NATO PARLIAMENTARY ASSEMBLY

SCIENCE AND TECHNOLOGY COMMITTEE (STC)

Sub-Committee on Technological Trends and Security (STCTTS)

BIOLOGICAL THREATS: TECHNOLOGICAL PROGRESS AND THE SPECTRE OF BIOTERRORISM IN THE POST-COVID-19 ERA

Report

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024 STCTTS 21 E rev. 1 fin | Original: English | 10 October 2021

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EXECUTIVE SUMMARY

The ongoing COVID-19 pandemic has exposed global vulnerabilities to biological threats and refocused attention on the possibility of deliberate biological attacks. This report discusses the opportunities offered by biotechnology and other Emerging and Disruptive Technologies (EDTs), as well as the main challenges presented by biological weapons. The report provides a general overview of the current threat landscape.

Recent scientific advances in the biotechnology sphere hold great promise in the fight against biological threats, whether intentional attacks or naturally occurring pandemics. However, these advances are also facilitating the development of increasingly sophisticated biological weapons, notably due to convergences between biotechnology and other EDTs. In this context, the report examines the risk of bioterrorism and the possibility of the proliferation of biological weapons capabilities to non-state actors such as terrorist groups. The activities of NATO and its members in strengthening resilience and preparedness across the spectrum of biodefence activity are also discussed. Finally, the report outlines the international arms control framework regarding biological weapons, identifies shortcomings of the "Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction" (BTWC) and suggests possible ways it could be strengthened.

The report offers several conclusions which highlight the role NATO parliamentarians can play in mitigating challenges to Allied biodefence. These include generating greater awareness of the need for robust biodefence measures, supporting the strengthening of the BTWC, and encouraging national authorities to ensure that their policies and capabilities are sufficient to respond to current and future biological threats. The rapporteur also stresses the vital contribution of NATO militaries to tackle biological threats and the need to not cut defence spending, but to better source biodefence capabilities and strengthen them.

I. INTRODUCTION

1. The ongoing COVID-19 crisis has exposed global vulnerabilities to biological threats. As of July 2021, the total number of confirmed COVID cases is 187 million globally with over 4 million people having died of the disease (European Centre for Disease Prevention and Control, 2021). The wide-reaching and disruptive consequences of the pandemic challenge the ability of national governments, public health authorities, medical services, and international organisations to respond effectively.

2. Rapid advances in biotechnology and related scientific areas have been crucial in mitigating the impact of the COVID-19 crisis. Moreover, biotechnology and other Emerging Disruptive Technologies (EDTs) are likely to take on increasing relevance over the next 20 years, according to the "Science & Technology Trends: 2020-2040" of the NATO Science and Technology Organization (STO) (NATO STO, 2020). However, while technological developments hold great promise in the fight against biological threats, the possible abuse of new technologies remains a concern. Biotechnological advances make it easier to manipulate pathogens and increase their virulence, transmissibility, or resistance to medical countermeasures. The convergence of biotechnology with other EDTs could also intensify the risk of a highly sophisticated targeted biological attack. Therefore, hostile states might seek to exploit new capabilities in the life sciences for nefarious purposes.

3. The COVID-19 pandemic is also giving rise to the spectre of bioterrorism. Experts have warned that the pandemic may lead to a resurgence in interest among terrorists in using chemical and biological weapons. The possible risk of biological attacks by either state or non-state actors highlights the need to ensure effective biodefence strategies and strengthen international governance frameworks in the field of biosecurity and arms control, including the "Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction" (BTWC). Preparedness is essential both for deterrence purposes and to ensure adequate mechanisms to monitor and when necessary to deny access to the building blocks of biological weapons as well as respond to a biological attack.

4. This report aims to provide an overview of the main challenges raised by scientific advances in the biotechnology sphere, shedding light on possible bioterrorist activity, and outlining the role of NATO and its members in strengthening resilience. It also suggests possible avenues to bolster and operationalise the BTWC to better respond to the contemporary threat landscape.

II. BIOLOGICAL WEAPONS – STATE OF PLAY

5. The World Health Organization (WHO) defines biological weapons as microorganisms such as bacteria (anthrax), viruses (Ebola and smallpox) as well as other toxins (ricin) which are deliberately produced and released to cause disease and death in humans, animals, and plants (WHO, 2021a). Biological weapons have been used in warfare since ancient times. As early as the fourth century B.C., Scythian horsemen are said to have brought their arrows into contact with corpses to infect their opponents with pathogens. Persians, Greeks, and Romans threw animal carcasses into the water of their opponents to contaminate it. Tartars used catapults to hurl infected corpses into the besieged city of Caffa on the Crimean Peninsula to force its surrender. In the 20th century, the cultivation of bacteria was used to develop bio-warfare agents into the weapons of mass destruction they are considered to be today. German troops experimented with anthrax in the First World War. In the Second World War, Imperial Japanese forces dropped plague fleas over Chinese territory (Frischknecht, 2003).

6. Research into biological weapons programmes continued into the Cold War. The United States and the Soviet Union maintained huge bioweapons programmes. However, concerns in both public and expert circles over the potentially devastating epidemiological effects of biological weapons gradually led to a change of mind. In 1957, the United Kingdom abandoned its offensive biological warfare research and destroyed stockpiles; the United States publicly renounced its bioweapons programme in 1969 (Riedel, 2004). The former Soviet Union, however, continued large-scale biological warfare programmes until it collapsed in late 1991.

Box 1: Signatories to the Biological Weapons Convention (BWC)

All NATO member states have ratified the BWC. Other notable signatories include Russia and China, which acceded to the BWC in 1975 and 1984 respectively. States which have not signed the treaty include Chad, Eritrea, Djibouti, Israel, and South Sudan. Those who have signed but not yet ratified the treaty include Egypt, Haiti, Somalia, and Syria.

7. The threat posed by biological weapons varies greatly depending on the biological agent, the delivery means, and the way it is disseminated. Even a low-level attack, which does not cause mass casualties, is likely to have grave consequences. This was demonstrated by the 2001 anthrax attacks in the United States, in which envelopes containing anthrax spores were disseminated via the postal system (US Department of Justice, 2010). The incident caused considerable disruption and incited widespread fear among the population (Bush and Perez, 2012; Dando, 2020). The 2018-2020 Ebola outbreak in the Democratic Republic of Congo took place as violent conflict was raging in the country. The convergence of both events amplified the crisis and provoked concerns that adversaries could deliberately spread disease in future conflicts to inhibit responses and decision-making (Singh et al., 2019). Moreover, biological agents can also be used on animals and agriculture with highly disruptive effects.

8. Due to technological advances the potential impact of biological weapons has evolved considerably. The combination of biological data with artificial intelligence (AI), deep learning and advanced genetic engineering now allow to make existing pathogens aggressive or infectious, or even to engineer entirely new pathogens (Lentzos, 2020). More sophisticated delivery mechanisms such as drones or nano-robots can also increase risks. What is more, enhanced computer power has resulted in the possibility of ultra-targeted biological warfare affecting only specific ethnic groups or even individuals opening the door for future mass extermination and genocide. Accessing such weapons, however, still requires extensive resources and expertise (Lentzos, 2020).

9. The COVID-19 pandemic has emphasised the importance of understanding the biological vulnerabilities and assessing biological threats in a comprehensive manner. Such an assessment of biological threats requires risk/capability evaluations in many different areas, among others in the state of national healthcare systems, risks arising from international trade/travel, or the resilience of global supply chains. The availability of resources to put in place adequate countermeasures (such as testing schemes) will be essential (Pilch and Tyson Kreger, 2020). A timely response to a biothreat requires that some biological agents are stockpiled and readily available as they cannot be produced in time, especially if the supply chain is not secure and/or if there are quality issues. Efficient and effective R&D capabilities are crucial as are capacities to manufacture countermeasures in Allied countries. As the COVID-19 pandemic has shown, the military are vital for national biodefence efforts but also make important contributions to mitigate the effects of pandemics (Jones, 2020). NATO Allies therefore need to develop post-COVD 19 recovery plans that must not undermine their commitment to allocating 2% of GNP to defence.

Box 2: Definitions

- **Biotechnology** is an area of biology which involves the exploitation of living systems, organisms, and processes for industrial, medical, or other production purposes. Biotechnology can also be used for other purposes, such as information storage and environmental alteration.
- **Genetic engineering** is a type of biotechnology which involves the manipulation of an organism's genetic makeup and may include the transfer of genes within and across species to produce improved or novel organisms. Genetic engineering has long been used for agricultural purposes (for example, to increase production or make a crop hardier) and to produce medications such as insulin. Similar processes could be used to increase the virulence or infectiousness of pathogens for use in biological weapons.
- **Nucleic acid vaccines** are a novel type of vaccine based on genetic material (either DNA or RNA) from a disease-causing virus or bacterium. The genetic material provides a blueprint which the human body uses to make specific proteins that trigger an immune response, thereby creating antibodies against the virus (GAVI, n.d.).

10. Today, no NATO member country has a biological weapons programme. However, Allies have maintained their defensive research on biological agents and continue to invest resources in this area in the context of chemical, biological, radiological, and nuclear (CBRN) defence programmes (NATO, 2018).

11. There are, however, concerns that several countries may pursue biological weapons programmes. During the Cold War period, the Soviet Union possessed a large covert biological weapons programme known as "Biopreparat", which was officially abandoned with the country's collapse. However, a 2019 US State Department report found that Russia's submissions under the BWC since 1992 have not satisfactorily documented whether biological weapons developed under this programme were destroyed or diverted to peaceful purposes (US State Department, 2019). The reported use of a chemical nerve agent against former Russian spy Sergei Skripal and his daughter in the United Kingdom in March 2018 also raised questions regarding the Kremlin's possible ongoing use of chemical and/or biological weapons (Trakimavičius, 2018). Meanwhile, reports indicate that the Democratic People's Republic of Korea is collaborating with foreign researchers to enhance its microbiology and biotechnology capacities (Baumgaerter and Broad, 2019). It remains difficult to accurately assess the threat due to the country's secrecy. Such capabilities could be operationalised for defensive use, in the form of a deterrent against potential aggressors, but there is also scope for offensive use.

III. TECHNOLOGICAL PROGRESS – A BOON AND A BANE

12. Biotechnology is at the cutting edge of the global response to the COVID-19 crisis. The pandemic has accelerated progress and new approaches in diagnostics, therapeutics, and vaccine developments which are crucial for tackling the spread of the virus. The rapid development of vaccines against COVID-19 is an example of how biotechnology may be harnessed to provide vital solutions in response to medical emergencies. As of July 2021, there are almost 300 vaccines in development, of which at least 170 are in clinical trials (WHO, 2021b). This includes nucleic acid vaccines, which are based on a technique using mRNA technology. Although researchers have been working with mRNA vaccines for several years, none had been through the full approval process for use in humans prior to the COVID-19 pandemic.

Box 3: Artificial Intelligence (AI), Machine Learning and Big Data

Artificial intelligence is a general term for a range of computational techniques that allow computers and robots to interpret data using algorithmic processes similar to those associated with human intelligence. This includes machine learning methods, which, through iterative algorithmic processing, can be used to make sense of large and heterogenous sets of data.

The combination of advanced **AI data processing with biotechnology** has merit in responding to biological threats such as pandemics, but also poses potentially serious security risks:
(1) Machine learning techniques can fast-track otherwise laborious manual processes of sorting through genetic sequences. The application of advanced pattern recognition techniques to genomic data could be used to significantly speed up the identification of toxins that could be used for hostile purposes, or to optimise the process of modifying or enhancing a pathogen's characteristics (Warmbrod et al, 2020).
(2) AI and access to large volumes of genomic data may also enable scientists to map infection susceptibilities in specific populations. This could enable a malicious actor to engineer biological weapons that would harm only a specific individual or group of individuals based on their genes, prior exposure to vaccines or known vulnerabilities in their immune systems (Brockmann et al, 2019). For example, a United Nations University report found that deep learning could facilitate the identification of 'precision maladies', or genetic functions that code for vulnerabilities (Pauwels, 2019). This would open up the possibility of ultra-targeted biological warfare.

13. The rapid development of EDTs like Artificial Intelligence (AI), biotechnology, Big Data and Advanced Analytics (BDAA), is likely to dramatically improve our ability to prevent, detect, and contain biological threats, whether deliberate attacks or naturally occurring pandemics. AI has notable applications in the rapid identification of pathogens due to its ability to process large amounts of data for pattern analysis and information extraction (Warmbrod et al, 2020). For example, natural-language processing (NLP) algorithms – which interpret the properties of biological systems in terms of words and sentences – are now able to generate protein sequences and significantly accelerate the prediction of possible virus mutations (Heaven, 2021). Such machine learning possibilities can be used in combination with rapidly growing databases of digitised virus sequences, enabling scientists to compare strains and identify common properties of viruses (Singer, 2013). AI can also be used more broadly in responses to biological incidents by providing situational awareness and assisting authorities in making informed decisions in crisis situations. For example, it can be used to merge data from multiple sources to detect, track or forecast biological incidents based on a combination of historical or real-time data (Brockmann et al, 2019).

14. Other scientific developments have enhanced systems for the reliable detection of biological agents. Researchers at MIT Lincoln Laboratory have developed a highly sensitive and reliable trigger used in the US military's early warning system for biological warfare agents. The trigger, called the Rapid Agent Aerosol Detector (RAAD), continually monitors the air in a location and identifies aerosolised particles that may be threat agents before using embedded logic to initiate successive phases in the detection process (Ryan, 2020). Detection is also possible from a distance due to the development of remote detection systems using hyperspectral imaging (based on high-resolution images obtained from satellites or aircraft) or light detection and ranging (LIDAR) techniques which analyse the signals reflected off a target to detect vapours of biological weapons (The Economist, 2002).

15. Emerging technologies have already been deployed in the COVID-19 response, helping to drive the development of early outbreak warning systems in the initial stages. For example, the Canadian AI platform BlueDot used an algorithm to identify a cluster of unusual pneumonia cases nine days before the WHO officially alerted the world to the emergence of a novel coronavirus (Stieg, 2020). Subsequently, AI has been used in diagnostic tools, including a method developed by researchers from the Huazhong University of Science and Technology (HUST) and Tongji Hospital in Wuhan which can quickly analyse blood samples to predict survival rates of COVID-19 infected patients with 90% accuracy. Another tool is used to distinguish COVID-19 from other

types of pneumonia within seconds by analysing patients' chest CT scan images (Dananjayan and Raj, 2020). The use of these methods on the front line of the medical response to COVID-19 is helping to improve early diagnosis and treatment and take pressure off hospitals. International efforts are now also focusing on deploying genome-sequencing technologies to developing countries and rural regions. This allows for improved viral surveillance and the monitoring of the evolution of new COVID-19 variants in particular. In addition to delivering training to educate local workforces, experts and scientists also explore low-cost versions of sequencing technologies in the form of handheld devices that would facilitate their dissemination – a solution widely used during the Ebola outbreak in West Africa (Schmidt, 2021).

16. As biotechnology and other life sciences are dual use, they can be used for peaceful purposes such as medicine and protection, but they can also be transformed into sophisticated weapons. Indeed, advances in biotechnological research can facilitate the manipulation of pathogens to make them more effective as targeted weapons. Through advanced DNA sequencing techniques, it is becoming easier to genetically engineer viruses and other disease-causing organisms. This can increase their virulence and transmissibility, expand their host range, or enhance their resistance to therapeutic interventions (Brockman et al, 2019). Furthermore, it is possible to recreate extinct pathogens or manufacture entirely new ones from scratch (Frinking et al, 2016). One of these gene editing techniques, known as CRISPR, can be purchased in the form of simple at-home kits for as little as USD 169 which constitutes a worrying trend as it lowers the barrier for acquisition by malicious actors (UN News, 2018). These technological advances and decreasing costs of synthesising biological agents increase the risk that yet unknown biological agents might be weaponised in the future and could lead to the development of new biological warfare agents.

17. Scientific progress in biotechnology and the easy availability of scientific research also increases the risk of dissemination of knowledge and technologies for the production and use of biological weapons. In combination with other EDTs such as artificial intelligence (AI), machine learning, nanotechnology, quantum computing, and additive manufacturing and robotics, biotechnology could be used to simplify or automate the processes involved in the development, production, and delivery of biological weapons (Brockmann et al, 2019). Moreover, the systems and processes involved in these emerging technologies and methods are increasingly digitised or hosted in cloud storage, which makes them more vulnerable to cyberattacks and cybertheft.

18. As scientific advances are driven by the private sector, including, for example, companies like BioNTech and Moderna, maintaining oversight of the technologies is difficult. Some international industry standards exist; for example, the International Organization for Standardization (ISO) publishes recommended standards and requirements in various areas of biotechnology including data publication, quantification methods and quality control (ISO, n.d.). However, because EDTs rapidly develop in parallel, and are often interconnected, national and international regulatory bodies struggle to monitor and assess the implications of these technology developments. The dual use nature of these technologies also complicates regulation, as the same technology can have multiple applications. Overall, the convergence of biotechnology with emerging technologies is dramatically changing the security environment. According to Hamish de Bretton-Gordon, the former commander of the UK's Chemical, Biological, Radiological and Nuclear regiment, "we need to see biological hazards as an existential threat to the 21st century in the same way that atomic science was to the 20th century" (Warrell, 2021).

19. Advances in technology could also allow for a more targeted delivery of biological weapons. At some point in the future, it may be feasible to develop pathogens that only target specific populations based on their genetic characteristics (see SIPRI, 1993; see box 3). For example, there are reports that China is actively gathering genome data and/or has access to it through the 'nationally' sponsored industries (National Counterintelligence and Security Center, 2021). For example, the PRC has recently come under suspicion of using genetic data obtained from pregnant women by way of a prenatal blood test to identify genetic defects in the populations of

hostile nations which could be potentially targeted by a genetically tailored biological weapon (Ankenbrand, 2021). In addition, China has acquired large Allied-nation genetic datasets through legitimate acquisitions of foreign genetic diagnostic and commercial companies. The PRC is also suspected in the theft of millions of medical and genetic records world-wide. Moreover, advanced delivery mechanisms will allow to deliver pathogens with greater precision (see box 4).

Box 4: Robotics and Nanotechnology

The convergence of biotechnology with advanced robotics poses new and worrying possibilities for the delivery of biological weapons (Warmbrod et al, 2020). Easily accessible commercial drones could be incorporated into the delivery systems of biological weapons to disperse biological agents over a large area (DeFranco, 2020). When combined with nanotechnology (defined as the range of tools used to manipulate materials at the nanoscale, ranging from 1 to 100 nanometres), the possibilities for targeted delivery are increasingly apparent (Brockmann et al, 2019). Miniaturised robotics systems or insect-sized drones could be used to transport pathogens into human bodies or target a specific individual. A 2010 report from the US Defense Threat Reduction Agency outlined how “transgenic insects could be developed to produce and deliver protein-based biological warfare agents” for offensive use (Daniels, 2017). Research into insect-scale robotic research is already underway in countries including the United States, France, the Netherlands, and Israel; for example, researchers at the US Air Force Office of Scientific Research are developing a ‘micro aerial vehicle’ (MAV) for espionage tasks which can land on human skin and even take DNA samples (Calderone, 2017).

20. Scientific advances do not only expand possibilities at the cutting edge; they can also make existing biological research and technology more accessible. Although a certain level of expertise is still required to effectively manufacture, process, and disseminate biological agents, the ease of microbiological manipulation is increasing and rapidly becoming less costly. For example, a state-of-the-art DNA synthesis facility can now be built in a space the size of a shipping container (World Economic Forum, 2019). The availability of knowledge about pathogens has increased in parallel. Today, information on the complete genomes and coding sequences of biological agents is publicly available in online databases such as the GenBank, the Ensemble project and the Viral Genome Resource (Frinking et al, 2016). This allowed a team of Canadian researchers to recreate the extinct horsepox virus in 2016, using a technique that could also be utilised to synthesise smallpox from scratch – a lethal relative in the family of pox viruses that was globally eradicated in the 1980s (Kupferschmidt, 2017).

21. Moreover, facilities that hold potentially dangerous bacteria, toxins, or viruses are sometimes shockingly ill-secured and the opportunity for theft, accident or leakage is high (Jenkins, 2017). To date, there are 59 known maximum containment Bio Security Level 4 (BSL-4) laboratories spread across 23 different countries with a majority located in Europe followed by North America and Asia. Mostly situated in urban environments, BSL-4 laboratories store and study highly infectious pathogens for which treatment is usually not available (Lentzos and Koblentz, 2021). Yet, a mere quarter of the countries hosting these facilities maintain a high level of biosafety and biosecurity practices (NTI GHS, 2019). While all countries report their labs as laid out in the BTWC, many of these facilities do not adhere to adequate security protocols (Warrell, 2021). Binding international standards that would codify standards for safe and secure work in BSL-4 facilities do not exist and the voluntary biorisk management standard introduced in 2019 by the ISO remains yet to be signed. In addition, there is no international oversight and control of whether these laboratories enforce the necessary high national security regulations and WHO biosecurity guidelines. As countries seek to ramp up their pandemic preparedness as a lesson of COVID-19, the likely increase in the number of BSL-4 laboratories and the expansion of research in laboratories with lower biosafety levels (for example BSL-3 and 2) could exacerbate safety and security risks in the future (Rodgers, Lentzos, Koblentz and Ly, 2021).

Locations of Maximum Containment Laboratories

Source: https://www.globalbiolabs.org/map

22. The combination of the increasing accessibility of technologies, equipment and information is likely to facilitate the dispersal of means to develop biological weapons to a variety of non-state actors, including terrorist groups (The Economist, 2016). The ability of more and more people able to access powerful biotechnologies that were once the sole purview of established and well-funded laboratories has serious implications for systems of governance and control. Rapid developments in this field have revealed gaps between existing laws and regulations, and the reality of how these technologies are used.

IV. THE SPECTRE OF BIO-TERRORISM

23. In April 2020, the United Nations Secretary-General warned that “the weaknesses and lack of preparedness exposed by this pandemic provide a window onto how a bioterrorist attack might unfold – and may increase its risks” (United Nations, 2020). The overall COVID-19 experience has stressed the importance of better preparedness against all types of public health threats, including bioterrorism.

24. Experts are concerned that the destructive social and economic implications of the COVID-19 crisis have drawn attention to the potentially potent impact of biological agents and may lead to a resurgence of interest in such methods among terrorists (Brzozowski, 2020; Warrell, 2020). These concerns are underpinned by reports that extremist groups have called on their followers to intentionally spread COVID-19 by coughing on targeted individuals or through other means. In the United States, at least two people have already been charged with terrorism offences after claiming they were intentionally trying to spread the virus (Silke, 2020; Binding, 2020). In the Middle East and North Africa (MENA) region, groups associated with Daesh and Al-Qaeda have also spread conspiracy theories claiming that the virus is a “soldier of Allah” that is being used to punish the enemies of Islam (UNICRI, 2020; Iftimie, 2020). As biotechnology

continues to evolve and terrorist organisations analyse our efforts to tackle biological threats, Allies need to constantly re-evaluate established procedures for effectiveness.

25. The common underlying objective of most terrorist attacks is to disrupt the normal functioning of society, disable governments by diverting resources, and ultimately create a climate of fear. To achieve such effects the use of biological agents may present an attractive solution for terrorists, as the release of a virulent and lethal pathogen in a civilian setting is highly likely to trigger widespread panic and challenge the ability of governments, healthcare systems and other emergency actors to respond effectively. The difficulty of detecting or tracing biological agents and the delayed effect these can have once dispersed may also constitute a factor in a terrorist group's decision to utilise biological methods. Perpetrators can retain a degree of anonymity and avoid responsibility if so desired, which may also enhance fear and uncertainty in the initial stages of an incident as responses get underway.

26. There have been several well-documented cases when terrorists used biological agents in the past with limited effect. In 1984 a religious sect in the United States deliberately contaminated restaurant salad bars with salmonella typhimurium, intending to incapacitate the voting population of the city of The Dalles, Oregon. The attack resulted in several hundred cases of salmonellosis but no deaths (Green et al, 2018). In the early 1990s, the Japanese apocalyptic religious sect cult Aum Shinrikyo experimented unsuccessfully with biological agents before switching to chemical agents; their release of the nerve agent sarin in the Tokyo underground system in 1995 ultimately killed 13 people and injured 5,500 (Zanders, 2001). The 2001 anthrax attacks in the United States involved the mailing of envelopes containing anthrax spores to media and prominent senators, infecting 22 people of which five died. The attacks instigated the largest epidemiologic investigation of an infectious disease outbreak in the history of US public health and were eventually concluded to be an act of domestic terrorism (Bush and Perez, 2012). In 2013, another incident occurred when two envelopes addressed to the US President and a Republican Senator were intercepted and tested positive for ricin, a highly toxic protein made of processed castor beans (Davis and Brown, 2013).

27. Historically, the influenza virus has been considered to be of only limited importance from the standpoint of a potential biological weapon, however, the "radical levelling" effect of COVID-19 might well increase the appeal of highly contagious and, therefore, widely disruptive biological agents that are easy to disseminate due to their ability to spread rapidly (Pilch and Tyson Kreger, 2020).

28. As mentioned above, technological progress and rapid communication via the internet increases the risk of proliferation of biological weapons to non-state actors, including terrorist groups (Green et al, 2018). Unlike states, such groups are not bound under the BTWC which primarily directs its prohibitions to the actions of states and does not seek to incorporate its interdictions into international criminal law (Meselson, 2001).

29. There are different ways terrorists could obtain biological weapons. First, they might culture the agent from samples of pathogens obtained from nature, such as Bacillus anthracis or Yersinia pestis, the organisms that cause anthrax and plague, respectively. Second, with adequate expertise, they could synthetically produce agents themselves using how-to manuals and other resources available online. The skill set required to successfully apply these techniques has continuously lowered and might soon resemble the simple process of using a cookbook (Dass, 2021). Third, non-state actors could also procure biological agents or toxins from legitimate suppliers such as culture collections (repositories of microbial materials which act as libraries for research and industry) or the stocks of medical supply companies. Finally, terrorists could either steal the agent or toxin from research or medical laboratories or misuse the research carried out there; this includes people with valid access to the facilities where these materials are kept (Carus, 2001).

30. Having acquired sufficient amounts of a biological agent or toxin, terrorists would need access to the equipment needed to weaponise the agent and prepare it for dispersal. Terrorists would not need to achieve a high level of technological sophistication or efficiency during the attack stage to meet their objectives. While the execution of massive attacks using virulent agents like botulinum toxin or smallpox may remain beyond reach, an uncoordinated small-scale attack using poorly prepared or haphazardly disseminated biological agents could still cause illness or death of dozens of people (Dando, 2020). Such an attack would therefore be within reach of a greater number of terrorist groups as well as “lone wolves”. In addition, even the knowledge itself that malevolent actors possess biological agents might trigger panic and disruption (Frinking et al, 2016; Dass, 2021).

31. Easier access to the knowledge and technology required to manipulate biological agents does not necessarily mean that widespread proliferation of these methods among terrorist groups will occur. Barriers limiting access of non-state actors to the development and use of biological weapons, at least on a technologically advanced and/or mass destructive scale, include the required necessary expertise, access to technical equipment and funding (Lentzos, 2020). In practice, terrorists need to acquire or produce stable quantities of a suitably potent agent, isolate it, and find an effective means of delivering the agent to the target (Block, 2001). The weaponisation of biological agents deemed of highest concern by the U.S. Centers for Disease Control and Prevention such as smallpox, the plague, or Ebola, therefore remains difficult (Blum and Neumann, 2020). Moreover, the features of terrorist groups themselves may limit their ability to produce biological agents. For example, a vertically integrated and ideologically uniform group will find it easier to set up a biological programme compared to a loosely structured, amorphous grouping with little centralisation (Zanders, 2001). While terrorists can therefore still be expected to revert to cheap and low-tech methods, developments in biotechnology, EDTs and possible cooperation between state and non-state actors warrants a comprehensive approach to biological risk mitigation in the 21st century.

32. Various measures are in place to mitigate the risk of proliferation of bioweapon knowledge and materials to terrorists. These are first and foremost national legal measures (including laws forbidding the possession of biological agents) which can potentially deter terrorists from carrying out biological attacks. Moreover, international cooperation among national authorities and regulators is very important in preventing biological attacks from terrorists. Interpol has a dedicated Bioterrorism Prevention Unit (BPU) which aims to reduce the threat of bioterrorism and provides targeted training for law enforcement agencies on how to prevent, prepare and respond to a bioterrorist attack (Interpol, 2017). The BPU is also working to develop an innovative biological incident analysis platform for the law enforcement community which will provide member countries with robust analytical support and intelligence sharing. Regulatory authorities can share their knowledge and experience as members of the International Experts Group of Biosafety and Biosecurity Regulators (IEGBBR). However, membership and, thus, efficacy of the forum remain incomplete as only nine out of 23 countries with BSL-4 laboratories have it. Under the auspices of the UN Office of Counter-Terrorism, the UN Global Counter-Terrorism Strategy calls upon member states and international organisations to ensure that advances in biotechnology are not used for terrorist purposes and combat smuggling of biological materials (UNOCT, n.d.). Similarly, UN Security Council Resolution 1540 condemns state support for non-state actors seeking nuclear, chemical, or biological weapons to prevent cooperation and the build-up of terrorist capabilities (Blum and Neumann, 2020).

33. As many compounds involved in the preparation of pathogens have multiuse properties, monitoring and control of the acquisition of dual-use materials is more practical than an outright ban (Tu, 2018). The Australia Group, an informal group of 43 countries established in 1985, exercises this function on an international level. It provides a platform for the coordination of national export controls to limit the supply of materials, equipment, and knowledge needed to produce chemical and biological agents to states and non-state actors suspected of pursuing such capabilities (Arms Control Association, 2018). Given the dual-use nature of knowledge involved in

the development of biological weapons, the regulation of research on infectious diseases has increased but still remains alarmingly low as fewer than five percent of countries pursue oversight of dual use research and practice a culture of responsible science (NTI GHS, 2019). Nevertheless, it is important to balance the cost of regulations in terms of the potential to stem international collaboration and scientific advancement (Green et al, 2018).

34. The pace of technological advances has far-reaching implications for the BTWC's applicability. With nearly half a century having elapsed since its conception, the treaty is ill-equipped to address the security applications of rapidly developing scientific research. There is a clear and urgent need to strengthen the treaty's capacity to address technological change, including via enhancing awareness of the implications of emerging technologies for the production and use of biological weapons. More systematic processes are needed to translate these insights into substantial provisions and develop policies and guidelines to manage the associated risks and opportunities. At the same time, the proliferation of actors involved in developing technology relevant to biological weapons means there would be considerable merit in expanding the treaty's applicability beyond states. and involving a wider range of stakeholders in discussions about standards, oversight, and controls.

V. TECHNOLOGICAL PROGRESS IN BIOTECHNOLOGY AND ARMS CONTROL

35. The 'Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases and of Bacteriological Methods of Warfare', commonly called the Geneva Protocol, which entered into force in 1925, was the first international agreement that prohibited the use of biological weapons in war (UNODA, n.d.). However, the Protocol did not contain provisions against research, development, and stockpiling of such weapons, nor did it address verification or compliance.

36. International agreements against biological weapons are centred on the Biological and Toxin Weapons Convention (BTWC). The BTWC entered into force in 1975 and was the first multilateral disarmament treaty banning an entire category of weapons. The Convention supplements the Geneva Protocol which prohibited the use of such weapons. The BTWC prohibits the development, production, stockpiling or other acquisition and retention of biological agents or toxins "of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes" (UNODA, n.d.). However, the BTWC still permits biological warfare research for defensive or protective purposes. However, the Convention does not address synthetic biology or other emerging and disruptive biotechnologies. As of January 2021, 183 states have ratified or acceded to the treaty, most recently Tanzania in August 2019. Eighteen states have not joined the treaty, which keeps it from being universal, and many States parties have not passed the necessary legislation to implement the treaty's provisions domestically. Fourteen countries have still not ratified the BTWC, including states in regions of major tension (Trezza, 2020). Nevertheless, the agreement remains a significant barrier to the development and use of biological weapons (Jenkins, 2017). States which have not signed the treaty include Israel, Eritrea, and Chad, and those who have signed but not yet ratified the treaty include Egypt, Somalia, and Syria.

37. The BTWC is the cornerstone for the protection against biological weapons. However, effective implementation is challenged on multiple fronts. Foremost among these is that it lacks a verification mechanism. Moreover, oversight of countries' work on biological agents is difficult to achieve, partly due to increasing private ownership of equipment, materials, and technical knowledge (Lentzos, 2020). The difficulty in distinguishing between permitted defensive research and prohibited offensive projects also means that it is not possible to verify disarmament in the same binary sense which is applied to the verification of nuclear treaties, such as the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). Instead, ensuring compliance involves qualitatively assessing justifications for countries' biotechnology research (Lentzos, 2020). What is more, the very definition of what constitutes a biological weapon is evolving alongside the science. Biotechnology has the potential to generate unconventional weapons as a by-product of the

dual-use nature of many biological agents. Traditionally, especially within militaries, biology and biological threats tend to be stove-piped, in that they are usually only considered in terms of weapons of mass destruction (WMD) and health and medicine. COVID has only reinforced this approach. It is therefore necessary to develop a more “unconventional” approach when it comes to the biological threat space in accordance with the latest developments.

38. An additional challenge is the lack of an implementing body. There is no biological weapons equivalent of the Organisation for the Prohibition of Chemical Weapons (OPCW), which functions as the international authority for the 1993 Chemical Weapons Convention. An implementation agency for the BTWC would allow signatory states to evaluate, verify, and deal with violations much more effectively. As there is no implementation body, BTWC signatories can only consult with each other in response to a perceived violation or take the issue to the United Nations Security Council (UNSC) with the hope of producing an enforceable UNSC Resolution. Alternatively, a country can also appeal to the International Court of Justice. It should be noted, though, that not all states are legally bound by the BTWC and not all countries have accepted the compulsory jurisdiction of the ICJ in all legal disputes. Therefore, the creation of an implementation body for the BTWC is urgently needed. However, given the current state of world affairs, this does not appear feasible now.

39. The primary responsibility for compliance assessment with the BTWC falls on the countries that are party to it. Since 2006, the implementation of the BTWC has been supported by a small Implementation Support Unit (ISU) housed in the UN Department of Disarmament Affairs (UNODA). The ISU provides administrative support to BTWC meetings, coordinates the exchange of information regarding national implementation measures, and organises the exchange of confidence-building measures. The ISU consists of only three permanent staff and has no significant funding outside of voluntary contributions provided by various States parties. This affects its ability to provide full and comprehensive support to activities under the BTWC (Jenkins, 2017).

40. Article XII of the BTWC provides for the holding of Review Conferences every five years, with the purpose of reviewing the operation of the Convention and ensuring the implementation of its purposes and provisions. At the last Review Conference in November 2016, States parties discussed the voluntary exercises which had taken place with the aim of improving transparency and coordination at the national level regarding the implementation of the Convention (United Nations, 2016). Such voluntary initiatives (including peer review, visits, expert-level exchanges, and demonstration of good practices) enable states to demonstrate transparency and build trust, and are essential components in compliance judgements (Lentzos, 2020). The Ninth Review Conference is scheduled to take place 8-26 November 2021. While it is unlikely that States parties will decide on a concrete framework for oversight and verification, the COVID-19 pandemic should spur discussions on new norms and standards to strengthen the BTWC such as strengthened transparency.

VI. BIOLOGICAL WEAPONS AND NATO’S ROLE IN BIODEFENCE

41. Biodefence forms an implicit part of the principle of resilience enshrined in Article 3 of NATO’s founding treaty, which commits Allies to “maintain and develop their individual and collective capacity to resist armed attack” (NATO, 2019a). NATO generally groups biological risks with chemical, radiological, and nuclear (CBRN) threats, and addresses these within the framework of preventing the proliferation of weapons of mass destruction (WMD) among states. The risk of terrorists using biological agents are factored into NATO’s counterterrorism strategy. At the 2018 Brussels Summit, NATO Heads of State and Government emphasised the need to defend against biological threats in both the context of broader counterterrorism efforts and of WMD non-proliferation (NATO, 2018).

Box 5: Biodefence

Biodefence refers to the defensive measures taken to minimise or negate the vulnerabilities to, and effects of, a biological incident. This includes the plans, procedures, policies, and legislation aimed at establishing and executing defensive measures against attacks using biological agents. There is no singular solution for eliminating the risks posed by adversary use of dangerous bioagents; an effective biodefence is multi-layered, and includes threat awareness, prevention and protection, surveillance and detection, and response and recovery (Singh, 2019). Biodefence relies on a broad range of stakeholders including public health authorities, medical services, intelligence, international organisations (including the United Nations and NATO), and the private sector (Katz et al, 2018).

42. While the main responsibility for preparing against biological attacks and preventing bioterrorism lies with member states, NATO has a role to play in developing biodefence and deterrence policies. At the Prague Summit in 2002, NATO Heads of State and Government reaffirmed their “commitment to augment and improve expeditiously NBC [nuclear, biological and chemical] defence capabilities” and endorsed the implementation of five initiatives to enhance the Alliance’s defence capabilities against WMD. This included a virtual Centre of Excellence for NBC weapons defence, a deployable NBC analytical laboratory, and a NATO biological and chemical defence stockpile (NATO, 2002). At NATO HQ, the Political Affairs and Security Policy Division remains responsible for the overall coordination and implementation of the CBRN-Defence policy adopted in 2009.

43. NATO’s CBRN defence capabilities comprise first and foremost the Combined Joint CBRN Defence Task Force (CJ-CBRND-TF), the NATO CBRN Reachback Capability, the Joint CBRN Defence Centre of Excellence (JCBRN Defence CoE), and the Defence against Terrorism CoE. The CJ-CBRND-TF conducts reconnaissance and monitoring operations and maintains a disease surveillance system. It also has a rapid response team that can be deployed, upon request and approval, to support national efforts to fight CBRN threats (NATO, 2018). The JCBRN Defence CoE in Vyškov, Czech Republic, improves Allies’ CBRN interoperability and capabilities by multinational education and providing training and exercises. This CoE also assists Allies in the development of defence doctrines as well as procedures and standards (NATO, 2020b). The NATO Centre of Excellence for Military Medicine in Budapest, Hungary, assists the Alliance in its goal of continuous transformation in the medical field. This CoE is also the main point of contact and coordinating body for Medical Lessons Learned within NATO Medicine (NATO, NATO Centre of Excellence for Military Medicine).

44. NATO also actively works on the political and diplomatic level to improve biodefence. All NATO Allies are party to the Biological Weapons Convention and NATO contributes to effective and verifiable arms control, disarmament and non-proliferation efforts through its policies and activities. For example, at the 2018 Brussels Summit, NATO Heads of State and Government called upon the Democratic People’s Republic of Korea (DPRK – North Korea) to comply with the BTWC. Moreover, NATO cooperates with the United Nations (UN), the European Union (EU) as well as regional organisations and multilateral initiatives to address the proliferation of biological weapons and other WMD.

45. NATO plays a crucial role in managing coordination among member states’ biodefence capabilities. Intelligence sharing via the NATO Intelligence and Warning System (NIWS) and the NATO Crisis Response System (NCRS), for instance, can be vital for member states’ early identification of biological threats (Iftimie, 2020). Sharing best practices through multi-national exercises and training – including through the virtual training centre of NATO’s CBRN Task Force – is also critical in preparing Allied countries for biological attacks.

46. Although there has been a renewed focus on the threat of biological weapons since 2001, the combination of technological advances with an already unpredictable threat environment complicates the scope of responses and limits the extent to which states can prepare. In practice

this has resulted in an unequal emphasis across the biodefence spectrum, with the focus being on response and recovery rather than bio-surveillance and detection (Frinking et al, 2016).

47. The COVID-19 pandemic has shown that NATO can play a key role in helping member states respond to health emergencies. The Euro-Atlantic Disaster Response Coordination Centre (EADRCC) functions as a clearing-house mechanism to coordinate requests and offers of international assistance amongst NATO Allies and partners during a crisis scenario (Coffey and Kochis, 2020). The EADRCC has been essential to the Allied response to the COVID-19 pandemic, having coordinated 21 requests for assistance as of October 2020 (EADRCC, 2020). Its mandate includes the coordination of efforts to prevent, protect from and prepare for CBRN incidents, making it NATO's principal civil emergency response tool in the event of a biological attack.

48. The COVID-19 crisis has also revealed security and societal challenges that go beyond the epidemiological situation, namely the disruption and polarisation of societies through targeted disinformation campaigns. Aimed at sowing division amongst NATO Allies and undermining the efforts of national authorities in handling the pandemic's impact, such narratives weaken the resilience of NATO and its member states as well as the effectiveness of their crisis response. Moreover, public information campaigns and public health guidance were all-too-often not well coordinated and even provided contradictory information to the populations, particularly during the beginning of the COVID-19 pandemic. Therefore, strategic communication has to be a crucial element of a comprehensive biodefence strategy. NATO's Public Diplomacy Division (PDD) has, throughout the pandemic, cooperated with the EU's East Stratcom Task Force (Ozawa, 2020; De Maio, 2020).

49. NATO's ability to respond to biological threats is underpinned by its science and technology network. In the event of a biological attack, NATO can draw on its pool of specialist personnel and facilities to aid in identifying scientific solutions to challenges such as detection, situational awareness, and decontamination. The NATO Science & Technology Organization (STO) would play a key role here. The world's largest collaborative research forum in the field of defence and security, the STO has a network of over 6,000 scientists, engineers, analysts, and associated research facilities (Jones, 2020). During the COVID-19 pandemic the STO set up a classified platform for scientists from Allied and partner nations to share contributions to the crisis response (NATO, 2020a). The NATO Collaboration Support Office (CSO) in Paris has also coordinated research to respond to the ongoing pandemic, including virtual reality scenarios for emergency medical care and laser testing of saliva samples. NATO's S&T network enhances the Alliance's resilience to biological threats and would form part of an effective Allied response to a biological attack.

50. More generally, the STO has an extensive programme of research covering the full range of science required for biodefence. Recently, for example, the Human Factors and Medicine (HFM) Panel of the STO successfully completed a Long-Term Scientific Study on CBR, looking out to 2030 and beyond. The topics covered included CBR Defence as a System; CBR Threats Environments; Knowledge Management; Detection, Identification, Monitoring and Diagnosis; Physical Protection; Hazard Management; Medical Countermeasures; Education and Training; and Arms Control, Disarmament and Non-Proliferation.

51. NATO's Civil Emergency Planning Committee (CEPC) published non-binding guidelines for enhanced civil-military cooperation dealing with the consequences of large-scale CBRN events associated with terrorist attacks (NATO, 2019b). In 2016, NATO defined seven Baseline Requirements, which includes the ability to deal with mass causalities, and has since then developed guidance to assist Allies in their efforts to enhance their level of resilience across these areas taking an against all hazards and whole-of-government approach. Moreover, the lessons learned from COVID-19 are being currently collected and examined, among these the need to strengthen the national security of supply arrangements for medical countermeasures. Amongst

others, NATO created the Pandemic Response Trust Fund which holds medical equipment and supplies readily available to support Allies and partners (NATO, 2021). On this basis, existing guidance will be updated to include mitigation measures to address the lessons identified.

52. Ultimately, however, the protection against the malicious use of biological agents is a national responsibility. It is important to underline that the biodefence capabilities of Allies, as well as their S&T network, vary greatly – as do the financial resources and expertise member nations command. Several Allies have taken noteworthy steps in the field of biodefence. The United States is a leading actor in this field and pursues a whole-of-government approach. For example, the United States has agreements with designated institutions for biodefence at federal, state, and local levels within government agencies. Its Biomedical Advanced Research and Development Authority (BARDA) maintains Project BioShield, a biodefence programme to prepare for a possible bioterrorist attack (Haseltine, 2020). In parallel, its Biodefense Knowledge Center provides the homeland and national security communities with expert assessment and data analysis on biothreats to inform preparedness, response planning and operational decision-making (Frinking et al, 2016). In 2003, the US also established a Strategic National Stockpile (SNS) which contains USD 7bn worth of medicine and medical supplies stored in strategic points around the country and aims to ensure a swift response to CBRN incidents (Chatfield, 2020).

VII. CONCLUSIONS

53. According to the 2019 Global Health Security Index, biosecurity and biosafety remain under-prioritised areas of health security. The COVID-19 pandemic was therefore a wakeup call for the international community that it can no longer afford to ignore the dangers of biohazards. COVID-19 has raised the profile of biological risks and exposed serious weaknesses of NATO nations' response to a large-scale biological threat. On the positive side, national military forces and NATO are making valuable contributions to mitigate the effects of the crisis. NATO forces and NATO have a highly relevant role for biodefence. They are crucial to protect our nations and our populations against future biological attacks by rogue states or terrorist groups. It is therefore vital that Allies implement their pledge to spend 2% of GNP for defence – and not reduce their defence spending.

54. NATO and Allied nations continue to improve their biodefence posture through development of existing capabilities. However, rapid progress in EDTs make it challenging for NATO to stay abreast of the evolving biological threats. Bioengineering is still in its infancy; the number of laboratories pursuing research in this area will only increase. Already today oversight over these facilities is insufficient as international organisations like the WHO and existing agreements like the BTWC lack the mandate and the resources to monitor the developments effectively.

55. NATO Parliamentarians can play an important role in mitigating challenges in our nations' biodefence by:

- Generating higher awareness of the spectre of biological threats and the importance of biodefence in national parliaments and in the public;
- Moving biohazards and the need for a more comprehensive biothreat analysis and robust biodefence higher on the security agendas of our nations and of the Alliance;
- Calling upon our national governments to improve expertise in biodefence by increasing the number of biodefence experts through the education of scientists and life science students, and to expand existing biodefence capabilities;
- Calling upon national governments to examine whether biodefence policies in place and the common biodefence capabilities are sufficient to meet current and future biological threats and to provide sufficient resources to tackle them;
- Evaluating the lessons learned from the COVID-19 pandemic regarding strategic/crisis communications and public communications, which should be strengthened, taking into

account the potential of dis- and mis-information that could undermine efforts by the national authorities;

- Ensuring additional resources for resilience, including capabilities needed for CBRN defence, and preventing that these are reduced further;
- Strengthening the international regulatory framework for biodefence by providing more support for the BTWC's ISU, which is woefully underfunded and understaffed;
- Evaluating if and how measures to detect and prevent proliferation of dual-use biological materials and equipment can be improved;
- Modernising Alliance capabilities to develop and produce biological countermeasures and securing the necessary supply chains and stockpiles to that effect, and using NATO's guidelines to continue to enhance resilience through civil preparedness, including for potential CBRN incidents;
- Encouraging national governments to make greater use of NATO for the exchange of experiences and best practices among member states, and with partners, including by increasing the number of biodefence exercises and supporting information exchange between civilian and military research to avoid redundant efforts;
- Prompting our governments to evaluate if the North Atlantic Council and its subsidiary Committees could serve as a political platform to discuss national approaches to the upcoming BTWC and future review conferences, thereby helping to align policy to strengthen the Convention;
- Evaluating if, and how, NATO Allies can contribute more to strengthen NATO's biodefence capabilities, including through the STO;
- Holding regular NATO training and table-top exercises, involving civil and military units, which serve the purpose of testing and enhancing rapid deployment, multi-agency collaboration, interoperability, and coordinated communication;
- Improving awareness of the shifting nature of biothreats, beyond pathogenic disease to avoid that dual-use developments in biotechnology catch NATO and Allied nations by surprise.

56. The ninth BTWC Review Conference which is taking place in 2021 and the fact that COVID-19 made our publics recognise the profound consequences of neglecting biological risks offer a chance to remedy the gaps in our nations' biodefence. We must not miss this opportunity.

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