THE CENTRE FOR
LONG-TERM RESILIENCE

Building the UK's resilience to future pandemic threats

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EXECUTIVE SUMMARY

- The COVID-19 pandemic has been a devastating event with significant impact on the lives and livelihoods of people across the UK and globally
- As damaging as COVID-19 has been, we must consider that future biological threats of a far-greater scope and impact are possible and increasing in likelihood
- By investing in our capability to prevent, detect and respond to high-consequence biological events now, the UK can reduce the risk these threats pose, nationally and globally
- Whilst no single intervention will be sufficient, a combination of robust, layered interventions makes it more likely that the UK will be prepared for future biological threats

NOTE: This report and the recommendations it contains were developed specifically for a UK-context. We would recommend a similar process be undertaken in other countries by those with relevant context to identify gaps and effective strategies or policy recommendations for those settings.

FUTURE PROOFING THE UK'S REFRESHED APPROACH TO BIOSECURITY

In the wake of COVID-19, the UK must take steps to improve preparedness for future biological threats. To ensure the success of the UK's National Biological Security Strategy (NBSS) refresh and bolster the UK's public health and national security, the UK Government should urgently undertake the following two activities:

(1) The 2023 NBSS must be accompanied by, or rapidly followed up with, an implementation plan.
(2) Relevant HMG departments need to be provided with the resources required to deliver on the commitments in the strategy.

RECOMMENDATIONS FOR IMPROVING THE UK'S RESILIENCE TO FUTURE PANDEMIC THREATS

Additional recommendations to build the UK's resilience to, and reduce the consequences of, future pandemics threats include:

(1) Identify the UK Government departments, teams and positions responsible for preventing, detecting or responding to deliberate or accidental biological threats. Leading teams should be given the authority to assign roles and responsibilities necessary to achieve the government's desired objectives, and held accountable for ensuring these objectives are met in a timely manner.

(2) Task UKHSA with the development of a comprehensive strategy for rapidly identifying and responding to novel pathogens. Existing tools and strategies are insufficient for dealing with high-consequence events involving unknown pathogens.

(3) Expand MOD's investment into R&D for tools and technology that can aid in the detection, characterisation or mitigation of the full spectrum of biological threats.

(4) Task UKHSA with directing a cross-sectoral scoping exercise to identify existing surveillance systems and gaps where additional infrastructure or emerging technologies can add the most value. It is crucial that new biosurveillance systems avoid duplicative collection of data, and instead complement and extend existing surveillance coverage.

(5) The Health and Safety Executive (HSE) should facilitate the transparent reporting of laboratory accidents, serious incidents and the timing and results of high-containment (e.g. CL-3 & -4) lab inspections and audit their findings annually. This allows for cost-effective allocation of resources when addressing gaps and reduces the likelihood of future major incidents in future.

CONTEXT: A SHIFTING RISK LANDSCAPE

Over 21 million people have died as a result of the COVID-19 pandemic.[1] The economic and social costs are wide-reaching, from devastated industries and millions of jobs lost to exacerbated inequalities and the undermining of progress toward achieving major global development milestones.[2]

As damaging as the COVID-19 experience has been, we must consider that future biological threats of a far-greater scope and impact than COVID-19 are currently possible, and increasing in likelihood.

We face an increased risk of naturally-occuring disease outbreaks due to anthropogenic factors (e.g. animal habitat encroachment, increasing globalisation, climate change) that make it more likely for zoonotic spillovers to occur.[3 - 6]

Deliberate biological threats may have been made a more attractive option to malevolent actors after COVID-19 exposed global vulnerabilities in health security,[7 - 9] and following escalating geopolitical tensions.[10] The perception of underperforming biodefense capabilities of countries like the US or UK (following their suboptimal handling of COVID-19), and the potential destructive power of biological weapons, may perversely incentivize state or non-state actors to explore and pursue biological weapons capabilities. Events such as Russia's invasion of Ukraine may also motivate states without nuclear capabilities to pursue alternative WMD capabilities as a form of deterrence.

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[1] Wang, Haidong et al. "Estimating Excess Mortality Due to the COVID-19 Pandemic: A Systematic Analysis of Covid-19-Related Mortality, 2020–21." The Lancet 399, no. 10334 (2022): 1513–36. https://doi.org/10.1016/s0140-6736(21)02796-3.

[2] From Equality to Global Poverty: the Covid-19 Effects on Societies and Economies." Wellcome Trust, September 2020. https://wellcome.org/news/equality-global-poverty-how-covid-19-affecting-societies-and-economies.

[3] Shaman, Jeffrey. "Pandemic Preparedness and Forecast." Nature Microbiology 3, no. 3 (2018): 265–67. https://doi.org/10.1038/s41564-018-0117-7.

[4] Plowright, Raina K. et a. "Pathways to Zoonotic Spillover." Nature Reviews Microbiology 15, no. 8 (2017): 502–10. https://doi.org/10.1038/nrmicro.2017.45.

[5] Nova, Nicole et al. "Global Change and Emerging Infectious Diseases." Annual Review of Resource Economics 14, no. 1 (2022): 333–54. https://doi.org/10.1146/annurev-resource-111820-024214.

[6] Smith, KF et al. "Global Rise in Human Infectious Disease Outbreaks." Journal of the Royal Society, Interface. U.S. National Library of Medicine, December 6, 2014. https://pubmed.ncbi.nlm.nih.gov/25401184/.

[7] Ackerman, Gary. Experimental Red Teaming to Support Integration of Information in Joint Operations. University at Albany, SUNY: Albany, NY, June 2021. https://nsiteam.com/social/wp-content/uploads/2021/08/IIJO-CART-Red-Teaming-Report-_FINAL.pdf?utm_source=rss&utm_medium=rss.

[8] Bajema, Natasha E. et al. "Understanding the Threat of Biological Weapons in a World with Covid-19." The Council on Strategic Risks. The Nolan Center, February 2022. https://councilonstrategicrisks.org/wp-content/uploads/2022/02/Understanding-the-Threat-of-Biological-Weapons-in-a-World-With-COVID_2022_2_17.pdf.

[9] Parachini, John V. and Rohan Kumar Gunaratna, Implications of the Pandemic for Terrorist Interest in Biological Weapons: Islamic State and al-Qaeda Pandemic Case Studies. Santa Monica, CA: RAND Corporation, 2022. https://www.rand.org/pubs/research_reports/RRA612-1.html. Also available in print form.

[10] Weitz, Richard. "Russia's War in Ukraine." International Centre for Defence and Security, July 2022. https://icds.ee/wp-content/uploads/dlm_uploads/2022/07/ICDS_Brief_Russia%C2%B4s_War_in_Ukraine_No8_Richard_Weitz_July_2022.pdf.

Advances in synthetic biology and artificial intelligence (AI) are also widening the possibilities for causing harm through the use of biology. Though the potential scientific and economic upsides of accelerating synthetic biology capabilities are profound, the risks associated with these rapid advances are also serious:

- **Direct misuse risks:** Advancements in our ability to synthesise DNA sequences unlock new ways to acquire, develop and produce biological weapons[11], whilst machine learning algorithms may eventually facilitate the identification of novel, more deadly pathogens and toxins.[12]
- **Indirect risks of misuse:** Applications of synthetic biology to areas such as personalised medicine, or the knowledge generated by these applications, could be repurposed by malicious actors to design and produce more powerful biological weapons.[13]
- **Risks of accidental release:** Even without malevolent intention, pathogen modification and design using synthetic biology tools for research purposes could have disastrous consequences if such agents were accidentally released from a laboratory.

The democratisation of the life sciences and emerging technologies also increases the number of malign actors with the ability to access and harness the tools needed to inflict harm.

Given the confluence of several increasing risk factors, it is imperative for the UK Government to aim to prevent, and prepare to rapidly detect and respond to, the full spectrum of biological threats.

SCOPE

The remit of biological security as we see it:

(i) encompasses all of the activities undertaken with the aim of **preventing, detecting and responding to** the **introduction or spread of harmful pathogens;**

(ii) with a view to **minimising the spread of infectious diseases and mitigating the threat posed by this spread on human, animal and plant health** (the latter of which impact human health directly—spillover risk—and indirectly via jeopardising food supply chains, etc.)

(iii) irrespective of whether the biological threat materialised through natural origins (zoonotic spillover), by accident (as a result of a lapse in laboratory safety) or as a result of deliberate release (e.g. as a bioweapon)

[11] Diggans, James. "Ensuring the Responsible Use of Synthetic DNA." AIChE: The Global Home of Chemical Engineers, November 2021. https://www.aiche.org/resources/publications/cep/2021/november/ensuring-responsible-use-synthetic-dna
[12] Urbina, Fabio et al. "Preventing AI from Creating Biochemical Threats." *Journal of Chemical Information and Modeling*, 2023. https://doi.org/10.1021/acs.jcim.2c01616.
[13] Lewis, Gregory et al. "Information Hazards in Biotechnology." Risk Analysis 39, no. 5 (2018): 975–81. https://doi.org/10.1111/risa.13235.

Our work focuses on building resilience to, and reducing the consequences of, extreme biological risks. This encompasses biological events with the potential to result in:

- wide, uncontrollable spread in human populations, and;
- substantial morbidity or mortality, or;
- significant economic and geopolitical instability

Though we focus on extreme biological risks, we recognise that strong national, regional and international health systems with robust public health functions are necessary for responding to biological threats. Efforts to bolster these systems have positive implications for biosecurity and human health more broadly. We believe suggestions addressing these are likely to be adequately addressed by others in their submissions to the Inquiry.

Extreme biological risks can arise from well-known high-consequence pathogens, new strains of recognised pathogens or novel pathogens. The UK—and most other countries—are particularly ill-prepared for detecting or responding to novel pathogen events.[14,15] Given these shortcomings and the substantial global threat they pose, preparedness for novel pathogen events warrants special consideration.

Examples of potential extreme biological risk scenarios that could threaten UK citizens and British interests include:

- **High-consequence zoonotic spillover:** A potentially pandemic pathogen spills over into the surrounding human population and sustained human-to-human transmission is established (e.g. avian influenza spillover).
- **High-consequence novel pathogen importation:** Several infectious individuals enter the UK following exposure to a novel pathogen in another country (e.g. a novel coronavirus).
- **Accidental release:** A high-containment research facility experiences a lapse in biosafety leading to the accidental release of a pathogen with the potential to cause significant harm (e.g. Q-fever, Marburg).
- **Deliberate attack:** A high-consequence pathogen is weaponised and released by a malign actor at several major travel hubs across the world, including Heathrow airport.

[14] Rosenberg, Ronald. "Detecting the Emergence of Novel, Zoonotic Viruses Pathogenic to Humans." SpringerLink. Springer Basel, November 22, 2014. https://link.springer.com/article/10.1007/s00018-014-1785-y.
[15] Osterhaus, A., Mackenzie, J. Pandemic preparedness planning in peacetime: what is missing?. One Health Outlook 2, 19 (2020). https://doi.org/10.1186/s42522-020-00027-2

Preparedness for biological events requires robust capabilities across three main areas:

PREVENTION	Efforts undertaken to try and stop biological threats from materialising in the first place. For example, screening DNA orders to prevent bad actors from acquiring the materials for developing biological weapons.[16 - 18]
DETECTION	The ability to monitor for, and rapidly identify, ongoing transmission of pathogens in humans or animals. Robust biosurveillance systems should be capable of rapidly identifying a high-consequence pathogen, before it is circulating widely in the human population, irrespective of the pathogen or its origins. Outbreaks are exponentially harder to contain once they've expanded beyond a limited area, making early detection capabilities a powerful tool.
RESPONSE	The ability to rapidly mount a coordinated response to major biological events and mitigate harm to the human population by reducing transmission. This includes putting in place temporary quarantine requirements or deploying countermeasures like vaccines.

Effective mitigation of biological risks requires all three of these capabilities at both a national and a global level.

PRIORITY INVESTMENT AREAS

Given resource constraints, and our limited ability to predict the next emerging infectious disease threat, prioritising investment in origin- and pathogen-agnostic capabilities can be extremely valuable, as these allow for agility and resilience in the face of even novel biological threats.

Some of the tools, strategies and capabilities needed to prevent, detect or respond to biological risks can be designed to be threat-agnostic.

Origin-agnostic interventions: These are applicable to the full spectrum of threats, irrespective of whether the threat is naturally occurring, accidental or deliberate in origin.

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[16] Baum, Carsten et al. "Cryptographic Aspects of DNA Screening." securedna.org. Secure DNA, January 2020. https://securedna.org/research/.

[17] The SecureDNA team. "Random Adversarial Threshold Search Enables Specific, Secure, and Automated DNA Synthesis Screening." securedna.org. SecureDNA, n.d. https://securedna.org/research/.

[18] Ord, Toby; Mercer, Angus; and Dannreuther, Sophie. "Future Proof: The Opportunity to Transform the UK's Resilience to Extreme Risks." Future Proof. The Centre for Long-Term Resilience, June 2021. https://www.longtermresilience.org/futureproof.

For instance, a national biosurveillance system that collected, sequenced, and analysed environmental samples from major UK travel hubs could detect the circulation of a high consequence pathogen, whether this was introduced by animal-to-human transmission, an ill traveller to the UK or a deliberate attack.

Pathogen-agnostic interventions: These are able to achieve the desired outcome, regardless of what kind of pathogen is involved.

For instance, investments in vaccine platform technologies could enable the rapid adaptation of vaccine manufacturing systems for use against different pathogens, be that a previously characterised strain of anthrax, a novel influenza strain or a currently unknown pathogen.[19 - 20]

Integrating metagenomic sequencing capabilities into biosurveillance systems could also provide us with the ability to identify evidence of a novel pathogen circulating in the human population, even if we had not detected that particular pathogen before.[21 - 23]

Investment in prevention capabilities should be prioritised because successful interventions in this area could substantially lower the risk that biological events with pandemic potential occur.

Investing in interventions that aim to prevent the occurrence of deliberate or accidental biological events could be particularly valuable, given:

- **Improved insights and understanding of risk factors.** We have a better understanding of the processes that result in deliberate or accidental events, which allows us to more effectively identify relevant risk factors and target them.
- **Many of the interventions addressing deliberate or accidental events have a defined scope.** Safeguarding DNA synthesis machines or improving the governance of high-containment laboratories is more feasible than, for example, interventions targeting the human-animal interface.
- **Such events could potentially have catastrophic consequences beyond that of naturally occurring disease outbreaks.** Preventing accidental and deliberate events is desirable and significantly more cost-effective than response efforts after a release has already occurred.

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[19] "Our Platform Technology." Coalition for Epidemic Preparedness Innovations (CEPI), December 28, 2018. https://cepi.net/research_dev/technology/.
[20] Simpson, Shmona et al. "Disease X: Accelerating the Development of Medical Countermeasures for the next Pandemic." The Lancet Infectious Diseases 20, no. 5 (March 17, 2020). https://doi.org/10.1016/s1473-3099(20)30123-7.
[21] Hopkins, Susan (Presenter). "UKHSA Advisory Board: Preparedness for Infectious Disease Threats." GOV.UK. UK Health Security Agency, January 24, 2023. https://www.gov.uk/government/publications/ukhsa-board-meeting-papers-january-2023/ukhsa-advisory-board-preparedness-for-infectious-disease-threats.
[22] Govender, Kumeren N. "Precision Pandemic Preparedness: Improving Diagnostics with Metagenomics." *Journal of Clinical Microbiology* 59, no. 6 (2021). https://doi.org/10.1128/jcm.02146-20.
[23] "Future Pandemic Preparedness, Powered by Genomics." Nature News. Illumina, December 18, 2020. https://www.nature.com/articles/d42473-020-00484-3.

However, implementation of activities or policy proposals within the UK aimed at achieving prevention of naturally occurring pandemic threats might only have marginal benefits.[24-25]

- Some interventions, such as strengthening the regulation and disease surveillance of farmed animals, would likely be valuable in reducing the likelihood of zoonotic spillovers of pathogens such as avian influenza.
- However, the UK lacks other risk factors driving the emergence of infectious diseases, which limits the applicability of other expert recommendations to prevent naturally occurring pandemic threats, such as:
    - Protect against, or limit, land-use change in tropical and subtropical forests
    - Ban or strictly regulate commercial wildlife markets and trade
    - Improve the health systems in emerging infectious disease hotspots[26]

Inevitably, preventative activities will not be able to stop all future biological threats from materialising—making countries' capabilities to rapidly detect and respond to these events vital.[27]

Bolstering detection and response capabilities could also provide broader public health and economic 'peacetime' benefits, such as reduced healthcare system costs, a reduction in livestock and poultry losses, or improved monitoring of population-level antimicrobial resistance levels. Multipurpose capabilities increase the impact of government spending, and help ensure operational longevity in the absence of an ongoing crisis.

No single intervention aimed at the prevention and detection of, or response to, biological events will be sufficient to mitigate the substantial threat posed by extreme biological risks. However, a combination of robust, layered interventions across all three pillars—prevention, detection, and response—makes it more likely that the UK will be prepared for future biological threats, regardless of their origin.

[24] Clifford Astbury, Chloe et al. "Policies to Prevent Zoonotic Spillover: Protocol for a Systematic Scoping Review of Evaluative Evidence." BMJ Open 12, no. 11 (2022). https://doi.org/10.1136/bmjopen-2021-058437.
[25] Harvard Chan C-CHANGE. Want to prevent pandemics? Stop spillovers. Harvard T.H. Chan School of Public Health, December 5, 2022. https://www.hsph.harvard.edu/c-change/news/want-to-prevent-pandemics-stop-spillovers/#:~:text=Recommended%20actions%20to%20reduce%20the,particularly%20live%20birds%20and%20mammals.
[26] Vora, Neil M. et al. "Want to Prevent Pandemics? Stop Spillovers." Nature 605, no. 7910 (2022): 419–22. https://doi.org/10.1038/d41586-022-01312-y.
[27] Maxmen, Amy. "Has Covid Taught Us Anything about Pandemic Preparedness?" Nature 596, no. 7872 (2021): 332–35. https://doi.org/10.1038/d41586-021-02217-y.

GAPS IN THE UK'S HISTORICAL APPROACH TO BIOSECURITY

The upcoming National Biological Security Strategy (NBSS) refresh will identify a variety of activities that should be undertaken to ensure the UK is prepared to handle the full spectrum of biological threats.

However, successful delivery on the NBSS commitments will require sustained funding and a detailed implementation plan, neither of which is guaranteed. The previous 2018 Strategy, though comprehensive on paper, appears to have fallen short of achieving many of its aims.

To ensure the resources invested in the strategy refresh are used effectively and bolster the UK's public health and national security, the UK Government should urgently undertake the following two activities:

(1) The NBSS must be accompanied by, or rapidly followed up with, an implementation plan.

The implementation plan for the refreshed NBSS should include, at a minimum:

- **Identify the government department, team and position who own each risk and are both accountable and adequately resourced to deliver on each of the strategy's commitments.** This will ensure the strategy actually improves the UK's resilience to the full range of biological threats (regardless of their origin).
- **Identify a corresponding set of targets and actions for every commitment within the strategy,** which provide a clear way to track progress toward achievement of the outcome.
- **Identify a timeline on which progress toward achieving each of the strategy's commitments is evaluated** by the National Security Secretariat team.

The 2018 NBSS provided little information on how or by who each of the commitments would be achieved, which may have contributed to the (apparent) lack of implementation of many of its recommendations.

- The section on implementation noted only that "most of the activities described... fall within existing government portfolios and governance mechanisms."
- Though potentially relevant government departments and teams were named at the end of the 2018 strategy, it did not clarify which departments or teams were responsible for delivering on each commitment, or by when.

(2) Relevant HMG departments need to be provided with the resources required to deliver on the commitments in the strategy.

- Our understanding is that a lack of funding commitment is the most likely failure-mode when it comes to achieving the outcomes outlined in the refreshed NBBS.
- The extent to which the 2018 National Biosecurity Strategy was funded is not known to us, but it appears that many of its commitments were not delivered on.

POLICY RECOMMENDATIONS

Identify the UK Government departments, teams and positions responsible for preventing, detecting or responding to deliberate or accidental biological threats at a team-level.

Biosecurity issues are inherently cross-cutting: the governmental departments, teams and positions responsible for contributing to the prevention, detection and response to a given biological event change depending on the nature (zoonotic spillover, lab accident, deliberate attack, etc.) and impacted population (humans, livestock, etc.) of the event.

The effort required to drive forward progress in the biosecurity landscape will require that all departments, teams and individual positions (where relevant) responsible for deliberate or accidental biological events be clearly identified.

A lead department or team should then be given the authority to assign roles and responsibilities necessary to achieve the government's desired objectives, and be held accountable for ensuring these objectives are met in a timely manner.[28]

UKHSA should be tasked with leading on the development of a comprehensive strategy for rapidly identifying and responding to novel pathogens.

The UK (like many other countries globally) lacks a comprehensive plan to rapidly characterise new pathogens and diseases—from achieving rapid detection in community and healthcare settings, to laboratory protocols that encompass previously unrecognised agents.

The ability to identify novel pathogens is a crucial component of pandemic preparedness and national security, as novel pathogens may:

[28] For additional resources on how the implementation of an enhanced accountability process within government could be achieved, see Toby Ord's 2021 proposal on a 'Three Lines of Defence' Approach to UK Risk Management

- Otherwise take a long time to detect, as we lack existing surveillance or diagnostic tools
- Result in more severe disease (as populations would not have existing immunity)
- Be harder to design vaccines or therapeutics (e.g. antivirals) for (depending on our existing scientific knowledge about the family they belong to)

Expand MOD's investment into R&D for tools and technology that can aid in the detection, characterisation or mitigation of the full spectrum of biological threats.

These teams are best placed for addressing deliberate biological threats, though the capabilities of these technologies will often extend beyond this to aid in the detection, characterisation or mitigation of accidental and naturally occurring threats.

Housing this type of R&D within the defence sector is a model that has proven successful in the United States (e.g. The US DOD's Chemical Biological Defense Program).

UKHSA should be tasked with leading a cross-sectoral scoping exercise to identify existing surveillance systems and gaps where additional infrastructure or emerging technologies can add the most value.

The UK's existing biosurveillance systems play an important role in the UK's capacity to detect emerging infectious diseases: going forward, it will be crucial to avoid duplicative collection of data, instead ensuring that new systems complement and extend existing surveillance coverage.

The scoping exercise should aim to:

(1) Identify existing surveillance systems and determine (i) their coverage and (ii) the type of data they are reporting

(2) Evaluate the potential capability of these systems to detect a given pathogen across the various scenarios that may result in a high-consequence public health event, including a novel pathogen event

(3) Identify gaps in the ability of the UK surveillance landscape to detect the circulation of pathogens that cause high-consequence public health events

(4) Evaluate the value of emerging technologies, such as metagenomic sequencing applications, for addressing these gaps

UKHSA Advisory Board reports and supplier opportunities indicate that steps are already being taken toward implementing this recommendation as part of an effort to scope and establish a National Biosurveillance Network under Cabinet Office's Biological Security Strategy refresh.

We are pleased to see these commitments, and strongly encourage that particular consideration is given to the UK's ability to detect novel pathogen circulation and the systems that would be required to do so reliably for the full spectrum of biological threats, irrespective of their origin.

The Health and Safety Executive (HSE) should facilitate the transparent reporting of laboratory accidents, serious incidents and the timing and results of high-containment (e.g. CL-3 and -4) lab inspections and audit their findings annually.

Observations in safety-critical fields such as aviation demonstrate that major disasters emerge from patterns of minor incidents or 'near-misses'.

Publicly available records of laboratory incidents are crucial to discover their frequency, uncover their root causes, and assess whether efforts to mitigate them are successful. A better understanding of these events could facilitate improved cost-effective allocation of resources to address gaps and reduce the likelihood of future major incidents in future—but this requires identifying and recording such events in the first place.

HSE should also be tasked with performing an annual incident audit analogous to the UK's National Maternal and Perinatal Mortality Audit to assess current gaps in the UK's biosafety landscape and provide recommendations on how repetitions of these incidents could be prevented.