelines Working Group, 2001).

67. The UK Health Security Agency publishes information about how it detects and assesses emerging infections using all of these techniques (UK Health Security Agency, 2018/2023). This includes horizon scanning, epidemic intelligence, risk

assessments and updates produced by various groups and committees. It also administers the Imported Fever Service which provides clinical advisory and specialist diagnostic service for medical professionals managing travellers who have recently returned to the UK with fever (Greener, 2019).

Q4: MAIN POINTS OF INTEREST OR SIGNIFICANCE FROM A HIGH-LEVEL REVIEW OF INTERNATIONAL PROCESSES DEALING WITH SURVEILLANCE AND THE CONTROL OF INFECTIOUS DISEASES AND VIRUSES AND A BROAD COMPARISON WITH THE UK GOVERNMENT AND ITS DEVOLVED NATIONS

4.1. Introduction

68. Global Health Security is governed both by international law, primarily through the International Health Regulations (2005) (IHR) as well as through technical data sharing and coordination mechanisms.

4.2. International Health Regulations (2005)

4.2.1. Overview

69. The IHR are the overarching legal framework that governs states' obligations and duties when faced with a public health event or emergency that could have international implications. The IHR are written into international law and, therefore, legally binding in 196 countries, including the 194 member states of the World Health Organization (WHO). Besides governing national requirements and duties, as outlined below as well as the appointment of national focal points for IHR to adhere to reporting and notification requirements, the IHR also outlines the criteria for the declaration of a Public Health Emergency of International Concern (PHEIC). For the declaration of a PHEIC, three criteria need to be fulfilled. The event needs to be "serious, sudden, unusual or unexpected; carries implications for public health beyond the affected State's national border; and may require immediate international action" (World Health Organization, 2005).

70. The WHO coordinates the IHR implementation in all State Parties and supports capacity building for countries to be able to fulfil the requirements outlined in the IHR (2005). Specifically, it requires that countries are able to:

- Detect: Make sure surveillance systems and laboratories can detect potential threats
- Assess: Work together with other countries to make decisions in public health emergencies
- Report: Report specific diseases, plus any potential international public health emergencies, through participation in a network of National Focal Points
- Respond: Respond to public health events (World Health Organization, 2005).

71. To assess countries' readiness, Joint External Evaluations (JEE) can be conducted. A JEE is "a voluntary, collaborative, multisectoral process to assess country capacities to prevent, detect and rapidly respond to public health risks whether occurring naturally or due to deliberate or accidental events" (World Health Organization, n.d.-a). However, JEEs measure theoretical readiness of public health systems based on a set list of indicators and do not assess actual response to past or current outbreaks when practical considerations have been taken into account, such as underlying health of the population, state of the health system, political and policy decision making.

4.2.2. Situation in the United Kingdom

72. In the latest self-assessment of IHR indicators for the Global Health Observatory in 2021, the UK ranked at an average of 93% across the 15 IHR capacity scores that were assessed (World Health Organization, n.d.-d). For comparison, other large European countries such as Germany, France and Italy scored 87%, 86%, and 72% respectively. The average score for the WHO European Region was 74% and the global average is 64%. The only two areas in which the UK scored below 80% in 2020 were IHR Coordination, National IHR Focal Point functions and advocacy as well as Points of entry and border health. For 11 out of 15 capacity areas, the UK scored 100%.

73. In general, the devolved nations follow the same public health procedures as England, and indeed often participate in committees that bring together representatives from across the UK. The size of the public health bodies is smaller in the developed nations than in England, which can create some human resourcing constraints, but set against that the smaller number of staff means that more people know each other which can foster the development of cohesive teams.

4.3. European Centre for Disease Prevention and Control

4.3.1. Processes

74. Founded in 2005, the European Centre for Disease Prevention and Control (ECDC) is the European Union (EU) agency tasked with coordination in case of and countering cross-border health threats in the EU. It works in close collaboration with national public health institutes. Currently, under review with processes on the way

for a revised and expanded remit, the relevant processes at ECDC-level span five areas, four of which cover surveillance and threat detection and the last one being capacity building in the areas of field epidemiology and public health microbiology. Within the field of surveillance, ECDC coordinates the Early Warning and Response System (EWRS) for notification of member states on emerging and ongoing epidemics and other public health events. Secondly, ECDC coordinates TESSY, the European Surveillance System and provides data aggregation and analysis for reporting to member states. The third mechanism, the Epidemic Intelligence Information System (EPIS) is an exchange platform for technical information on health threats and finally, the Threat Tracking Tool (TTT) provides a database of public health events.

75. On the capacity-building side, ECDC coordinates the ECDC fellowships consisting of the European Programme for Intervention Epidemiology Training (EPIET) and the European Public Health Microbiology Training Programme (EUPHEM). These are the two advanced Field Epidemiology Training Programs (FETP) of the EU and member states with individual FETPs can be integrated into the EPIET/EUPHEM curriculum as EPIET-associated programs (EAPs), such as the German FETP (Postgraduiertenausbildung für Angewandte Epidemiologie).

4.3.2. Situation after Brexit

76. While ECDC is an EU agency, membership is possible beyond the member states of the EU, such as in the case of Norway. In 2018, the Faculty of Public Health (FPH) estimated that full membership at the time would have cost approximately 6 million euros per annum (Faculty of Public Health, 2018). With the end of the transition period as of 11 pm on the 31st of January 2020, the UK has formally left the ECDC and, therefore, the above-mentioned mechanisms. There are still options to access EWRS on a case-by-case basis if necessary. The UK FETP already left EPIET and the joint curriculum in the summer of 2020. Field epidemiology training is now provided by the UK Health Security Agency through a bespoke 2-year program that is no longer formally aligned with EPIET but covers broadly a similar curriculum and structure.

4.3.3. Enhanced mandate, EU Serious Cross-Border Threats to Health Regulation (2022) and creation of HERA

77. In response to the COVID-19 pandemic, the EU has made significant changes to its approach to cross-border health threats. In 2022, the new EU Regulation on Serious Cross-Border Threats to Health was formally adopted (European Parliament and Council of the European Union, 2022). This together with further changes has laid the foundation for an enhanced EU (and to a certain extent EEA) health security framework and health union. This includes an enhanced mandate for ECDC and the formation of a Health Emergencies task force as well as powers for the newly created European Health Emergency Preparedness and Response Authority (HERA). The thus completed EU Health Union now covers all aspects of responding to serious cross-border threats to health from early detection, surveillance and response to

medical countermeasures (Delsaux, 2022). Serious cross-border threats to health are therein defined as (pathogens with high pandemic potential; chemical, biological, radiological, and nuclear (CBRN) threats originating from accidental or deliberate release; and antimicrobial resistance (AMR)(Health Emergency Preparedness and Response Authority (HERA), 2022).

4.4. Other international initiatives

78. WHO established a Hub for Pandemic and Epidemic Intelligence in 2021 in Berlin, Federal Republic of Germany (Morgan and Pebody, 2022). This conducts global surveillance of emerging public health threats, is part of the WHO Health Emergencies Programme and works with all member states including the UK (see more details above in section 3.4). This Hub links to the Global Outbreak and Alert Response Network (GOARN) which brings together public health institutions around the world, with coordination from WHO, to enhance health emergency preparedness, response and resilience. The main thematic areas of GOARN are collaborative surveillance, clinical care, access to countermeasures, coordination and community protection. GOARN training fellowships have recently been announced and field training programmes in applied epidemiology and public health practice are conducted regularly. The GOARN Strategy was updated in 2022 (Global Outbreak Alert and Response Network (GOARN), 2023).

79. Public Health England has been seen internationally as something of a beacon in the area of public health, in particular for incorporating health promotion with other public health functions such as surveillance, research and emergency response capabilities. Both France (Santé Publique France) and Singapore (Communicable Disease Agency) have established or are establishing new agencies bringing these functions together to replicate the activities of PHE (Santé Publique France, 2021).

80. Sante Publique France hosts the secretariat of the International Association of Public Health Institutes (IANPHI) (The International Association of National Public Health Institutes, n.d.) which is a global network aiming to build public health capacity and capability by connecting, developing and strengthening national public health institutes. IANPHI was established in 2006 and has 115 member institutions in 98 countries, including the UK Health Security Agency, Public Health Scotland, Public Health Wales and the Institute of Public Health in Ireland (a research and policy analysis body, jointly funded by the Departments of Health in Ireland and Northern Ireland). By fostering international public health networks and strengthening institutional capacity IANPHI contributes to enhanced global health security.

81. The Task Force for Global Health, founded in 1984, is an international, non-profit organisation that works to improve the health of people most in need, especially in low- and middle-income countries (The Task Force for Global Health, n.d.). The Task Force runs the Training Programs in Epidemiology and Public Health Interventions Network (Training Programs in Epidemiology and Public Health Interventions Network (TEPHINET), 2023). TEPHINET runs 77 Field Epidemiology Training Programs (FETPs) in more than 100 countries to develop a workforce capable of

detecting and responding to health threats with the aim of strengthening public health systems and advancing global health security.

4.5. International coordination: Summary and conclusion

82. Global coordination in light of cross-border health threats and public health events is essential. This global coordination is formalised in international law and treaties and changes to the political landscape can have significant impacts such as seen in light of the changed relationship between the UK and ECDC.

83. At the moment, the global landscape of surveillance coordination for infectious diseases is in flux as changes are being made at several levels and it will take time to gather sufficient evidence to assess the impacts of these changes. On the global level, the negotiations about a Pandemic Treaty that may replace the current IHR are ongoing and, on the European level, the changes to the mandate of ECDC and the creation of a new EU agency, the Health Emergency Preparedness and Response Authority is shifting the landscape of surveillance and response. Developments regarding the Pandemic Treaty are likely in 2023 and the new ECDC mandate has come into force in 2022.

Q5: ANY IMPROVEMENTS IN INFECTIOUS DISEASE SURVEILLANCE THAT MAY BE MADE TO PREPARE THE UK FOR FUTURE PANDEMICS

5.1. Learning points from the COVID-19 pandemic

84. Following the main epidemic of COVID-19, The Independent Panel for Pandemic Preparedness & Response produced a main report which was presented to the World Health Assembly in May 2021 (Independent Panel for Pandemic Preparedness and Response, 2021). The main points were that if the global community wished to make COVID-19 the last pandemic, there was a need for:

- stronger leadership and better coordination
- a more focused and independent WHO
- investment in epidemic preparedness now
- stronger accountability mechanisms to spur action
- improved system for surveillance and alert
- a platform for vaccines, diagnostics, therapeutics and supplies with equitable delivery
- access to financial resources, for preparedness and response.

85. This recognises the need for robust surveillance and situates it within a system for pandemic preparedness and response. This includes:

- A trained, skilled workforce in multiple disciplines needed at community and national level
- Stockpiling of supplies: drugs, vaccines, infection prevention control equipment, and ensuring adequate transport and communication
- Preparedness planning: Joint External Evaluations (World Health Organization, 2018) and National Action Plans
- Scale up of in-country and external support for preparedness, including surveillance
- Improved Participation – from all walks of life, from marginalised communities to national experts.

5.1.1. Learning points for the United Kingdom

86. Reflecting on what this means for the UK, it is worth mentioning that overall the UK public health system was thought to be fairly well prepared for epidemics before the COVID-19 outbreak. This was evidenced by a high score in the Joint External Evaluation (JEE) exercise carried out in the pilot phase pre-pandemic and a score of 4/5 on the WHO Preparedness index (World Health Organization, 2017). A JEE is an information gathering tool mainly focused on low-resource countries to evaluate national capability to implement the IHR in 19 technical areas. These cover measures in place for epidemic prevention, detection, and response, border health arrangements, and for related hazards such as chemical and radiation events. The COVID-19 epidemic was unprecedented in recent times, and it would not be reasonable to expect the UK to be fully prepared for a hypothetical epidemic of this size of a previously unknown pathogen, with all the unknown variables involved.

87. Some of the recommendations that have been made by the scientific community to improve preparedness and response to epidemics include:

    a. Securing reserve laboratory capability within the health system to provide surge capacity for future outbreaks and pandemics. This needs a few highly skilled staff to develop new tests and larger numbers of less skilled people to do the testing. There is a need to balance effectiveness with sustainability. A mix of retained staff and voluntary reserves should be considered (Skittrall, Bentley et al., 2022).

    b. Better understanding of how to support minority ethnic groups and how healthcare providers and public health teams can work alongside community leaders to promote health messaging, improve health access, and prevent mistrust (Nellums, Latif et al., 2022).

    c. Ensuring scientific advisors appointed by the government are not only independent but autonomous. Independence is an essential element of the transparency required to gain community trust and engagement with clear understanding of who gave advice, what was that advice and what was done with it. Autonomy is needed to allow advisors to pose their own questions, and not simply answer questions posed by the government. This avoids potential omissions and assumptions, and guards against group-think (Jarman, Rozenblum et al., 2022).

    d. Re-evaluating the role of mathematical modelling in future pandemic responses. While modelling can be extremely useful for formulating an epidemic response, it needs to be better recognised by policymakers that modelling is inherently difficult given the complexity of the relationship between key parameters in the real world and the difficulty of quantifying those parameters. Consideration needs to be given to obtaining input from a wider range of sources including domain experts, e.g. the social care sector when designing models and assessing their plausibility. Communication could also be improved, for example, policy-makers and the general public have poor understanding of concepts such as exponential growth and the limitations of long-term forecasting (Pagel and Yates, 2022).

e. Making sure that structured learning happens in the aftermath of serious public health events such as a pandemic. This can be done by way of in-action and after-action reviews (AARs). The design of AAR will differ depending on the scope and type of emergency but is generally guided by five questions: What happened during the response (and what was supposed to have happened)? Why did it happen? What can be learned? What should change? Have changes taken place? Technical guidance for conducting AARs specifically for the COVID-19 pandemic response are available (European Centre for Disease Prevention and Control, 2020, European Centre for Disease Prevention and Control, 2023). AARs form part of the monitoring and evaluation framework within the IHR (World Health Organization, 2005).

88. We also recommend that consideration is given to the following:

a. Ensuring that action is taken from the learning points of regular simulation exercises for known and unknown epidemic threats.

b. Learning from the experiences in China and neighbouring Asian countries during the early stages of the COVID-19 epidemic, such as: being able to scale up diagnostic testing expertise and capacity early in an epidemic, being able to scale up case detection and contact tracing early in an epidemic, having a flexible approach to risk assessment for incoming travellers, ensuring hospitals and care homes are adequately resourced to cope with an influx of infected and infectious patients.

c. Recognition of the threat that epidemics pose to national security and ensuring adequate investment in preparedness, response capability and resilience. This requires clear senior political leadership, and long-term investment in health services, public health and social care.

d. Strengthen and clarify scientific leadership by reinstating the National Expert Panel On New and Emerging Infections (NEPNEI), or a similar body. NEPNEI provided independent expert advice to the Chief Medical Officer of England on the public health risk from new and emerging infections until it was disbanded (see section 2.3 for more details of NEPNEI). At present, there are a number of expert committees that fulfil part of this role, but it is not clear if and how these sources of advice are integrated into an overall national response.

e. Bringing together surveillance for influenza, and other respiratory viruses, with surveillance for other pathogens with epidemic potential. At present, these are treated separately by WHO and the UK. This is perhaps for historical reasons. The Global Influenza Surveillance and Response System was established in 1952 to make recommendations for the composition of seasonal and pandemic flu vaccines, provide scientific support for decision-makers and advise on pandemic preparedness for flu and other respiratory pathogens such as SARS-CoV1, MERS and SARS-CoV2 (Ziegler, Moen et al., 2022).

f. Ensure the UK has the ability to adequately respond to an epidemic with good epidemiological surveillance, including genomic sequencing, effective engagement and communication with society, rapid launch of clinical trials, development of diagnostic tests, vaccines and therapeutics (preventative and curative). This needs to be focused squarely on the NHS and public health capacities together with academia, which is where the vast majority of UK expertise resides. Examples of how this worked well during the COVID-19 pandemic include the COVID-19 Infection Survey led by the University of Oxford, an unbiased community-based survey which collected data from household visits and, later on, posted test kits, from April 2020 to March 2023; and the VIVALDI studies, which conducted sentinel surveillance in care homes, a high-risk group, led by University College London (UK Health Security Agency, 2023).

g. Engagement in this way with academic research groups is needed so that key unanswered questions arising during the early stages of an epidemic can be rapidly addressed. An example from the COVID-19 epidemic would have been to determine the role of airborne and droplet spread of infection (Lawton and Alwan, 2022).

h. In order to better assess public health workforce assessment a definition of epidemiologists and tracking of numbers of trained epidemiologists is advisable. This would be analogous to the Assessment of Epidemiology Capacity in State Health Departments regularly conducted in the US and could provide both current workforce and capacity assessments as well as form the basis for assessing workforce needs and related requirements for training and recruitment.

5.2. UK surveillance systems and possible future directions

89. The UK uses data from a number of sources for public health surveillance. Information on deaths broken down by age, sex, area and cause of death is collected by the Office for National Statistics (Office for National Statistics, 2023). Details of admissions, outpatient appointments and Accident and Emergency department attendances at National Health Service (NHS) hospitals in England are collected by NHS England (NHS Digital, 2023).

90. Surveillance is a core function for the UK Health Security Agency (previously Public Health England (PHE)) which manages a number of primary data collections (Public Health England, 2017) including:

- health protection incident/case management and outbreak control
- vaccination and immunisation services

- communicable and non-communicable disease surveillance
- microbiological and other specialist laboratory testing and reporting services (Public Health England, 2014)
- environmental, socio-economic, behavioural, and genetic health risk factor monitoring.

91. The Royal College of General Practice Research and Surveillance Centre (RCGP RSC) provides a general practice sentinel network that collects and monitors data from over 1700 practices across England and Wales. This reports on clinical syndromes with a limited amount of laboratory confirmatory testing, mainly for influenza by PCR testing (Royal College of General Practitioners, 2022).

92. In Scotland information on deaths is collected and reported by the National Records of Scotland, and Public Health Scotland collects information on hospital admissions and attendances, and surveillance and control of infectious diseases is conducted by the Clinical and Protecting Health Directorate (Public Health Scotland, 2022). Surveillance of 6% of GP practices has been conducted by Public Health Scotland and a new initiative Scotland Primary Care Information Resource (SPIRE) is planned to enhance this activity.

93. In Wales death information and GP consultations are covered by the same systems as in England. The Patient Episode Dataset for Wales (PEDW) collects information on inpatient and day case activity. The Health Protection Division of Public Health Wales aims to protect the population from the threats of infectious diseases (Public Health Wales, n.d.).

94. In Northern Ireland the Statistics and Research Agency collects information on deaths and the Department of Health publishes information on patient, day case and outpatient hospital activity. The Health Protection Service of the Public Health Agency of Northern Ireland conducts surveillance for infectious diseases, while the Department of Health is responsible for pandemic preparedness.

95. These surveillance systems are good for delivering a pandemic response that is based on deaths and hospitalisations, and health care consultations but less good for identifying infections, illness or chronic disease and disability in the community. Consideration could be given to ramping up testing within the RCGP RSC system, but even then, this would not give an unbiased picture of what is happening in the community.

96. Consideration could be given to developing stronger community-based surveillance. This could be built on the model of the community-based surveillance system established by the Office for National Statistics (ONS) during the COVID epidemic, (Office for National Statistics 2023) perhaps scaled-back with self-reporting of symptoms and swabbing done monthly to identify infectious agents. We welcome the recent announcement that following the closure of the COVID-19 Infection Survey led by the University of Oxford in March 2023, ONS has set up a new community-based respiratory illness surveillance programme (CRIS: COVID-19 and Respiratory Infections Survey) which started in April 2023 (Office for National Statistics, n.d.). The

REACT study has also demonstrated that this approach is feasible and affordable (Imperial College London, n.d.). Another approach could be to establish crowd-sourced information, as pioneered by the ZOE app which showed that it is possible to recruit 1 million people to self-report symptoms (ZOE Health Study, 2023). Crowd sourcing surveillance is relatively easy and cheap to set up, and builds community engagement, but it could provide a biassed sample as it will likely recruit people already interested in health.

97. The use of genomic sequencing in the future needs further consideration. A network of laboratories able to sequence and report on selected pathogens of interest is increasingly feasible. This was conducted successfully in the UK during the height of the COVID-19 epidemic and judgement is required to maintain this capability at a level that allows variants of concern for whatever pathogens are deemed of interest to be identified sufficiently quickly to be useful for policy decisions. In addition to sequencing of clinical cases of infection, community-based surveillance can be conducted on waste water samples from sewage systems to give early signals of clusters of infection, as was trialled for COVID-19 in the UK (UK Health Security Agency, 2022a). This approach can also be used for surveillance for other pathogens of epidemic potential such as polio and has the advantages of providing an unbiased community-based surveillance of everyone connected to the sewage system without any inconvenience to the general public (UK Health Security Agency, 2022b). This approach can give signals of the presence of a pathogen in the population in a locality which then prompts further targeted investigations to determine the prevalence and characteristics of those infected.

98. Surveillance also needs to include longer-term sequelae, such as Long COVID. This was done for Zika congenital syndrome through funding of a consortium of research cohort studies in Brazil (Alecrim, Amorim et al., 2021). We note that the new ONS CRIS study (see paragraph 95) includes surveillance on Long COVID.

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