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Research Article

Rethinking biosecurity in the 21st century: An enhanced role for civil society

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ABSTRACT

In this paper, we briefly discuss the historical issues concerning the Biological and Toxin Weapons Convention (BTWC) and analyse the current situation after the COVID-19 pandemic with emphasis on the new developments at 9th Review Conference of the BTWC. In particular, we discuss the mission of the new working group agreed at the review conference to identify, examine, and develop specific and effective measures, including possible legally binding measures and to make recommendations to strengthen and institutionalise the Convention in all its aspects, and compare it with productive activities associated with the Chemical Weapons Convention (CWC) and the World Health Organisation (WHO). The enhanced role for civil society in support of the BTWC is then proposed with some solid examples from our own recent projects. We hope this analysis will help to facilitate new thinking about strengthening BTWC in coming years.

1. Introduction

At the time of writing this paper in early June 2023 the World Health Organisation (WHO) website indicated that there had been 767,364,883 confirmed cases of COVID-19 and 6,938,353 deaths reported to the WHO.[1] Of course, the actual number of deaths during the pandemic was certainly much higher than that,[2] and there were also large numbers of people who had or were still suffering from the debilitating illness called long COVID.[3] There can be little doubt that the pandemic had a profound effect on health, society and the economy around the world and that biological security, defined here as the prevention of natural, accidental and deliberately caused disease, will be important in coming decades.

In July 2018 the UK published its Biological Security Strategy that stated:[4]

> "There are many different definitions of biological security. *In this strategy we use the term to cover the protection of the UK and UK interests from biological risks (particularly significant disease outbreaks) whether these arise naturally, or through the less likely event of an accidental release of hazardous biological material from laboratory facilities, or a deliberate biological attack.* These risks could affect humans, animals or plants. "(Emphasis added)

It is still unclear whether the COVID-19 pandemic resulted from a natural outbreak or an accidental release from a laboratory,[5] but what is clear is that a deliberate biological weapons attack could be much worst. This was made very clear by a former US official with particular expertise in biological security when he noted that:[6]

> ". . . As bad as this pandemic is, imagine if instead it were caused by the deliberate release of a sophisticated biological weapon. About 2 percent of those infected have died of COVID-19, while a disease such as smallpox kills at a 30 percent rate. A bioengineered pathogen could be even more lethal. . ."

And he continued:

> ". . .This fact, as well as the increasing availability of advanced biotechnologies, contributes to a growing threat. Furthermore, the taboo against developing and using banned biological weapons is eroding. In recent years, Syria, Russia and North Korea have employed prohibited chemical weapons in brazen attacks. . ."

It may be argued that chemical and biological weapons are not so similar and therefore that the recent use of chemical weapons does not erode the overall taboo against chemical and biological

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weapons. We would disagree and see the erosion of either the CWC or the BTWC necessarily impacting the other. It may also be argued that the use of such a contagious agent would not be a rational action in a biological attack, but, nevertheless, contagious agents were weaponised by States during the last century and therefore cannot be easily dismissed. So, whilst acknowledging the need to improve our defences against natural and accidentally caused disease, we also need to consider the state of our defences against deliberately caused disease and how our defences against biological attacks can be strengthened.

2. Biological threats and responses

Despite the abundance of available evidence there is still little public awareness of the scale of the offensive biological weapons programmes during the last century. For example, before it abandoned its programme in 1969, the United States had developed a series of pathogens and toxins as anti-personnel and anti-plant weapons[7] as set out in Table 1.

Because of the threat of such weapons, during the last century the international community gradually agreed a series of measures to reduce the threat. Even the 1925 Geneva Protocol, negotiated after the extensive use of chemical weapons during the First World War, included in its prohibition what was then known as bacteriological warfare. The relevant section of the Protocol states that:[8]

> "Whereas the use in war of asphyxiating, poisonous or other gases, and of all analogous liquids, materials or devices, has been justly condemned by the general opinion of the civilized world; and …. To the end that this prohibition shall be universally accepted as a part of International Law, binding alike the conscience and the practice of nations;
>
> Declare: That the High Contracting Parties, so far as they are not already Parties to Treaties prohibiting such use, accept this prohibition, *agree to extend this prohibition to the use of bacteriological methods of warfare* and agree to be bound as between themselves according to the terms of this declaration…" (Emphasis added)

This prohibition on the use of biological warfare was supplemented in the 1970s by the Biological and Toxin Weapons Convention (BTWC) which in its first Article adds a series of other restrictions on the non-peaceful use of biological and toxin agents in what has been called its General Purpose Criterion. The Article states that:[9]

"Each State Party to the Convention undertakes never in any circumstances to develop, produce, stockpile or otherwise acquire or retain:

1. Microbial or other biological agents, or toxins, whatever their origin or method of production, of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes
2. Weapons, equipment or means of delivery designed to use such agents or toxins for hostile purposes or in armed conflict."

Table 1
United States standardised biological weapons.*

Anti-personnel
Bacillus anthracis (lethal)
Franciscella tularensis (lethal)
Bruccella suis (incapacitating)
Coxiella burnetti (incapacitating)
Yellow Fever virus (lethal)
Venezeulan equine encephalitis (incapacitating)
Botulinum toxin (lethal)
Staphylococcal enterotoxin Type B (incapacitating)
Saxitoxin (lethal)
Anti-plant
Puccinia graminis var, tritici: stem rust of wheat
Piricularia oryzae: rice blast disease

* From reference 7.

Two decades later it was also possible to agree the Chemical Weapons Convention (CWC) at the end of the East-West Cold War. This Convention also contains an equivalent General Purpose Criterion. Its Article I prohibits the development, production, acquisition, stockpiling, retention, transfer or use of Chemical Weapons, which are defined under Article II as follows:[10]

> "1. 'Chemical Weapons' means the following, together or separately:
> Toxic chemicals and their precursors, except where intended for purposes not prohibited under the Convention, as long as the types and quantities are consistent with such purposes…"
> and
>
> 2. 'Toxic Chemical' means:
> Any chemical which through its chemical action on life processes can cause death, temporary incapacitation or permanent harm to humans or animals. This includes all such chemicals, regardless of their origin or of their method of production, and regardless of whether they are produced in facilities, in munitions or elsewhere…"

For the purpose of implementing the Convention some chemicals were also identified in Schedules which are used in the application of verification measures. Clearly the CWC therefore covers natural toxin and their synthetic analogues as well as natural and synthetically produced chemical agents.

It should also be understood that the meaning of the word 'toxin' for the Conventions is not the same as is standardly used by scientists. As the World Health Organisation pointed out in 2004:[11]

> "In the sense of the Biological and Toxin Weapons Convention, 'toxin' includes substances to which scientists would not normally apply the term. For example, there are chemicals that occur naturally in the human body that would have toxic effects if administered in large enough quantity. While a scientist might see a bioregulator, say, the treaty would see a poisonous substance produced by a living organism, in other words a toxin – nor is this unreasonable. Wasp venom, for example, is clearly a toxin, yet its active principle is histamine, which is also a human bioregulator…"

The text goes on to say that while histamine might not be made into an effective weapons agent "the same cannot necessarily be said for other bioregulators."

The biochemical threat spectrum and response was summarized at the turn of the century by Graham Pearson as shown in Fig. 1.[12] So clearly there is intended to be an overlap between the two Conventions as both cover the mid-spectrum toxins and bioregulators and thus both impact on biological security.

3. Advances in biotechnology

Two forecasts also at the turn of the century indicated how the ongoing advances in biotechnology were going to impact the problem of ensuring biological security. In general terms, Professor Matthew Meselson of Harvard University pointed out how these advances were going to illuminate our understanding of the physiological processes of living system and thus our ability to modify them for good purposes or ill:[13]

"...During the century ahead, as our ability to modify fundamental life processes continues its rapid advance, we will be able not only to devise additional ways to destroy life but will also become able to manipulate it – including the processes of cognition, development, reproduction and inheritance.... Therein could lie unprecedented opportunities for violence, coercion, repression, or subjugation..."

And he pointed out that dangerous capabilities could be available to a much wider range of actors than were available in relation to nuclear weapons stating that:

"...Unlike the technologies of conventional or even nuclear weapons, biotechnology has the potential to place mass destructive capabilities in a multitude of hands and, in coming decades, to reach deeply into what we are and how we regard ourselves. It should be evident that any intensive exploitation of biotechnology for hostile purposes could take humanity down a particularly undesirable path."

Then the specific impact of this process for the production of weapons was identified by US analysts who noted that it would enable weaponeers to shift their focus from making changes to potential agents towards being able to rationally engineer agents to attack specific targets within living systems.[14] Clearly, if this process was allowed to get underway biodefence would become much more difficult as the array of potential agents would expand more rapidly than the defence was able to counter.

It is important to grasp this point because, as Julian Perry-Robinson noted in 2008, while the use of chemical and biological weapons as weapons of mass destruction would be dreadful:[15]

"... that is ... not the primary risk inherent in CBW. Their main danger is precisely that they need not be weapons of mass destruction, for what is unique about them is that they could in principle serve to subjugate or coerce people, even very large numbers of people, *without necessarily threatening their lives*. A capability for exerting that form of force could become attractive in circles where the capability for mass destruction is unattractive." (Original Emphasis).

Events in recent years in the use of chemical agents against civilians in Syria in order to move them from their homes and in assassinations around the world have surely well illustrated such concerns over the future use of such weapons, and the relentless advances in the life and associated sciences have been documented in many official papers, for example at meetings of States Parties to the Biological and Toxin Weapons Convention.[16]

4. The state of the conventions today

Because of changes in arrangements caused by the pandemic the 5 Year Review Conferences of the BTWC and the CWC were held within 6 months of each other, the BTWC review in December 2022 and the CWC review in May 2023. This provided a chance to assess the state of the two Conventions as the pandemic came to a close. The BTWC was negotiated in the 1970s and lacks a verification system and a major international organisation. After the failure to agree to measures to correct this situation in 2001–2002 there has been little progress in strengthening the Convention despite regular meetings of the State Parties in Inter Sessional Processes between the review conferences.

In early 2022 the United Nations Institute for Disarmament Research (UNIDIR) published a discussion of the possible outcomes of the upcoming review and the potential consequences of each type of outcome. The review suggested four possible outcomes:[17]

"A very limited outcome. No BWC Review Conference has completely failed to reach some form of agreement, and while failure to agree an outcome is possible, the history of the Convention indicates a limited outcome is more likely than failure.

A status quo outcome of a final declaration and a continuation of the Meetings of Experts and annual Meeting of States Parties. This would be very similar to the practice over the last two decades, where States parties agree to discuss and promote common understandings and effective action on identified issues. *This approach has diminishing value to all involved.* (Emphasis added)

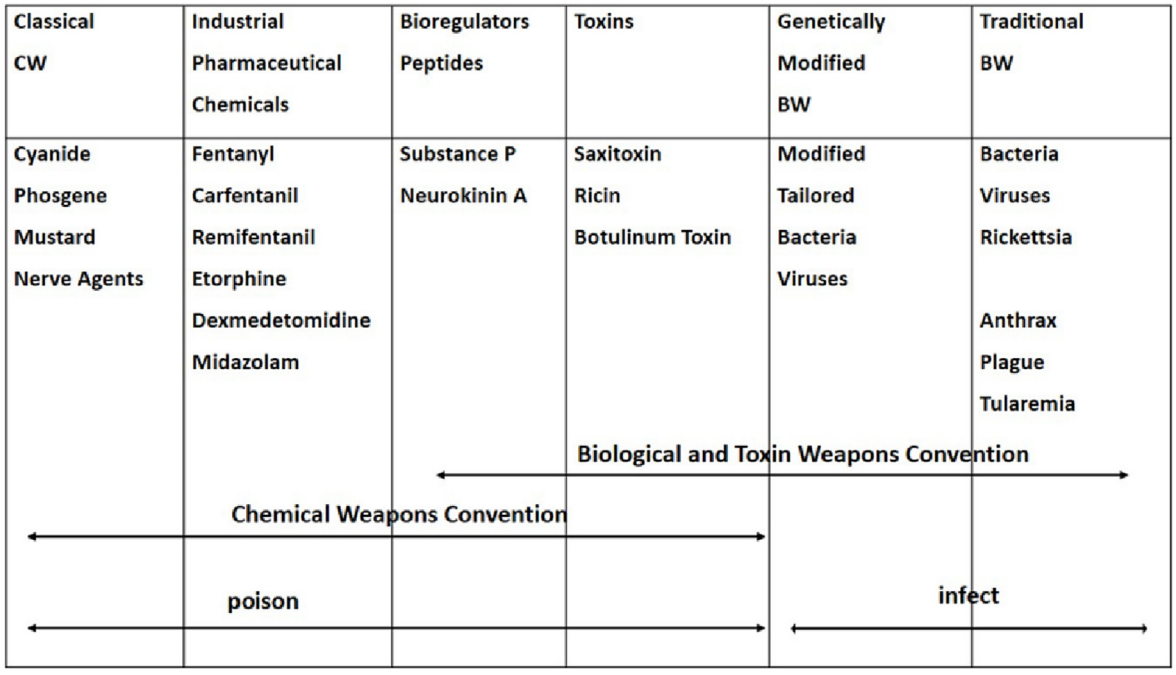

Fig. 1. The biochemical treat spectrum and response* From reference 12.

A forward-looking outcome of a final declaration and a newly mandated work programme that explores ways to enhance biological disarmament and report to the next Review Conference.

A negotiation outcome that includes a final declaration and a mandate to start negotiations on ways to enhance biological disarmament."

Unfortunately, the delay in holding the review conference meant that State Parties met against the backdrop of the war in Ukraine. Despite the amount of effort put into the preparation of the conference and the work during the conference, the outcome could be seen, unfortunately, as being in the second "diminishing value" category as it strongly resembled what had gone before during this century. The advanced version of the final report of the Review Conference demonstrated that no practically implementable decisions were possible. Instead, under Section II "Decisions and Recommendations" it was decided to establish a new Working Group on strengthening the Convention:[18]

"8. Determined to strengthen the effectiveness and to improve the implementation of the Convention in all its aspects, the Conference decides to establish a Working Group open to all States Parties.

The aim of the Working Group is to identify, examine and develop specific and effective measures, including possible legally-binding measures, and to make recommendations to strengthen and institutionalise the Convention in all its aspects, to be submitted to States Parties for consideration and any further action. These measures should be formulated and designed in a manner that their implementation supports international cooperation, scientific research and economic and technological development, avoiding any negative impacts."

Given the amount of effort that has already been spent in trying to get action agreed and implemented on these issues through previous annual meetings, arrangements for the Working Group that look much like what has been done before. The text stated that " [T]he first meeting will be held from 15 to 16 March 2023 to discuss organisational issues. The substantive meetings of the Working Group will be held from 7 to 18 August and from 4 to 8 December 2023." One potential bright spot was the inclusion of a specific arrangement for the review of science and technology developments relevant to the Convention. Nevertheless, it is hard to avoid the conclusion that the pandemic had not created a situation in which States Parties felt it necessary to urgently improve the Biological and Toxin Weapons Convention, and given the continuation of the war in Ukraine progress in 2023 progress was likely to remain slow and difficult.[19]

Similarly, in early 2023 the United Nations Institute for Disarmament Research published an analysis of what was at stake at the upcoming 5th Review Conference of the CWC and of the need for careful preparations to ensure that there was a useful outcome in view of the limited time (just one week) set aside for the meeting.[20] The analysis pointed out that, of course, there had already been considerable preparations for the review through the operations of the Open-Ended Working Group that had been established in March 2022 and the preparations of various key documents such as the summary of the operations of the Convention since the last review by the Technical Secretariat. However, the authors also noted that the 5th Review Conference was to take place in a challenging global context involving the implications of the war in Ukraine, the approaching end of the verified destruction of all declared chemical weapons stockpiles (and thus the need to reorientate the verifications system), the continuing threat of chemical weapons use, and the ongoing scientific and technological revolution in relevant fields of research and development.

In this analysis it was suggested that the key issues to be decided at the review conference included:

"a. international cooperation and assistance under the Convention;
b. allegations of CW use in Syria and elsewhere;
c. the future of verification measures following the end of the verified destruction of declared CW stockpiles; and
d. organizational matters, such as those related to the new Centre for Chemistry and Technology, the OPCW's tenure policy and gender issues."

It was clear from this analysis that a successful review was far from assured and the possibilities ranged from an unlikely ideal of "a substantive, strategically orientated outcome document adopted by consensus," to a repeat of the last review in 2018 with just a chairperson's report on "major developments in CWC implementation and reflecting deliberations during the review process" or a modification of that kind of outcome, through to a "watered-down outcome document" adopted by consensus, or even "a substantive outcome document" adopted by vote. Unfortunately, as with the BTWC, the States Parties were unable to agree to a final report by consensus and the review ended as in 2018 with a chairperson's report and no agreed re-direction of the Convention to meet the evolving international and scientific and technological situation. Given the ongoing conflict in Ukraine it again seems unlikely that there will be rapid progress in strengthening the CWC either. In short, the current situation can be summarized as shown in Table 2.

Given that unsatisfactory situation some new thinking is required about biological security after the pandemic.

5. The role of civil society

Fortunately, it has long been understood that these chemical and biological prohibitions cannot function effectively in isolation, and for several decades it has been argued that a web of preventive policies such as national implementation of the Conventions, export controls on dangerous materials and oversight of some research activities is also required.[21] Indeed, last year UNIDIR published a study that argued:[22]

"Efforts to enhance biological disarmament and build biosecurity can no longer be achieved by States alone. Input from – and collaboration with – a wide range of stakeholders is required to achieve progress in the implementation of the Biological Weapons Convention (BWC) and wider efforts to strengthen biological security…"

The publication presented a series of articles from various sectors of civil society discussing what has been done by their community, and what might better be done by that community, to help support the prohibition embodied in the CWC and particularly the BTWC. The articles demonstrated clearly that many members of civil society who have some responsibility for supporting the BTWC are life scientists, and given the convergence of biology with many other sciences such as chemistry and information technology, that responsibility also extends to other associated scientists and technologists.

A major problem arises however, because as the World Health Organisation recently noted in its *Global Guidance Framework for the Responsible Use of the Life Sciences*:[23]

"A chronic and fundamental challenge is a widespread lack of awareness that work in this area – which is predominantly undertaken to advance knowledge and tools to improve health, economies and societies – could be conducted or misused in

Table 2
The current state of the conventions.

The Biological and Toxin Weapons Convention
• Weak: Only a small organization in Geneva and inadequate verification.
• Stalemate since the failure to negotiate a verification system in the 1990s.
• Progress in dealing with the biotechnology revolution likely to remain slow.
The Chemical Weapons Convention
• Stronger than the BTWC: Large organization in The Hague and good verification system for the destruction of 20th Century chemical weapons.
• Having to resort to majority voting to deal with chemical weapons use in Syria and CNS-Acting chemicals.
• Has ability to carry out present functions but slow progress likely in dealing with the impact of the biotechnology revolution.

ways that result in health and security risks to the public. Also, incentives to identify and mitigate such risks are lacking."

Obviously, if life and associated scientists and technologists are not aware of the problem that their benignly-intended work may be misused by others in the future they will not be able to engage effectively in the efforts to protect their work from such misuse.[24]

One approach to dealing with this problem has been the consideration of codes of conduct for scientists under the Conventions.[25] Such considerations led to the agreement of The Hague Ethical Guidelines for Chemists in 2015. These guidelines had five key elements: Awareness and Engagement, Sustainability, Ethics, Education, and Safety and Security. They were also backed up by the foundation of an Advisory Board for Education and Outreach (ABEO) within the OPCW.[26] A similar process led to the development of the Tianjin Biosecurity Guidelines that were endorsed by the InterAcademy Panel of National Science Academies and presented to the Meeting of Experts of the BTWC in June 2021.[27] These guidelines are more complex and detailed than The Hague Ethical Guidelines and consist of ten key elements: Ethical Standards; Laws and Norms; Responsible Conduct of Research; Respect for Research Participants; Research Process Management; Education and Training; Research Findings Dissemination; Public Engagement on Science and technology; Role of Institutions; and International Cooperation. The element on Education and Training states that:

"6. Education and Training

Scientists, along with their professional associations in industry and academia, should work to maintain a well-educated, fully trained scientific community that is well versed in relevant laws, regulations, international obligations and norms. Education and training of staff at all levels should consider the input of experts from multiple fields, including social and human sciences, to provide a more robust understanding of the implications of biological research. Scientists should receive ethical training on a regular basis."

Numerous efforts have been made over the last two decades to develop effective methods of teaching life scientists about the general problem of biosecurity and particularly about the specific problem of dual-use, for example by the use of cartoons.[28] Such a cartoon series has been developed as part of a Biological and Chemical Security Project implemented by London Metropolitan University, UK. The cartoon series is open source and available in all six official UN languages (Fig. 2).

Fig. 2. Using cartoons for biosecurity education* From reference 27.

Table 3
Sections and chapters of biosecurity and the prevention of biological warfare.*

Section 1: Introduction and Overview
Chapter 1: Biosecurity After the Pandemic
Section 2: The Threat
Chapter 2: The CBW Agent Threat Spectrum.
Chapter 3: A Multifaceted Threat.
Chapter 4: Biological Weapons from Antiquity to 1946.
Chapter 5: Biological Weapons from 1946 to 2000.
Chapter 6: The Problem of Dual Use in the 21st Century.
Chapter 7. Key Cutting-Edge Biotechnologies Today.
Chapter 8: Convergence of Science and Technology.
Section 3: The International Response
Chapter 9: The Idea of a Web of Prevention.
Chapter 10: The 1925 Geneva Protocol and the BTWC.
Chapter 11: Other Relevant International Agreements.
Chapter 12: The Role of International Organisations: WHO, OIE, FAO, ICRC.
Section 4: The Role of Scientists
Chapter 13: Biorisk Management.
Chapters 14: Examples of National Regulatory Systems.
Chapter 15: Lessons from ePPP Research and the COVID-19 Pandemic.
Chapter 16: The Hague Ethical Guidelines and the Tianjin Ethical Guidelines.
Chapters 17: Engaging Scientists in Biorisk Management.
Chapter 18: The Role of Ethics in dealing with Dual Use.
Section 5: The Future
Chapter 19: Where is the Government of Dual- Use Science Going?
Chapter 20: Towards an International Biological Security Education Network (IBSEN)

* From reference 29.

Despite that and other creative projects there is, as the WHO suggested, much that needs to be done to improve the biosecurity education of life and associated scientists and technologists. A recent survey of such education projects came to the optimistic conclusion that:[29]

> "... our survey shows that while all of the ideal elements required to effectively implement the Tianjin Guidelines are obviously not yet in place, the efforts of multiple groups over the last two decades has put in place resources and experience that can be fruitfully used in that endeavour over coming years, and that the deficiencies identified here can also be remedied relatively quickly if efficiently addressed."

However, it also noted the deficiencies that remain, stating, in particular, that:

> "... it should be noted that the original language used in these projects was usually English and very few involved making translations of the material used even into the six official UN languages. This is a problem that will have to be addressed if the kind of progresses needed is to be achieved ..."

And, more generally that:

> "... It seems to us that to meet the scale of the awareness-raising and education requirements in biosecurity for life and associated scientists, much more effort will have to be put into finding ways of engaging larger numbers of people such as through developing innovative methods ..."

There is clearly a need for a biosecurity resource book to assist lecturers in universities and colleges and teachers in high schools to add some information on future biosecurity to their lectures and lessons and this is being addressed by an edited book that should be published by Wiley next year (Table 3).[30]

Yet it seems to us that in order to relatively quickly remedy the present lack of awareness and education amongst relevant scientists and technologists a major multi-year effort similar to the International Nuclear Security Education Network (INSEN)[31] run for over a decade by the International Atomic Energy Agency (IAEA) will be required in the area of the life and associated sciences and the resources necessary for that is nowhere in sight at the present time.

6. Conclusion

The delayed 9th BWC Review Conference held in Dec 2022 faced complicated issues under the difficult international security situation after pandemic and the hostile nature of the international environment, specifically Russian allegations of Ukrainian bioweapon programs. Yet, State Parties to the Biological and Toxin Weapons Convention (BTWC) were still able at least to reach consensus agreement to initiate a renewed effort to strengthen the Convention at the 9th Five-Year Review Conference in Geneva in December 2022. The establishment of a new Working Group and its first meeting held in March 2023 symbolised a potentially major step forward in strengthening the Convention after years of slow and progress over the last two decades since the failure to agree a BWC verification protocol in 2001–02. The challenges the working group faces are even more complicated than those that were inherited due to the fast development of science and technology, such as gene editing, artificial intelligence applying to the life science, and the still labouring efforts to educate the life and related scientists involved in these technology evolutions about the problem of dual use and biosecurity more generally. Therefore, selectively absorbing effective applications and excellent experiences from CWC, WHO, and IAEA, etc and imaginatively integrating them into the application of BTWC is worth great efforts. It is obvious that biological security needs to be considerably strengthened by improving many aspects of the web of prevention in coming years. However, it is also clear that civil society, and particularly the scientific community, could play a key role in helping to prevent future misuse of the biotechnology revolution in the development and use of biological weapons. What is needed now is a collective effort to develop and implement imaginative civil society actions to assist in the strengthening of the BTWC and CWC.

Credit Author Statement

Both authors contribute equally to this paper.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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