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Assessing the Risks and Benefits of Advances in Science and Technology: Exploring the Potential of Qualitative Frameworks

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Continuing rapid advances in science and technology both pose potential risks and offer potential benefits for the effective implementation of the Biological Weapons Convention (BWC). The lack of commonly accepted methods for assessing relevant risks and benefits present significant challenges to building common understandings that could support policy choices. This article argues that qualitative frameworks can provide the basis to structure BWC discussions about potential risks and benefits, reveal areas of agreement and disagreement, and provide a basis for continuing dialogue. It draws on the results of a workshop held in Geneva during the 2019 BWC Meetings of Experts. A diverse group of international experts were given the opportunity to apply 2 qualitative frameworks developed specifically to assess potential biosecurity concerns arising from emerging science and technology to BWC-relevant case examples. Participants discussed how such frameworks might be adapted and put into action to help support the BWC. They also began a discussion of how a comparable framework to assess potential benefits could be developed.

Keywords: Biological Weapons Convention, Risk communication, Biodefense policy

The security implications of continuing, rapid advances in science and technology are commanding increasing international attention. In his speech to the United Nations General Assembly marking the 75th anniversary of the United Nations, for example, Secretary-General Gutierrez referred to the "the dark side" of technology as 1 of "four horsemen' in our midst—four looming threats that endanger 21st-century progress and imperil 21st-century possibilities."[1] He devoted a section of his agenda for disarmament, *Securing Our Common Future*, to addressing the challenges of emerging technologies for future generations.[2] Similar discussions can be found among international and regional organizations and venues where the potential risks and rewards of science and technology are essential elements of their agendas.

One such venue is the Convention on the Prohibition of the Development, Production, and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction, commonly known as the Biological Weapons Convention (BWC). The Convention, which entered into force in 1975, was the first multilateral disarmament treaty banning an entire category of weapons. It effectively prohibits the development, production, acquisition, transfer, retention, stockpiling, and use of biological weapons. The

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Convention is also a key element in the international community's efforts to address the proliferation of weapons of mass destruction. A total of 183 countries are now parties to the Convention and have agreed to abide by its provisions.

In addition to the review conferences held every 5 years, where member states may make formal decisions, the BWC currently functions through annual intergovernmental meetings held in Geneva, Switzerland. Since these meetings began in 2003, the scope and provisions of the convention have been adjusted and enhanced at the 2006, 2011, and 2016 review conferences. Between the review conferences, 5 technical Meetings of Experts are held in the middle of each year, followed by a more political meeting at the end of that same year. Each technical meeting focuses on a specific topic that was agreed upon by all BWC States Parties at the previous annual intergovernmental meeting. For example, one technical meeting was mandated to review developments in the field of science and technology related to the BWC, such as biological risk assessment and management. The outcomes and recommendations from the Meetings of Experts, will be considered by the Ninth BWC Review Conference to be held in 2021.

In 2017, BWC States Parties agreed to include discussions of "biological risk assessment and management" as part of a comprehensive package. This was not a novel addition to the agenda of BWC meetings, however. From the mid-2000s onward, for example, references to topics such as "risk assessment" and "risk management strategies" can be found in the common understandings agreed by BWC States Parties. The BWC meetings between 2012 and 2015 took these deliberations further by including a specific agenda item on "possible measures for strengthening national biological risk management, as appropriate, in research and development involving new science and technology developments of relevance to the Convention."[3] At all times, as discussed further below, BWC States Parties have been careful to ensure that references to the "risks" posed by advances in science and technology are balanced by references to the "benefits" of such advances and that measures aimed at mitigating risks do not hamper legitimate activities.[*]

Although a range of methods exists for assessing potential risks from scientific and technological advances, a significant challenge that emerged during the BWC discussions is that no approach for reaching common understandings is accepted by all States Parties. In addition, few, if any, comparable approaches are available for assessing potential benefits and comparing them with potential risks. This article presents the argument that qualitative frameworks can provide a basis to structure BWC discussions about both potential risks and benefits, reveal areas of agreement and disagreement, and provide the basis for a more constructive consideration of the implications of advances in science and technology. The results from a pilot project held in Geneva during the 2019 BWC Meetings of Experts illustrate how such frameworks might be put into action.

Qualitative Frameworks

Qualitative frameworks are one of a number of approaches—including formal quantitative models and a variety of data analytic approaches—used to assess potential risks. Examples of these approaches are discussed in The Royal Society and International Council for the Life Sciences[4] and Morgan's risk analysis and risk management of nanoparticles.[5] Each approach can contribute to the BWC efforts, such as national assessments carried out by States Parties or the work of external experts and civil society, to grapple with the implications of scientific and technological advances. However, each type of approach has advantages and disadvantages. Qualitative models offer flexibility and adaptability, whereas quantitative models offer a perception of rigor. Using qualitative models as a starting point allows for the needs and interests of the participants to be more fully captured. Quantitative models are often perceived as being more objective but come at a high cost of data needs and requirements for analytical power. When data are incomplete or highly uncertain, the use of quantitative methods can lead to an unjustified sense of confidence in the results. On the other hand, qualitative methods, when followed without due attention to method, can be overly influenced by less relevant factors.

This project focused on the use of structured qualitative frameworks to guide systematic discussions among experts of complicated topics relevant to the BWC. The use of a group process, with collective discussions among participants, was a key feature that helps reduce the impact of less relevant factors on the final outcome. Qualitative frameworks have more options to support the development of a consensus agreement within a group of participants.

The word "framework" is often used but does not have a clear definition. In general, it means a basic structure underlying a system, concept, or text. For example, a skeleton could be thought of as the framework for the body, or an outline as the framework for a paper. It is the structure that the content is built around, therefore, the establishment of an accepted framework for a certain task can lead to increased consistency and completeness of that task.

In decision making, frameworks are useful because they provide comparability between 2 different decision cases. Without a common framework, the information gathered may focus on different aspects of a decision in different cases, making accurate comparisons difficult to make. As a simple example, imagine an environmental problem in which 2 options were being considered. One option was shown to

[*]For example, BWC Article X (2) states "This Convention shall be implemented in a manner designed to avoid hampering the economic or technological development of States Parties to the Convention or international cooperation in the field of peaceful bacteriological (biological) activities, including the international exchange of bacteriological (biological) and toxins and equipment for the processing, use or production of bacteriological (biological) agents and toxins for peaceful purposes in accordance with the provisions of the Convention."

reduce contaminant X by 10% and another was shown to reduce contaminant Y by 25%. An observer might think that 25% is better and choose the second option. However, based on the pathogenicity of the contaminants, the public health impact of the reduction of contaminant X might actually be greater than the 25% reduction of contaminant Y. A decision maker would need a risk framework to determine which contaminant would make more of an impact on the risk measures important to a decision maker. With only the initial information about contaminant reduction available, these 2 options cannot be directly compared. In another example, the US Food and Drug Administration developed a qualitative framework to address consistency in drug review decisions.[6,7] These frameworks were meant to standardize best practices used by reviewers to make their decision, so that decisions made by different reviewers had a consistent basis. In addition to the consistency provided, a framework can also ensure that all important components are included. For example, in the environmental decision case, the framework could specify that public health impact, rather than contaminant reduction, is the information that should be used to inform the decision. A framework should provide enough detail so that, if it is used multiple times by different people comparability is possible among all outcomes.

Most generally, a framework is a model for or structured approach to effectively thinking about a problem. Ideally, it provides a list of decision criteria that are a shared representation of expert thinking on an issue. If the framework is evaluated by its ability to meet the needs of a certain decision maker, one could review the elements of the framework to ensure that everything relevant to this decision maker is represented. These types of frameworks are helpful because they:

- Provide the basis for structured, systematic discussions by clearly defining a problem's essential elements
- Establish common terminology, thus ensuring that people are not talking past one another
- Enable participants to identify underlying assumptions, areas of agreement, disagreement, and consensus, as well as any remaining open questions

The effort to create a qualitative framework is an opportunity to engage technical experts from a range of subjects and sectors.

> "With varying levels of time and effort, a shared qualitative framework for potential implications of advances in [science and technology] can be applied to assess a single research paper or proposal, a line of experimentation ([eg,] studies of enhancing transmissibility of a virus), a research field ([eg,] gain of function research), or to compare different capabilities to provide an assessment of relative potential risk among them."[8]

A jointly developed framework can be used to shift the thinking of an area of practice. For example, the commonly used ecosystem-based framework considers the value of social and economic benefits arising from ecosystem services. This framework became inadequate for addressing climate resilience and health and wellbeing in urban areas, so the field of urban management decided to shift to a nature-based solutions framework, which more explicitly incorporates a broader set of benefits contributed by nature and seeks "solutions to societal challenges that are inspired and supported by nature."[9]

Benefits Frameworks

Comparing the benefits of multiple initiatives, programs, or projects is a common need. One way to address this task is to convert outcomes into common units, such as currency or aggregated units like quality-adjusted life years or disability-adjusted life years, that are relevant to certain issues. However, this approach has limitations, such as necessary assumptions about weights and scaling factors, lack of clarity about what is and is not included, and uncertain information about who receives the benefits. To address these limitations, a more nuanced comparison may be needed to provide a richer description of the types of benefits that accrue and metadata about the benefits, such as to whom they accrue and what form they take. For decisions in which multiple stakeholders may have different values of the types and receivers of benefits, a single number may not be enough; in that case, it would be useful to develop a benefits framework. A benefits framework would ensure that different applications provide similar data from the assessed benefits components. Atkinson and Cooke[10] provide an example of the categories of benefits that might make up a framework to help decision makers understand the value of conducting a health impact assessment. Similarly, Halpern et al offer a list of criteria that can be used to assess the health of an ocean related to the benefits it provides.[11]

To summarize, frameworks help clarify and standardize the approach being used, which accomplishes 2 important things: first, they ensure that estimates include all the components that the decision makers believe are important, and second, they enable comparisons across multiple estimates. Developing shared frameworks increases the usefulness of estimates.

Pilot Project

To explore how qualitative frameworks might be useful for the BWC, the InterAcademy Partnership (IAP), a global network of more than 140 national and regional academies of sciences and medicine, collaborated with the US National Academies of Sciences, Engineering, and Medicine (NASEM) on a pilot project. Given that any such framework would have to be accepted and adapted by States Parties before being used, the project was treated as an experiment rather than an attempt to develop any specific recommendation.

On August 1, 2019, IAP and NASEM organized a workshop in Geneva, Switzerland, during a break in the Meetings of Experts to take advantage of the diverse international experts attending the meetings. Two qualitative frameworks specifically developed to assess biosecurity concerns were tested using 2 hypothetical case examples that illustrated 2 different types of scientific and technological advances relevant to the BWC.[12,13] Almost 30 participants from 17 countries and 3 international organizations, whose expertise included the life sciences and chemistry, biosafety and biosecurity, public health, and science and security policy, took part. This diversity gave the organizers the opportunity to examine how well the frameworks could facilitate communication across cultures, fields, and languages.

One of the frameworks tested was developed by NASEM at the request of the US Department of Defense to assess whether capabilities enabled by synthetic biology could pose biodefense concerns.[13] The assessment is based on 4 key factors: usability of the technology, usability as a weapon, requirements of actors, and potential for mitigation (Figure 1). Within each of the factors are subelements to support a more detailed analysis, and an appendix offers an extensive list of questions to stimulate discussion. Applying this framework would typically involve a comparative factor-by-factor analysis that would lead to an integration across all 4 factors to produce an overall assessment of issues raises by a specific capability. The framework enables users to evaluate a capability using expert-based criteria that contribute to the capability's level of concern.[8]

Using this framework enables a panel of experts to develop a rich description of the factors that apply to the analysis of a specific capability and to assess relative concern across a set of capabilities. Users can contribute their particular technical or security expertise, for example, to identify where scientific or technical barriers to the full development of a capability could be monitored. The framework can also identify when additional information is needed to support the assessment process. Importantly, although the framework offers a way to understand risk, it "does not explicitly identify policy responses to identified concerns."[8]

The second framework (Figure 2) was developed by Jonathan Tucker, a US expert on the problems of chemical and biological nonproliferation and disarmament, to support the identification of options for the governance of dual use technologies.[12] This more elaborate framework begins with a technology assessment directed toward both the risk of its misuse and the potential for governance to address identified risks. It proceeds through a multistage decision tree analysis that explicitly considers the policy options resulting from the assessment. Since the technology assessment portion of the Tucker framework is similar to the 2018 NASEM framework, for purposes of comparison, the workshop focused only this component.

The participants in the August 2019 workshop were divided into groups of about 12 to 15 people. Each group had the opportunity to use both frameworks to examine 2 illustrative case examples (Box 1). After this group work, a general discussion explored how well each framework facilitated a structured conversation and what lessons could be learned to support future risk assessment efforts relevant to the BWC.

Developing a Comparable Framework

Within the BWC, discussions focus not only on what potential risks could occur but also how new capabilities could

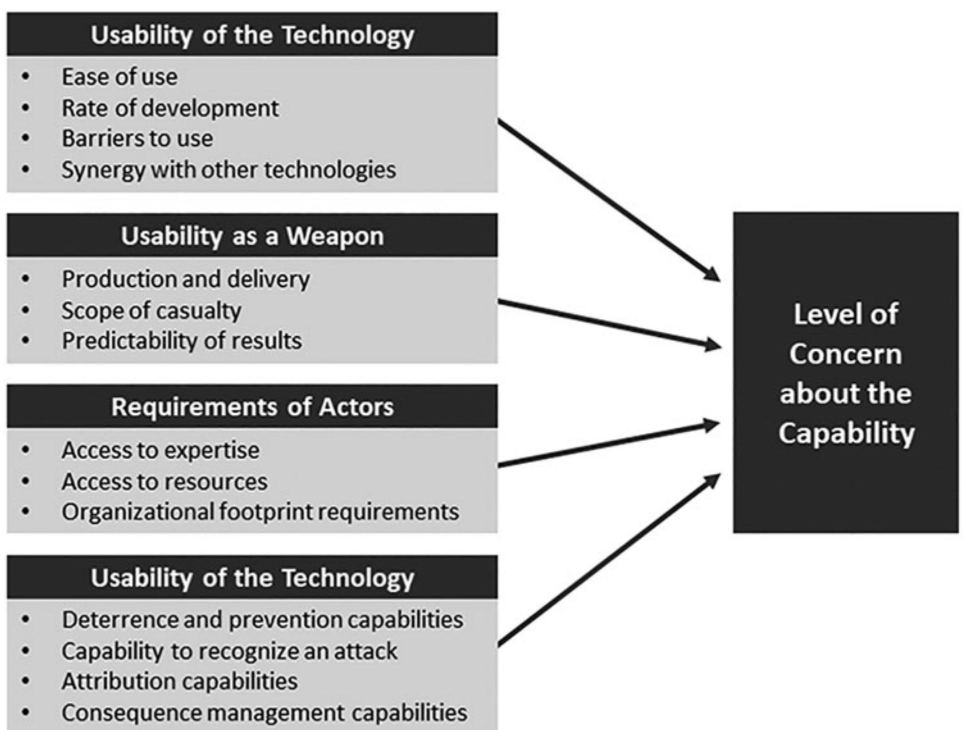

Figure 1. The National Academies of Sciences, Engineering, and Medicine Framework

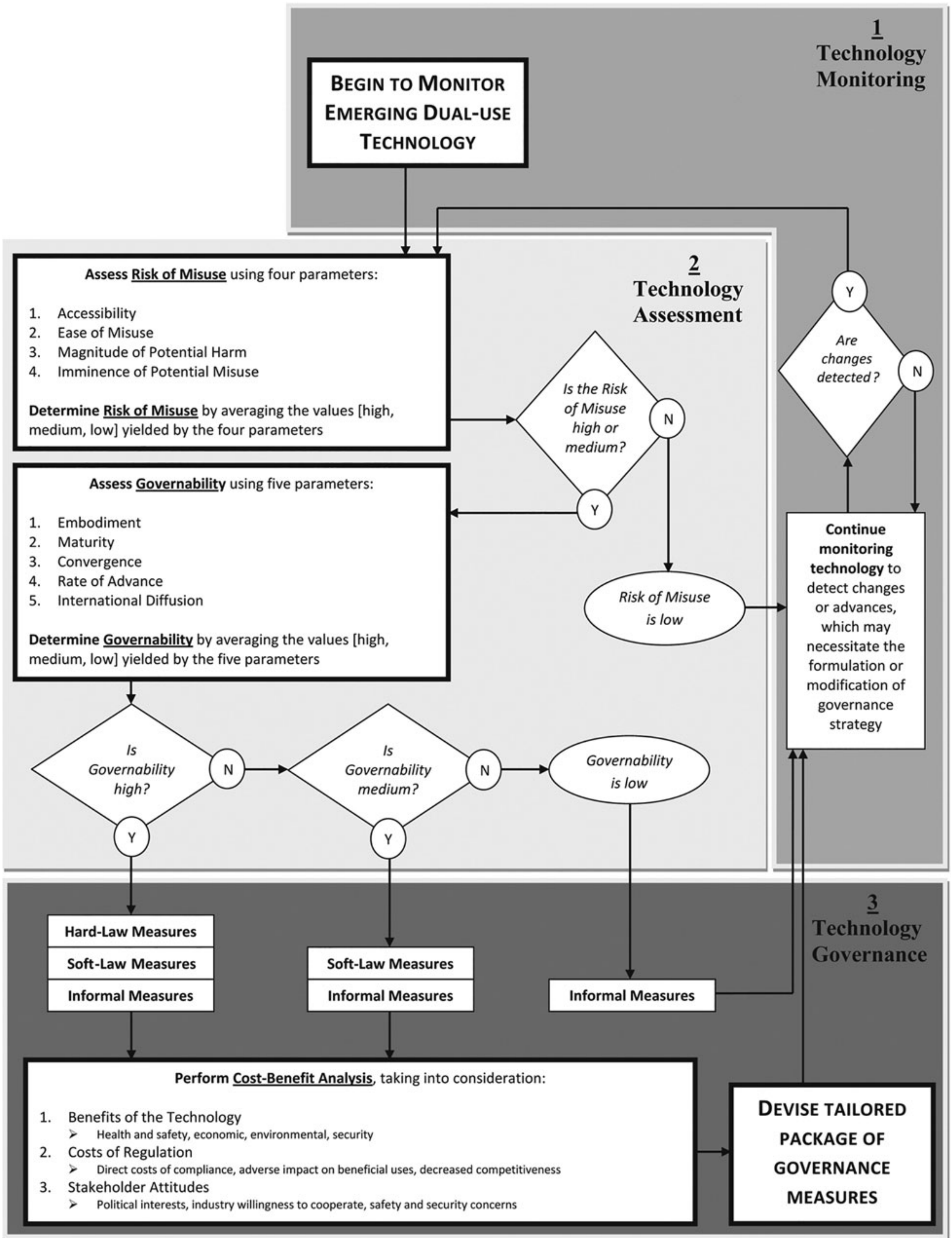

Figure 2. The Tucker Framework

Box 1. Hypothetical Case Examples Used at the Meeting

These 2 case examples drew on illustrative scientific and technical advances as an opportunity for participants to work through the 2 frameworks; they were not intended to be comprehensive or fully realistic.

Case example 1: Change in transmissibility of an emerging viral pathogen
In this example, research to develop a vaccine for an emerging animal pathogen resulted in generation of a human transmissible strain. The example drew on capabilities such as access to databases of genetic sequences, the ability to make targeted mutations in viral genomes, and the generation of resultant live virus. It presented a circumstance in which at least some experimental information was made available in the scientific community prior to discovery of the unanticipated and undesired result.

Case example 2: Engineering the microbiome
In this example, a common gut microorganism was engineered as a live microbial therapeutic to combat *Clostridium difficile* infection—a serious cause of hospital-acquired illness. The microorganism was engineered to produce a toxin whose expression would be switched on when a surface protein bound to *C. difficile.* A "kill switch" would also be inserted so that the engineered therapeutic strain could survive only in the presence of supplementing artificial molecules. This example drew on several synthetic biology techniques and reflected growing interest in the human microbiome as a therapeutic target.

Source: IAP, forthcoming.

support the effective implementation of the Convention, recognizing that efforts to minimize or manage potential misuses of scientific and technological advances should not unduly impede efforts to use their potential beneficial applications. The contributions of science and technology in investigating and responding to the alleged use of biological weapons under Articles VI and VII of the BWC are one example. More broadly, States Parties are committed to supporting the peaceful uses of science and technology through Article X.

Accordingly, the qualitative framework could provide the BWC with a tool to evaluate risks and benefits and determine how to address them both.[8] In the final plenary session workshop, participants considered how a framework to assess potential risks comparable to those available could be developed to enable assessments of the potential benefits of advances in science and technology and suggested what types of elements could be included in such a framework.

Workshop Results

The Geneva workshop began with what the organizers hoped could become a broader discussion of how the 2 frameworks considered, and qualitative frameworks more generally, could support scientific and technological assessments under the BWC. After their experience applying the 2 frameworks, participants discussed which features worked well and which might need further adaptation to meet the BWC's needs. Although the focus was on the BWC and similar international forums, participants also identified the frameworks' potential application to local, national, or regional assessments as a way of supporting the construction of common understandings. More general applications, such as providing tools to raise awareness and educate scientists about potential implications of their research, were also discussed.

Both the NASEM and the Tucker frameworks provided a useful method to structure the information in the case examples and promote fruitful conversations. Interestingly, the conclusions reached by the breakout groups about the potential biosecurity concerns raised by the 2 case examples were the same, regardless of the framework used. Both frameworks resulted in greater concern about the implications of the case on altering the properties of a viral pathogen and less near-term concern about the case about microbiome engineering capabilities.

The value of the frameworks in structuring information through the use of a group process was underscored during the breakout sessions. Although English was the working language of the meeting, it was not the first language of many participants. At points during the breakouts, when assessments differed, participants discovered through discussion that they were interpreting framework components differently or assuming different background circumstances that affected their judgment, such as the potential risks that could arise in a large, well-resourced laboratory versus those from a laboratory in a lower-resource setting. The structured framework of the discussions and the direct interactions of the participants enabled quick identification of the sources of the differences and facilitated their clarification or resolution. International and domestic settings that require experts from a range of fields and sectors to be engaged could find these features of a qualitative framework particularly helpful.

To increase its effective application, the process of adapting or developing a new framework begins by providing key stakeholders with the opportunity to reflect and agree on what they need, for example "by identifying, incorporating, and adjusting the terminology and assessment elements to be most applicable in the context of the particular use."[8] By including stakeholders from the beginning, the process ensures that "the framework includes the most relevant features and that there is buy-in from the community that will be using it."[8]

One key part of the process of creating a framework suitable for the BWC is the identification of its primary users and the purposes for which it would be used. To help ensure that a BWC-focused framework is relevant to all States Parties, it is important for the users of the framework to identify the questions the framework must address. As part of this process, users should explore the utility of existing frameworks developed for assessing biological risks such as those evaluated by the World Health Organization in their 2010 guidance on how to conduct responsible life sciences research. The document includes frameworks and self-assessments tools from a range of international nongovernmental organizations, other organizations, and governments to address biorisks associated with laboratory biosafety and biosecurity that could be used for BWC evaluation.[14] A framework's design could also be affected by the inclusion of technical experts from government agencies of different States Parties, nongovernmental academic and industry professionals, and policymakers from States Parties—individually or in various combinations.

The frameworks evaluated in the workshop both require up-to-date knowledge of the state of scientific capabilities and any barriers or bottlenecks to their development as part of their technical assessment component. If technical assessment is the primary purpose for a BWC-relevant framework, its effective use requires the inclusion of topic-specific information. The Tucker framework enables the user to go beyond technical assessment to identify governance and policy options. Some participants saw value in the potential to use a full decision tree, while others expressed concern that States Parties would perceive this as a potential intrusion on their authority.

Several additional features would be valuable in a qualitative risk framework for the BWC. For example, enabling identification of which developments or circumstances are of the most immediate concern, versus those that could be monitored and revisited, would be important. Both the NASEM and the Tucker frameworks could support this comparative analysis. The structure of a generally accepted framework could help facilitate comparison of the results of analyses of the same scientific and technological developments by different States Parties or outside experts. A shared framework, using a core set of factors and considerations, could become a common first step in the development of more formal and complex risk assessments.

As mentioned above, participants took the initial step to discuss how to develop a comparable structured approach to analyzing the potential benefits of scientific and technological advances and whether an integrated risk and benefit assessment framework would be possible or desirable. One result was their realization that considerably more discussion would be needed. A key difference among participants was whether the factors used to assess potential risks and potential benefits should be similar. Some participants advocated the use of the same factors in both frameworks; "Ease of Use," for example, could be a concern for a risk assessment but also signify the relative ability to capture a benefit. Other participants stated that factors to assess benefits should reflect the ways in which science and technology could be applied to help States Parties, for example, improve public health, contribute to economic development, or support environmental protection. Although the length of the workshop limited activities to framing questions, the facilitators underscored this step as essential for finding common ground on the design of a benefits framework. Participants also identified the importance of further discussions on how best to capture the inherent uncertainty in the results of scientific research, particularly in its early stages, and in the timeline for realizing anticipated benefits.

Meetings of Experts Discussions

The 2018 and 2019 BWC Meetings of Experts on science and technology featured in-depth discussions on biological risk assessment and management. A number of working papers on the subject by States Parties, presentations by experts, and side events on the margins of the meetings provided context and additional reinforcement for the significance of the topic to the BWC. For further background, Box 2 contains a list of working papers published from 2012 to the 2019 meeting related to risk assessment and management submitted by States Parties.

Taken together, the inputs from 2018 and 2019 provide the most detailed discussions of the topic to date within the context of the BWC. During the meetings, States Parties noted the difficulty of adequately predicting and anticipating future advances, including assessing the related risks and benefits. With reference to the convergence of technologies, States Parties stressed the need for a holistic approach toward biorisk assessment and management that would cut across scientific disciplines and involve stakeholders from various backgrounds. At the 2018 and 2019 meetings, several States Parties informed their peers about their existing national biorisk and management approaches and noted that a "1 size fits all" solution is not possible in the context of the Convention. States Parties, therefore, emphasized the need to develop broad guiding principles for biorisk assessment and management on issues specific to the Convention that could then be adapted to national contexts and circumstances.

Qualitative frameworks were considered during the 2018 and 2019 meetings and in some States Parties working papers. In 2018, the US working paper discussed the NASEM framework within the broader context of the challenges of assessing the potential risks and benefits of research. In 2019, the US discussed the NASEM and the Tucker frameworks, expanding on issues related to assessing and weighing potential risks and benefits. The United Kingdom's 2019 paper also discussed the role that qualitative frameworks and related tools could play in supporting a more developed process of scientific and technological review. In addition, in 2018, the newly released NASEM framework was presented in plenary and discussed as part of a side event organized by IAP and NASEM. In 2019, the initial results of the August 1 event were presented at a side

Box 2. Biological Weapons Convention Working Papers Related to Risk Assessment and Management

BWC/MSP/2019/MX.2/WP.3 - Approaches to Risk and Benefit Assessment for Advances in the Life Sciences. Submitted by the United States of America

BWC/MSP/2019/MX.2/WP.6 - Biological Risk Assessment and Management: Some Further Considerations. Submitted by the United Kingdom of Great Britain and Northern Ireland

BWC/MSP/2018/MX.2/WP.1 - Germany's Best Practice in Handling (Bio)Security-Relevant Research: Self-Governance Organized by the German National Academy of Sciences Leopoldina and the German Research Foundation (DFG). Submitted by Germany

BWC/MSP/2018/MX.2/WP.5 - Recent Advances in Gene Editing and Synthesis Technologies and Their Implications. Submitted by the United States of America

BWC/CONF.VIII/WP.32 and Corr.1 - A Coordinated Approach to Enhancing Bio-Risk Mitigation: National CBRN Action Plans. Submitted by Cote d'Ivoire, Gabon, Georgia, Kenya, Montenegro, Morocco, Philippines, Republic of Moldova, Serbia, Senegal, and Uganda

BWC/CONF.VIII/PC/WP.25 - Frameworks for Effective Oversight of Scientific Research Facilities and Awareness of Dual-Use Risks. Submitted by Canada

BWC/MSP/2015/WP.2 - Biosafety and Biosecurity: Today's Challenges for Politics and Science. Report from a Seminar Held on 25 June 2015 in Vienna. Submitted by Austria

BWC/MSP/2015/MX/WP.4 - The United States of America High Containment Laboratory Policy. Submitted by the United States of America

BWC/MSP/2015/MX/WP.17 - Consideraciones y medidas para mejorar la biocustodia de los materiales y agentes biológicos y de las instalaciones biológicas. Presentado por Chile, Ecuador, El Salvador, España, Italia, y Panamá

BWC/MSP/2015/MX/WP.19 - National Measures to Address Dual Use Research. Submitted by Indonesia, Malaysia, Netherlands, and the United States of America

BWC/MSP/2014/MX/WP.7 and Corr.1 - The United States of America Government Policy for Oversight of Life Sciences Dual Use Research of Concern (DURC). Submitted by the United States of America

BWC/MSP/2014/MX/WP.6 - Aplicación nacional de la Convención sobre las Armas Biológicas: Una herramienta para la evaluación de las instalaciones con agentes biológicos. Presentado por Chile, Colombia, España, y México

BWC/MSP/2013/MX/WP.4 - Key Biosecurity-Related Changes Made to the USA Select Agent Regulations. Submitted by the United States of America

BWC/MSP/2012/WP.3 - The United States Government's Biotransparency and Openness Initiative. Submitted by the United States of America

BWC/MSP/2012/MX/WP.12 - Measures for Mitigation of Risks Due to New Science and Technology Developments of Relevance to the BWC. Submitted by the European Union

BWC/MSP/2012/MX/WP.15 - Update on Australia's Security Sensitive Biological Agents (SSBA) Regulatory Scheme. Submitted by Australia

Source: Papers compiled from BWC website

event the following day,[15] and IAP and NASEM presented those results at the plenary.

Two questions were subsequently asked by delegates. The first asked about the possible role of the private sector in providing expertise to frameworks discussions on potential new technologies or their applications. The second queried whether frameworks could be used to analyze benefits. Both questions demonstrated significant awareness among the delegates of the potential value of a frameworks approach and the need to develop a systematic way to assess the benefits of advancing technologies relevant to the implementation of and compliance with the BWC. These working papers, side events, and discussions illustrate the increasing interest in developing practical tools that can be used to address risks and benefits of science and technology for the BWC.

Key Messages and Looking Ahead

Evaluating the utility of the NASEM and Tucker frameworks in the context of BWC-relevant scientific and technological examples illuminated several key messages.

- Participants from a range of countries and areas of expertise were able to successfully apply the frameworks, suggesting they are widely useful.
- The process of using the frameworks to discuss scientific and technological capabilities organizes information in ways that illuminate unstated assumptions, clarify areas of agreement and disagreement, bring forward questions, and facilitate productive discussions. In this way, the frameworks enable potential security risks to be assessed in a systematic way to inform policymakers and support the goal of evidence-informed policy.
- A parallel framework or section of a framework to promote understanding and assessment of the benefits of technologies could also be developed. This process was started during the workshop.

Looking ahead, the development of a framework that meets BWC needs to address potential risks will require further opportunities to adapt and test ideas. It would also be useful to conduct preliminary research to propose a related benefits framework. Word focused on risks and benefits should include additional groups of intended users and use different types of case examples in order to capture the breadth of issues that have implications for the Convention. Continuing to use and adapt qualitative frameworks for scientific and technological assessment purposes other than application to the BWC will also continue to provide valuable insights. Any assessment framework adopted for routine use by the BWC will ultimately be the choice of the States Parties. Their input is essential to clarify the ways in which a BWC-relevant framework might be used in the context of the Convention and identify who primary user communities could be. As is made clear in Article X, such a framework should also allow the assessment of the benefits of advances in science and technology. IAP and NASEM will continue to develop, test, and refine suitable frameworks with the aim of providing BWC States Parties with a workable option.

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