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Promoting responsible science and CBRN security through codes of conduct and education

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ABSTRACT

The paper examines the utility of codes of conduct for promoting responsible science and chemical, biological, radiological, and nuclear (CBRN) security education. It reviews the growing international consensus on the need for developing codes of conduct as a way of engaging scientists with the broader social, ethical, and legal implications of their work and examines the ongoing efforts to develop and promulgate such codes. The paper argues that the effectiveness of codes of conduct requires sustained and tailored effort in promoting education and awareness of security issues among scientists.

1. Introduction

While the rapid scientific and technological advancement over the past few decades offers tremendous prospects for public (and private) betterment, it has significantly altered the global security landscape, not least because of its potential to facilitate the development and spread of chemical, biological, radiological, and nuclear (CBRN) materials and novel sophisticated weapons of mass destruction (WMD) as well as older technologies which could be applied to achieve mass destruction [1–4]. In 2010, the Chinese Academy of Sciences hosted an international workshop titled "Trends in Science and Technology Relevant to the Biological Weapons Convention". Three main trends in the life sciences and related fields that "could lead to the production of new or more deadly biological weapons or lower the barriers for bioterrorism" were identified:

- The pace of science and technological advancement;
- Diffusion of research and capacity;
- Convergence between disparate areas of science [5].

These trends coupled with the ever growing reliance upon scientific and technological innovation in responding to health, societal and environmental issues pose obstacles to devising effective policies and governance mechanisms for maximising the benefits of modern science and technology and ensuring that related knowledge and materials are not misused for hostile purposes. There is a need for broadening the scope of efforts to curtail WMD proliferation by complementing formal governance mechanisms with, *inter alia*, measures and initiatives aimed at engaging a range of expertise within the science community that can contribute both to the monitoring of scientific and technological developments and the assessment of implications thereof [5]. Fostering a security culture among those engaged in the field of science and technology is an essential prerequisite for achieving such monitoring and assessment. Security culture is the assembly of characteristics, attitudes and behaviour of individuals, organisations and institutions which serves as a means to support and enhance international security [6–8]. Engaging scientists and technicians with the security concerns arising from their work is therefore a critical component of the development and promotion of security culture [9,10]. Codes of conduct are considered important tools for promoting responsible science through self-regulation. This paper, first, reviews efforts to develop and implement codes of conduct for those engaged in CBRN-related science domains and,

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second, highlights the fundamental role of security education for ensuring the effective promulgation and functioning of codes of conduct.

2. Scientist engagement against the spread of WMD

Efforts to engage scientists working in sensitive fields considered dual-use as a way of curtailing the spread of WMD date back at least to the end of the Cold War. Initially conceived as programmes for redirection of former-weapon scientist to civilian practice, over the past decade those initiatives have been vigorously transformed and adapted to the changing international landscape and novel security concerns arising from the synergistic interplay between the forces of globalisation and rapid scientific and technological advancement. This transformation has manifested itself, *inter alia*, in the significant emphasis laid on the need for education and outreach among practitioners working in sensitive areas of knowledge considered dual-use [11].

The Sixth Review Conference of the Biological and Toxin Weapons Convention (BTWC) held in 2006 recognised the importance of codes of conduct and self-regulatory mechanisms in raising awareness, and called upon States Parties to "support and encourage their development, promulgation and adoption" [12].

The Eighth Review Conference of the BTWC held in 2016, using language similar to that adopted at the previous Review Conference, also acknowledged the value of codes of conduct in the context of the national implementation of the Convention [13].

At the Meeting of Experts on Review of developments in the field of science and technology related to the Convention in August 2018, China and Pakistan tabled a Working Paper titled "Proposal for the development of a model code of conduct for biological scientists under the Biological Weapons Convention" [14]. As noted in the Working Paper, "such a model code of conduct would encourage biological researchers to timely evaluate and consciously avoid bio-research related risks, to properly tackle any possible negative impacts, and to make all efforts to prevent misuse and/or abuse of bio-technology."

In 2015, the Conference of the States Parties to the Chemical Weapons Convention acknowledged the establishment of "The Hague Ethical Guidelines" noting that they "constitute an important step to advance understanding among chemistry practitioners of the importance of nurturing responsible and ethical norms for scientific research and development" [15].

Besides intergovernmental organisations, professional bodies and epistemic societies, such as the International Union for Pure and Applied Chemistry (IUPAC) [16] and the Royal Society in the UK have also sought to promote the value of awareness-raising and codes of conduct [17].

3. Professional codes: their role, purposes, and implementation

Codes are voluntary self-governance mechanisms that establish a set of common principles which professional communities agree to abide by. Professional codes have a long-standing tradition in professional practice. In the early 19th century, for instance, codes were deemed an essential attribute of professions. Indeed, they constituted one of the chief criteria that distinguished established professions, such as medicine, law and accountancy from other occupations. By design, spheres of professional activity were considered superior *vis-à-vis* other trades not only because they required sophisticated training but also, and even more so, because their practitioners were expected to build a relation of trust with their clients, employers and the public. To gain and sustain their credibility professions had to demonstrate that they could manage their affairs autonomously [18]. Professional codes were thus indispensable, not least because they specified the acceptable norms and modes of behaviour that the members of a certain professional clique had to abide by. A breach of such a code amounted to a serious deviation of professional practice incurring severe criticism and sometimes even resulting in exclusion from the guild. In this sense, codes served a two-fold purpose allowing professions considerable space for self-regulation/self-discipline while at the same time protecting their integrity by discouraging professional misconduct. The Hippocratic Oath, the Nuremberg Code [19] and the World Medical Association's Declaration of Geneva, *The Physician's Pledge* [20] are all examples of professional codes that sought to formalise acceptable working practices.

3.1. Types of professional codes

According to their conception and aim, codes broadly fall into three categories: *aspirational*, *educational/advisory*, and *enforceable* [21]. **Aspirational** codes, often designated as 'codes of ethics', set out ideals that practitioners should uphold, such as standards of research integrity, honesty, or objectivity. Carlson and Frankel underscore that "scientists must be prepared to consider their responsibilities associated with, for example,

Box 1
Sample Code of Ethics – Pugwash Ajaccio workshop on Science, Ethics and Society, 2004.

Code of Ethics for Persons and Institutions Engaged in the Life Sciences [25]
"[A]ll people and institutions engaged in all aspects of scientific research and development, in particular, in the life sciences, must:
1. Work to ensure that their discoveries, knowledge, and application of those discoveries and knowledge, first do no harm.
2. Work for the ethical and beneficent advancement, development and use of scientific knowledge.
3. Refuse to engage in any research, development or use of science that is unethical, in particular, that is intended to facilitate – or when there is a real possibility of its being misused to facilitate – biowarfare or bioterrorism.
4. Never, under any circumstances, knowingly or recklessly to contribute to the development, production or acquisition of microbial or other biological agents or toxins…that cannot be justified on the basis of their being necessary for prophylactic, protective, therapeutic, or other peaceful purposes.
5. Take steps to prevent any research or use of science that is unethical, especially that which could facilitate biowarfare or bioterrorism.
6. While facilitating, to the fullest extent possible, the exchange of biological materials for peaceful purposes, take prudent steps to assure biosecurity by seeking to ensure that only individuals for whom there are reasonable grounds to believe will not misuse them are provided with biological agents that could be used unethically, in particular as weapons.
7. While facilitating, to the fullest extent possible, the generation and exchange of biological, scientific, and technological information and knowledge for peaceful purposes, in those rare cases where there is reasonable concern that information or knowledge could be readily misused to do harm […] seek to restrict the dissemination of such dual use information or knowledge to those who need to know.
8. Ethically justify undertaking any given scientific research or development, in particular, through ethics and safety reviews.
9. Abide by prevailing laws and regulations that apply to the conduct of science, unless doing so would be unethical.
10. Faithfully transmit the duties and obligations embodied in this code of ethics, and the principles upon which it is based, to students, trainees and others who are, or may become, engaged in the conduct of science."

Box 2
InterAcademy Panel Statement on Biosecurity, 2005.

"The 1972 Biological and Toxin Weapons Convention reinforced the international norm prohibiting biological weapons […]. Nevertheless, the threat from biological weapons is again a live issue. This statement presents principles to guide individual scientists and local scientific communities that may wish to define a code of conduct for their own use.

- **Awareness**. Scientists have an obligation to do no harm. They should always take into consideration the reasonably foreseeable consequences of their own activities. They should therefore: always bear in mind the potential consequences – possibly harmful – of their research and recognize that individual good conscience does not justify ignoring the possible misuse of their scientific endeavour; refuse to undertake research that has only harmful consequences for humankind.
- **Safety and Security**. Scientists working with agents such as pathogenic organisms or dangerous toxins have a responsibility to use good, safe and secure laboratory procedures, whether codified by law or common practice.
- **Education and Information**. Scientists should be aware of, disseminate information about and teach national and international laws and regulations, as well as policies and principles aimed at preventing the misuse of biological research.
- **Accountability**. Scientists who become aware of activities that violate the Biological and Toxin Weapons Convention or international customary law should raise their concerns with appropriate people, authorities and agencies.
- **Oversight**. Scientists with responsibility for oversight of research or for evaluation of projects or publications should promote adherence to these principles by those under their control, supervision or evaluation and act as role models in this regard [27]." [Emphasis as original]

emerging technologies, public pressure for better communication of and access to scientific work, their role in public policy deliberations, and the relationship between science and human rights" [22]. Kuhlau has suggested the following list of duties that researchers need to fulfil in order to address risk of possible hostile misuse of their work:

- The duty to prevent [CBRN] terrorism.
- The duty to engage in response activities.
- The duty to consider negative implications of research.
- The duty not to publish or share sensitive information.
- The duty to oversee and limit access to dangerous material [23].

A sample code of ethics that elucidates the responsibilities of life scientists with regard to the prevention of bioterrorism is presented in Box 1 [24]. While the code is specifically targeted at the life science community, it is evident that the principles contained therein are applicable to research in other areas of science and technology.

Educational/advisory codes, often designated as 'codes of conduct', tend to be prescriptive providing guidelines on how to act appropriately. "Considerations of guiding principles for codes of conduct need to reflect the breadth of concerns – relating to health, safety, security, and the environment. In order to have an impact on practice, codes need to be dynamic rather than static, and need to be incorporated into a continuing process akin to the considerations of health and safety that are considered prior to each new piece of work" [26]. The *InterAcademy Panel Statement on Biosecurity* and the *Hague Ethical Guidelines* are indicative in this regard. The *Statement* [27] issued in 2005 lays down a set of fundamental principles to be '*taken into account when formulating codes of conduct*' that are indicative in this regard (Box 2).

The *Hague Ethical Guidelines* developed by a group of chemical practitioners from around the world and adopted in September 2015 under the auspices of the Organisation for the Prohibition of Chemical Weapons (OPCW) are based on the premise that "achievements in the field of chemistry should be used to benefit humankind and the environment" (Box 3) [28].

Enforceable codes, often designated as 'codes of practice', seek to further codify what is regarded as acceptable behaviour. They focus on setting out certain permissible processes and ways of carrying out work and are embedded within wider systems of professional or legal regulation.

3.2. Implementation of codes of conduct

In 2008 the Royal Dutch Academy of Arts and Science issued a *Code of Conduct on Biosecurity*, a non-binding document designed to raise awareness

Box 3
Hague Ethical Guidelines, 2015.

Key elements of the Hague Ethical Guidelines

"Sustainability: Chemistry practitioners have a special responsibility for promoting and achieving the UN Sustainable Development Goals of meeting the needs of the present without compromising the ability of future generations to meet their own needs.
Education: Formal and informal educational providers, enterprise, industry and civil society should cooperate to equip anybody working in chemistry and others with the necessary knowledge and tools to take responsibility for the benefit of humankind, the protection of the environment and to ensure relevant and meaningful engagement with the general public.
Awareness and engagement: Teachers, chemistry practitioners, and policymakers should be aware of the multiple uses of chemicals, specifically their use as chemical weapons or their precursors. They should promote the peaceful applications of chemicals and work to prevent any misuse of chemicals, scientific knowledge, tools and technologies, and any harmful or unethical developments in research and innovation. They should disseminate relevant information about national and international laws, regulations, policies and practices.
Ethics: To adequately respond to societal challenges, education, research and innovation must respect fundamental rights and apply the highest ethical standards. Ethics should be perceived as a way of ensuring high quality results in science.
Safety and Security: Chemistry practitioners should promote the beneficial applications, uses, and development of science and technology while encouraging and maintaining a strong culture of safety, health, and security.
Accountability: Chemistry practitioners have a responsibility to ensure that chemicals, equipment and facilities are protected against theft and diversion and are not used for illegal, harmful or destructive purposes. These persons should be aware of applicable laws and regulations governing the manufacture and use of chemicals, and they should report any misuse of chemicals, scientific knowledge, equipment and facilities to the relevant authorities.
Oversight: Chemistry practitioners who supervise others have the additional responsibility to ensure that chemicals, equipment and facilities are not used by those persons for illegal, harmful or destructive purposes.
Exchange of information: Chemistry practitioners should promote the exchange of scientific and technical information relating to the development and application of chemistry for peaceful purposes [28]."

among practising researchers of the dual-use potential of modern biotechnology and thus facilitate the development of culture of responsibility in the life sciences. In particular, the *Code* seeks

> "to prevent life sciences research or its application from directly or indirectly contributing to the development, production or stockpiling of biological weapons, as described in the Biological and Toxin Weapons Convention (BTWC), or to any other misuse of biological agents and toxins" [29].

To this end, the *Code* sets out a set of guidelines for conduct in the following areas:

- Raising Awareness.
- Research and Publication Policy.
- Accountability and Oversight.
- Internal and External Communication.
- Accessibility.
- Shipment and Transport [29].

Following the H5N1 controversy that unravelled in the Netherlands in 2011–2012 [30], the Royal Netherlands Academy of Arts and Science in 2013 published a report titled *Improving Biosecurity – Assessment of Dual-Use Research*. This report noted that "the primary responsibility for dealing with potential dual-use risks of life science research lies with the researchers and parties in the knowledge chain" and that "the *Code of Conduct for Biosecurity* should be an ongoing topic of interest in education and researcher training and for research team heads and funding bodies" [31]. The report further highlighted that "drawing attention to the *Code* will raise awareness of possible dilemmas in dual-use research and may encourage stakeholders to be more active and vigilant" [31]. Amid the H5N1 controversy, some commentators have underscored the critical need for raising awareness and educating life scientists of their responsibilities to prevent the hostile misuse of their work [32].

4. Enhancing the utility of codes: the role of CBRN security education

In its report *Enhancing Responsible Science* published in February 2012, the US National Science Advisory Board on Biosecurity (NSABB) underlined that:

> "Disseminating a code of conduct is not simply a process of distributing the code to affected parties; it is also a process of ensuring that the code will be a "living" document and, as such, a vital force in shaping the day-to-day moral behaviour of scientists in a given context. To achieve this aim, the following points should be considered:
> - To make a code effective, strong institutional commitment is needed. This entails that sufficient resources would need to be allocated for developing and disseminating the code.
> - A successful code also depends on a strong commitment by individuals who undertake the responsibility for "championing" the code and for disseminating it throughout the institution. Institutions should identify such individuals.
> - Allocation of time for discussing the code is required. Multiple existing venues can be used, for example, student orientation sessions, faculty meetings, lab meetings, [responsible conduct of research] RCR courses, conferences and workshops, *etc*." [33].

As the discussion in the preceding section vividly illustrates, the effectiveness of codes need not be taken for granted. On the contrary, considerable attention should be given to the way in which codes of conduct are developed and promulgated among those engaged in science and technology. In this regard, one of the chief challenges that should be addressed is the pervasive lack of awareness among scientists, technicians and engineers of how their work may be misused for hostile purposes [34]. Over the past few years several important steps have been taken to address the existing deficiency in security awareness among scientists.

4.1. Nuclear security education

The area of nuclear security – a novel discipline designed to raise awareness of the legal, social and security issues arising in the physical sciences – has undergone a rapid expansion over the last few years. In 2009 the International Atomic Energy Agency (IAEA) published a Guide entitled *Educational Programme in Nuclear Security*, which first appeared in 2010 in No.12 of the *IAEA Nuclear Security Series* [35].

The guide outlined a model of a Master of Science (M.Sc.) and a Certificate Programme in Nuclear Security in order to provide Member States with a comprehensive strategy for the implementation of nuclear security education and also to encourage universities and other educational institutions to develop relevant academic programmes. In 2010, the IAEA facilitated the establishment of the International Nuclear Security Education Network (INSEN) with the aim of promoting nuclear security education [36]. Promoting nuclear security education is among the priorities identified in the *Nuclear Security Plan 2018–2021* that the IAEA adopted on 13 September 2017 [37].

4.2. Chemical security education

Similar calls for awareness raising and education have been apparent for a number of years in the area of chemical security within the framework of the Chemical Weapons Convention (CWC) [38,39].

In December 2015, the Conference of the States Parties at its Twentieth Session approved the establishment of an Advisory Board on Education and Outreach (ABEO) under the auspices of the OPCW. The primary role of the ABEO is to

> "to provide specialised advice in areas of education and outreach relevant to the Organisation's mandate […] in order to ensure that the Organisation's education and outreach activities, and those of States Parties, are effective, sustainable, cost-effective, and benefit from the latest advances in education and outreach theory and practice [40]."

4.3. Biosecurity education

The need for enhancing the awareness of the potential security risks posed by the on-going development of biotechnology among life scientists has been acknowledged within the context of the BTWC when discussing the national implementation of the Convention:

> 13. "The Conference notes the value of national implementation measures, as appropriate, in accordance with the constitutional process of each State Party, to:
> (a) implement voluntary management standards on biosafety and biosecurity;
> (b) encourage the consideration of development of appropriate arrangements to promote awareness among relevant professionals in the private and public sectors and throughout relevant scientific and administrative activities and;
> (c) promote among those working in the biological sciences awareness of the obligations of States Parties under the Convention, as well as relevant national legislation and guidelines;
> (d) promote the development of training and education programmes for those granted access to biological agents and toxins relevant to the Convention and for those with the knowledge or capacity to modify such agents and toxins [13];" [Emphasis added]

4.4. Reflections

It is evident that education and training about the security concerns arising from the rapid advancement of science and technology are essential for the implementation of all three international legally-binding regimes against the spread of weapons of mass destruction. Education and awareness-raising of the ethical, legal and social aspects

related to science and engineering should be considered as key prerequisites for the development and articulation of formal and informal mechanisms designed to avert the hostile misuse of emerging science and technology. Indeed, there are strong reasons to assume that scientists who have been sensitised to the potential risks would be more likely to demonstrate competence about their responsibilities in preventing the misapplication of their research for malevolent purposes. When underpinned by CBRN security education, efforts to develop and promote codes of conduct will meet with more success and make a significant contribution toward fostering a culture of security and responsibility among those engaged in science and technology. Hence, enhancing awareness of dual use and the potential security concerns arising from novel scientific and technological advances should be treated as an essential condition for the development and promulgation of codes of conduct. Efforts to formalise security education and training both for prospective and practising scientists therefore need to be comprehensive, systematic and adequately funded. To achieve greater effectiveness, these efforts need to be supplemented with active engagement among different stakeholders to facilitate the introduction of relevant teaching material in academic curricula and vocational training. Epistemic organisations, such as learned societies and science academies should take the lead in formulating guiding principles and fostering a continuous dialogue with university and research science faculties on promoting a culture of security and responsible science. The development of certification and competency standards needs to be encouraged and professional associations have an important role to play in this endeavour [41,42]. Last but not least, the private sector and its resources should be leveraged for promoting the norms of safe, secure, and responsible science, including through the incorporation of security issues into the existing mechanisms for industry self-regulation and by encouraging vocational training and human resource development in chemical security, nuclear security, and biosecurity management [43]. Only in this way the concept of codes of conduct is likely to win sufficient buy-in from researchers and actually influence their professional practice, and thus strengthen the governance regime for mitigation of CBRN risks.

Conflict of interest statement

The authors declare that there are no conflicts of interest.

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