Journal of Biosafety and Biosecurity 6 (2024) 252–257

Contents lists available at ScienceDirect

Journal of Biosafety and Biosecurity

journal homepage: www.keaipublishing.com/en/journals/journal-of-biosafety-and-biosecurity/

Short Communication

Lessons for biosecurity education from the International Nuclear Security Education Network

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ARTICLE INFO

Article history:
Received 30 July 2024
Received in revised form 19 September 2024
Accepted 23 September 2024

Keywords:
Security education
Biological and Toxin Weapons Convention (BTWC)
Chemical Weapons Convention (CWC)
Nuclear security education
International Nuclear Security Education Network (INSEN)
International Biological Security Education Network (IBSEN)

ABSTRACT

With the rapid advances in technology and life science, biological security is now at a defining moment. The mandate of the 2022 Biological and Toxin Weapons Convention 9th Review Conference emphasised the urgent need for new tools to strengthen the Convention. In this paper, we review the development and efforts of the International Nuclear Security Education Network (INSEN) to provide examples of best practice for implementation of the newly founded International Biological Security Education Network (IBSEN). Learning from the lessons of the INSEN, the sustainability of the network through continuous engagement of its members is essential for the further development of global biosecurity education.

1. Introduction

Rapid technical and scientific advances have increased the number and scale of biosecurity challenges faced by society.[1] These challenges are exacerbated by a lack of formal biosecurity training among scientists and policymakers. A similar defining moment took place 15 years ago in the field of nuclear security. At that time, the International Nuclear Security Education Network (INSEN) was set up to address the absence of trained professionals in nuclear security and enhance global security through the introduction of a formal education network.[2] In this article, we explore the history of INSEN and its implementation practices over the past 15 years as well as the lessons learned, especially in the era of advanced science and technology. This information has very useful implications for the newly established International Biological Security Education Network (IBSEN).

1.1. History and challenges in nuclear security

The Nuclear Non-Proliferation Treaty was first proposed by Ireland at the meeting of the General Assembly of the United Nations in 1961.[3] A vital element in developing an effective arms control treaty was for non-nuclear states to accede to the treaty. This was a very challenging aspect of the treaty as non-nuclear states had to agree to not receive, attempt to develop, or acquire nuclear weapons. The Nuclear Non-proliferation Treaty was subsequently signed in 1968 and entered into force in 1970. Signatories agreed to not transfer nuclear weapons and technology, to cooperate in developing peaceful nuclear technology, and to submit to safeguards against proliferation established by the International Atomic Energy Agency. The treaty originally had a time limit of 25 years; however, it was extended indefinitely in 1995.

The terrorist attacks on September 11, 2001 and the subsequent impact on international security played an important role in the creation of the INSEN. The international community became increasingly aware of the risk of terrorists obtaining weapons of mass destruction, alongside increasing tensions regarding Iran's nuclear program. This context led to increased awareness among the international community, manifested by the amendments of

Peer review under the responsibility of Editorial Board of Journal of Biosafety and Biosecurity.
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https://doi.org/10.1016/j.jobb.2024.09.002
2588-9338/

the Convention on the Physical Protection of Nuclear Materials in 2005. United States President Barak Obama presented a notable speech on April 5, 2009 in Prague, where he pledged to work towards a nuclear-free world.[4,5] Following this call introducing a new kind of multilateralism, the first Nuclear Security Summit was organised in April 2010.[6]

2. Establishment of the nuclear security education network and recent developments

The 2009 Nuclear Security Plan agreed by the International Atomic Energy Agency (IAEA) Board of Directors emphasised the need to develop educational programmes in nuclear security.[7] As a result of the initiative put forward by the IAEA, a Master of Science (MSc) programme and a certificate programme in nuclear security were proposed.[6,8,9] These programmes were developed in line with technical guidance from the IAEA Nuclear Security Series No 12 - Educational Programme in Nuclear Security.[10] The MSc and certificate programmes aimed to be complementary to academic programmes already implemented in some universities.[7] A workshop organised in March 2010 by the IAEA brought together academics, international organisations, and government representatives to discuss this complementarity and to deliberate on the foundations of the network.[7] The objective of INSEN given by the IAEA is to enhance nuclear security education globally. INSEN defined its mission in 2012 as being to develop educational materials (peer-reviewed textbooks, online teaching tools, and instructional material including exercises and materials for laboratory work), collaborate internationally at different levels (faculty, academic, and student), and enhance quality assurance (consistent with IAEA-defined terminology) and assessment mechanisms (such as the effectiveness of nuclear security education via evaluation, coordination, and improvement).[7]

As of 2023, the INSEN includes 204 institutional members from 72 IAEA member states and 13 observers.[11] To reach the above objectives and promote awareness about nuclear security, the INSEN was structured into three working groups (Fig. 1).[10] Members of the INSEN can participate in multiple groups and group meetings are held either at the annual meeting or in working group meetings.[7]

2.1. Overview of nuclear security training developed by INSEN

Training courses have been developed to target students with a range of academic backgrounds and are included in the MSc programmes, 2-week summer schools, and short courses. Below are a few examples.

The INSEN had an important role in the establishment of the Joint International Centre for Theoretical Physics (ICTP)–IAEA International School on Nuclear Security overseen by the IAEA and the ICTP. The 2-week International School on Nuclear Security provided an overview of contemporary nuclear security and was open to professionals with various science and social science backgrounds.[10]

King's College London (KCL) pioneered the development of Professional Development Courses (PDCs) within the Network. The INSEN also provided training in the form of Faculty Development Courses (FDCs).[12]

The MSc programmes are guided by the curriculum put forward by the IAEA Nuclear Security Series No 12 - Educational Programme in Nuclear Security (2010).[10] The guide first suggests conducting an assessment of nuclear security needs at national level, followed by an analysis of the multidisciplinary aspects of nuclear security. The proposed MSc in Nuclear Security includes 12 required courses that discuss the international/national legal frameworks, methods and instruments involved in dealing with nuclear material, effects of radiation, threat assessment, systems of physical protection, security for nuclear material, as well as the detection, response, and investigation of criminal or unauthorised acts. Elective courses include nuclear material accountancy, import/export and transit control mechanisms and regimes, nuclear security at major public events, nuclear forensics, and information technology/cybersecurity, among other elective courses. On the basis of this IAEA guide, the European MSc in Nuclear Security was administered by Delft University in the Netherlands and supported by five universities: University of Oslo, Technical University of Vienna, Brandenburg University of Applied Sciences, Dalton Nuclear Institute at the University of Manchester, and the National Centre of Scientific Research 'Demokritos' in Greece.[4]

The *Model Academic Curriculum in Nuclear Security*, released in 2021, included new technical guidance.[13] The updated MSc curriculum introduced new modules and divided the core modules into three categories: protection, detection and response, and cross-cutting topics. This new guidance recognised that each university would implement the degree structure differently, based on analysis of the resources and national job market.[13] It is estimated that 2500 undergraduate and postgraduate students have participated in nuclear academic programmes offered by members of the INSEN.

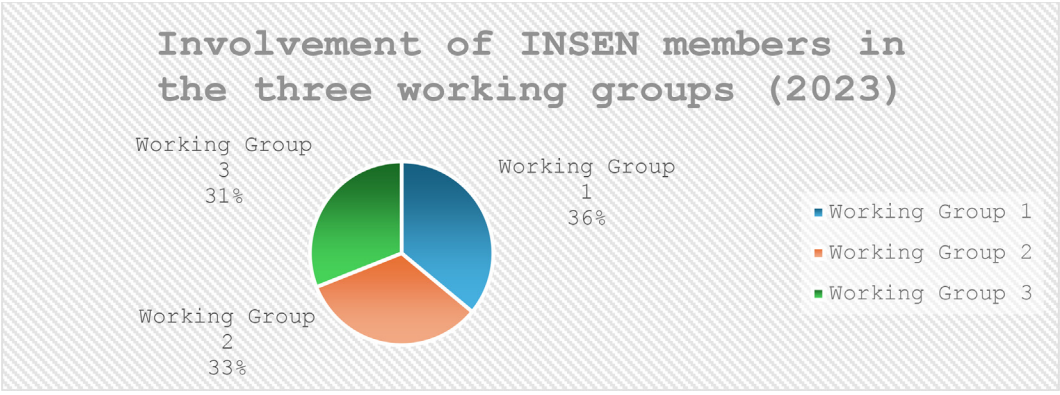

Fig. 1. Involvement of the International Nuclear Security Education Network (INSEN) members in the three working groups, "Exchange of information and development of teaching materials for nuclear security education" (working group 1), "Faculty development and cooperation among universities" (working group 2), and "Promotion of nuclear security education" (working group 3).[11]

The aforementioned programmes have made considerable contributions to the promotion of the network and training of a new generation of policymakers, scholars, and professionals educated in nuclear security.

2.2. Recent developments in the INSEN

The Annual Meeting of the International Nuclear Security Education Network (INSEN) – Chair's Reports 2022 and 2023 highlighted recent developments in the INSEN.[14,15] These reports emphasise the importance of sustainability and flexibility in the network and illustrate the network's ability to adapt to constantly changing international and local contexts. The renewed framework for nuclear security education (2022–2025 Nuclear Security Plan), approved during the 2022 annual meeting, supported this view. Members at the 2022 annual meeting also discussed the release of the IAEA Nuclear Security Series No. 12-T (Rev.1) and its implementation.

The recently published *Oxford Handbook of Nuclear Security* illustrates the important role played by researchers in enhancing nuclear security education within this new framework. Training of early-career professionals is key in creating a sustainable network. In the previously mentioned meetings, members discussed multiple approaches to engage students and young professionals. This focus on young professional engagement was included in the IAEA International Conference on *Nuclear Security: Shaping the Future* (ICONS 2024).

INSEN members have also placed emphasis on their commitment to gender parity within the network and field of nuclear security. This can be seen through the Women in Nuclear Security Initiative (WINSI) and the Marie Sklodowska Curie Fellowship Programme.

3. Successes and challenges of INSEN

With its rapid growth, the INSEN has had a substantial impact on advancing worldwide nuclear security. This has been facilitated by the affiliation with and support from the IAEA, which has an important role in promoting the INSEN by prioritising nuclear security education. The IAEA *Nuclear Security Plans* give high priority to nuclear security education and assist IAEA member states in establishing educational programmes.[12] These plans also provide a secretariat function for the INSEN and hosting of the Nuclear Security Information Portal (NUSEC), the coordination platform for the three working groups. These resources enable INSEN to multiply its educational approaches to nuclear security through the design of PDCs and FDCs, summer schools, master's programmes and educational material on the NUSEC platform, with each targeting different audiences. Specific initiatives, such as WINSI, foster the participation of women through dedicated events and opportunities.[16] The network also benefits from considerable outreach and promotion strategies with members regularly presenting at diverse conferences.[12] INSEN members also promote the network and its research locally, which leads to a multiplier effect and a regionally focused approach.

3.1. King's College London (KCL) as a local INSEN champion in nuclear security education

As a member of INSEN, KCL has a globally and regionally important role in promoting the network by delivering cutting-edge training on nuclear security. In partnership with the INSEN, in 2010, the KCL Centre for Science & Security Studies launched the first PDC. During the first 3 years of the KCL PDCs, these courses were attended by more than 100 academics from 30 institutions and 15 countries.[17] The PDCs organised by KCL include six different workshops, such as *Physical Protection of Nuclear Materials* and *Insider Threat and Preventative Measures*, each lasting between 2 and 6 days. These courses and workshops follow an interdisciplinary approach and use different methods to apply theoretical concepts such as case studies, site visits to an operational nuclear power plant, or video walk-through of a site containing radiologic sources.[17]

KCL had to adapt to both the variety of backgrounds of its students and the interdisciplinary nature of nuclear security concepts. The courses taught at KCL were focused on both analysing nuclear security issues and on teaching methods and case studies. For this first half of the course, introductory e-learning with videos explaining the key concepts of nuclear security were sent to students prior to the classes. The assessment mechanisms of these courses were also adapted to include short-answer exercises and open-ended policy questions. On the basis of the principles of a 'learning paradigm' in nuclear security education, outlined by Professor Christopher Hobbs, KCL developed efficient educational tools as part of its INSEN membership.[18] Furthermore, between 2014 and 2016, KCL organised some courses locally in Sub-Saharan and North Africa, the Middle East, and Southeast Asia that focused on regional nuclear security education. The last KCL PDC was organised in 2017.

KCL also developed a Master of Arts (MA) in Science and International Security programme. The programme focused on the policy aspects of nuclear security, but interestingly, it also included classes on biological security. There were approximately 25 students per cohort coming from interdisciplinary backgrounds. However, owing to a lack of funding and other internal decisions, the MA programme was discontinued after the 2023–2024 academic year. The modules of the MA programme are now offered as optional courses to students in the 13 master's courses offered by the KCL Department of War Studies.

KCL has established itself as a hub for nuclear security education in the INSEN thanks to the variety of programmes offered and the diversity of empirical methods used and adapted to different student backgrounds.

3.2. Challenges faced by the INSEN: How to build a sustainable network

3.2.1. Coordinating members from different backgrounds

Owing to its interdisciplinary nature combining social sciences and nuclear science, nuclear security still faces difficulty in being recognised as an individual/separate educational field.[8] This is particularly the case for social scientists, as compared with life scientists. Challenges also arise from the discrepancy of subject backgrounds with students in the field of social sciences when paired with trainers in the field of natural sciences and vice versa.[4]

Although the network has been continually welcoming new members since its creation, it has also been faced with the difficulty of involving institutions from all continents. The geographic distribution of the INSEN members (Fig. 2) highlights that only 3 % of members are from Latin America. However, this region has an important role in nuclear security.[19] One of the only members in Latin America is Brazil, who joined the network very recently. Although the INSEN is willing to expand the participation of Latin American states, there seem to be few answers to this call. This raises questions regarding the efficiency of the INSEN outreach strategy in the region, especially in areas with different geographic and cultural backgrounds. Additionally, some registered members are inactive, with only an estimated 25 % of INSEN members who are regularly participating and engaging locally with the educational material. While providing numerous opportunities for

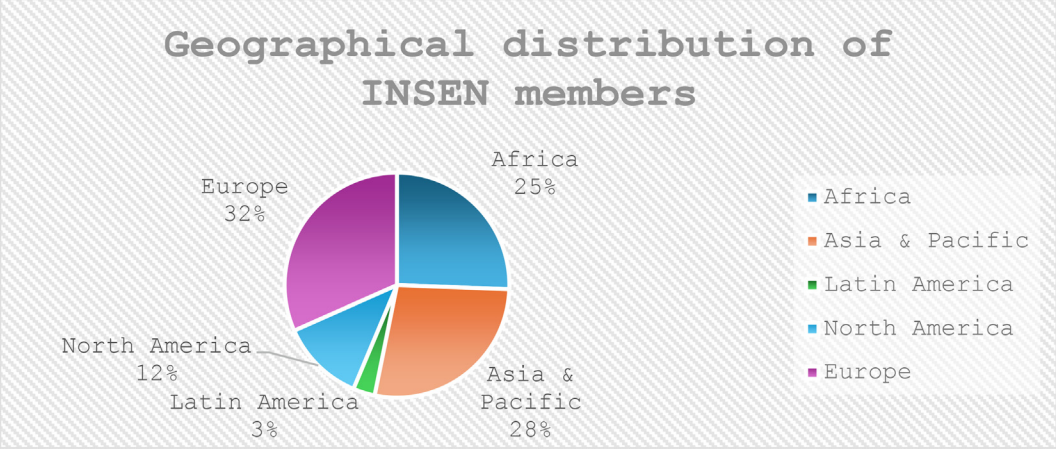

Fig. 2. Geographic distribution of the International Nuclear Security Education Network (INSEN) members, as of 2023.[20] HYPERLINK "SPS:refid::bib20"

transnational collaboration, the considerable number of members also can lead to coordination challenges within the INSEN.

An issue of unbalanced digital infrastructure access among the various regions of the world was highlighted during the COVID-19 pandemic.[14] Some countries and regions had difficulties accessing online resources and receiving reliable information owing to a lack of digital infrastructure. A few members also faced difficulties in attending the INSEN annual meetings remotely in 2021 and 2022 owing to restricted internet access.[14] These differences must be considered by the network to prevent the inequitable dissemination of nuclear security educational materials owing to poor digital access among some countries and members.

3.2.2. Diverging approaches to nuclear security education

The IAEA had a different approach to educational materials compared with some INSEN members. The IAEA did not recognise the variations evident between training courses provided by international organisations and those developed by INSEN. This is illustrated by the reliance on the IAEA Nuclear Security Series No 12 for the structure of a MSc programme in Nuclear Security.[10] However, this MSc structure is broad and does not take into consideration regional challenges and available resources. The approach of implementing a single MSc structure in Nuclear Security would not be efficient for the development of different local nuclear security education projects.

Some members also have different views regarding the approach to the type of educational programmes that INSEN should develop. Indeed, the 2-week summer schools are considered by some to be more sustainable than the master's programmes. This is owing to the difficulties in recruiting master's students interested in the subject. Moreover, the network needs to ensure that the universities at which the master's programme is developed have experts with the appropriate knowledge and infrastructure. This was a criticism made of the European MSc in Nuclear Security because it was implemented in five different universities, some of which were not necessarily specialised in nuclear security. However, the summer schools and the master's programmes target different audiences and meet different needs in nuclear security education. The INSEN seemed to have difficulty finding a balance between these different deliverables.

Despite these difficulties, developing nuclear security education is an ongoing process. The INSEN has adapted to these challenges and has proven to be an essential tool in enhancing excellent global education in the field.

4. Implications for biological security education

Although biological security education, defined as 'the prevention of natural, accidental, and deliberate disease in humans, animals, and plants', has been advocated for decades, it is still overlooked in life science curricula.[21] The necessity of including biosecurity education within the framework of the Biological and Toxin Weapons Convention (BTWC) was highlighted during the side event *From the Tianjin Biosecurity Guidelines to an International Biosecurity Education Network*, organised at the 2023 Meeting of BTWC State Parties. Current efforts in the field have been fragmented and geographically limited.[22] Initiatives previously developed in biosecurity education include the resources and methods designed by The Bradford Disarmament Research Centre at the University of Bradford (United Kingdom, UK), the postgraduate courses in biosecurity education at the National Defence Medical College in Japan, the joint projects on fostering the biosecurity norms with the Landau Network Centre Volta in Italy, and the work of the Biological Security Research Centre, London Metropolitan University (UK).[9] Although each such initiative developed good practices, these were also limited owing to the difficulty in coordinating their actions and sharing adapted resources in biosecurity education. Other resources, such as the newly published book *Essentials of Biological Security: A Global Perspective* (Shang, Zhang, Dando, 2024), aim to fill this gap in available tools for stakeholders.[21] These resources are important and could be the first step for a network that would raise awareness of the urgent need for biosecurity education and help with implementing the mandate of the 2022 BWC 9th Review Conference to strengthen the Convention.

Founded in February 2024 by the London Metropolitan University's Biological Security Research Centre, the IBSEN aims to help raise awareness about the risks of dual-use research in the life sciences and to initiate lasting changes in widespread implementation of biosecurity education. This unique initiative, supported by the Joseph Rowntree Charitable Trust, provides a platform to facilitate the exchange and creation of biosecurity education resources.

It is essential that the IBSEN learns from the experience and expertise of the INSEN. This analysis of the INSEN led to six key lessons for the IBSEN (Table 1).

Since its foundation, the IBSEN has had to answer important structural questions. Contrary to the INSEN, the IBSEN is not directly affiliated with any international organisation. Although this can lead to substantial challenges, such as difficulty in finding sustainable funding, it can limit bureaucratic constraints, which is evidenced in the INSEN of the IAEA. This organisational indepen-

Table 1
Table of the lessons for IBSEN from the experience of INSEN.

Lessons for IBSEN from the experience of INSEN	
1. *Affiliation*	An organisational affiliation can provide support and sustainability, but it could also impose restrictions according to the organisation's mandate.
2. *Participation*	Worldwide participation is desirable but could also cause problems in co-ordination.
3. *Interdisciplinarity*	Security education is difficult as it requires natural science and social science teaching expertise and equally broad interest in the students.
4. *Focus*	Security education needs to be implemented in different ways, but too broad a range of activities risks loss of focus on key elements.
5. *International structure and regional application*	Centralised control of activities is desirable but risks lack of adaptation to diverse local circumstances.
6. *Evaluation*	The importance of clear evaluation targets and methods.

INSEN, International Nuclear Security Education Network; IBSEN, International Biological Security Education Network.

dence enables the IBSEN to rely on a horizontal and bottom-up organisational approach to ensure broad engagement of its members. The nature of academic initiative could greatly help in improving biological security education. It is essential to strengthen the engagement of international and regional actors in developing educational tools and methods adapted to their needs. Learning from the difficulties faced by the INSEN in continuously involving members from all continents and backgrounds, one of the first actions of IBSEN was to constitute a database of interested stakeholders, from high schools and universities to professionals working in biological security, including local champions. To achieve this global reach, the resources and IBSEN communications are available in three languages—English, French, and Spanish—with the aim to reach a linguistic plurality as the network expands.

The difficulty in finding appropriate resources in biosecurity education limits its development, and therefore the IBSEN created a freely accessible website similar to the NUSEC portal of the INSEN. However, the IBSEN will encounter challenges that are specific to the field of biological security. These include the bioscience revolution and the interrelation of biological and chemical research. The IBSEN will therefore need to have a broad view of biosecurity, integrating common issues from the BTWC and Chemical Weapons Convention. The interdisciplinary nature of the IBSEN has been a factor considered since its foundation. The network was developed to include actors from the life, physical, chemical, computing, materials, and social sciences. This is directly related to the complexity of dual use in the life and associated sciences. Because biological and chemical weapons are a direct consequence of dual use, the IBSEN will help the scientific community with understanding the prevention of dual use concerns. Biosecurity must adopt different approaches as research is conducted in commercial and academic laboratories rather than nuclear research sites, which are relatively limited to governmental infrastructures.[23] These aspects add complexity to the challenges already identified from the lessons learned in studying the INSEN.

5. Conclusion

Similar to nuclear security education in 2010, biosecurity education is now at a defining moment. The rapid advances in life sciences and technologies require sustainable biosecurity education to meet the developing challenges. Learning from both the successes and challenges of the INSEN, the newly founded IBSEN initiative aims to have a lasting and global impact on biosecurity education. The IBSEN will adapt the characteristics of the INSEN and integrate other initiatives and collaborations, such as with the Advisory Board on Education and Outreach of the Organisation for the Prohibition of Chemical Weapons and the World Health Organization Global Framework. Biosecurity education cannot be implemented using a 'one-size-fits-all' framework. The IBSEN will therefore have the important responsibility of connecting relevant actors in biosecurity education to help them in developing educational tools adapted to local circumstances. This is reflected in the report of our recent Policy Workshop.[24] The challenges identified for the IBSEN will be the focus of research in our IBSEN in the next 2 years during the initial project. The materials to be produced and the implementation tools and methods to be tested will yield a thorough evaluation and assessment of how the IBSEN could and should be sustainable in the long term.

CRediT authorship contribution statement

Iris Magne: Writing – original draft, Formal analysis, Conceptualization. **Olivia Ibbotson:** Writing – original draft, Formal analysis, Conceptualization. **Lijun Shang:** Writing – review & editing, Funding acquisition, Conceptualization. **Malcolm Dando:** Writing – review & editing, Funding acquisition, Conceptualization.

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.

Acknowledgements

We would like to thank Dr Matteo Gerlini, former Chair of the International Nuclear Security Education Network (INSEN), and Professor Christopher Hobbs, Professor of Science and International Security at King's College London for the constructive discussions in which they shared their expertise on the INSEN. The IBSEN is supported by the Joseph Rowntree Charitable Trust (JRCT), United Kingdom, grant ID NO5469.

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