EMERGING BIOSECURITY LANDSCAPE IN SOUTHEAST ASIA

UPDATED REPORT (EXECUTIVE SUMMARY)

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Emerging Biosecurity Landscape in Southeast Asia – Updated Report

Executive Summary

In Southeast Asia, porous borders are closely associated with transnational security challenges, including environmental degradation, irregular migration, smuggling and human trafficking of women and children. Against a rapidly changing environment, the concept of security has evolved, encompassing not only traditional human security challenges but also unseen threats. One such novel threat comes from lethal biological diseases, pathogens, toxins and weapons, collectively referred to as biosecurity threats.

Unlike in the West, where biosecurity is primarily focused on the proliferation of biological weapons and bioterrorism,[1] in the Asia-Pacific, particularly Southeast Asia, biosecurity originated as a critical component of national health strategies aimed at combating infectious diseases within a country's borders. The initial focus was on preventing the spread of diseases that could affect human populations, animals and plants. Over time, the concept of biosecurity came to also cover a broader spectrum of protective measures that acknowledge the interconnectedness of human, animal and environmental health (in line with the One Health approach) and the potential for disease transmission across species and borders.

However, because of conflicting priorities, lack of awareness and resource constraints, biosecurity continued to be discussed only among professionals, experts and other stakeholders, and did not result in any significant policy development. It was not until the COVID-19 pandemic, with its higher impacts and casualties, that biosecurity discussions were revived in Southeast Asia. The pandemic highlighted the critical role of laboratory capacity in public health surveillance and research; the threats posed by dual-use research of concern (DURC) and gain-of-function studies; the potential for laboratories to be sources of biological agents; and concerns about cyberbiosecurity.[2] These had a clear impact on biosecurity discourse and prioritisation.

The rapid development of biotechnology also spurred increased discussions on biosecurity. Biotechnology brings significant advancements and new capabilities in various fields, including medicine, agriculture and environmental science. However, these innovations also pose potential risks if not properly managed, as they involve manipulating biological materials that could be harmful if misused or accidentally released.

In 2024, ASEAN leaders, through the Declaration on Strengthening Regional Biosafety and Biosecurity, made the collective call to 'ensure the provision of necessary human resources for biosafety and biosecurity in a sustainable manner through training, education and certification for all relevant personnel'.[3] This represents recognition among ASEAN member states (AMS) of the rising importance of biosecurity and biosafety. The declaration provides a strong foundation for robust collaboration among countries in the region, ASEAN dialogue partners and international organisations, as discussed in this report.

Amid these recent developments, the main objective of this report is to provide an overview of the biosecurity landscape in Southeast Asia. The analysis is guided by five major questions:

1. *How* has the concept and definition of biosecurity evolved over time in each Southeast Asian country?
2. *What* are the primary biological threats, concerns and risks in each country in the region?
3. *What* are the key biosafety and biosecurity policies and responses in Southeast Asia?
4. *What* are the key challenges to biosecurity governance in Southeast Asia?
5. *How* can ASEAN member states strengthen biosecurity governance and cooperation?

This report will examine the evolution of the concept and definition of biosecurity over time in Southeast Asia. And it will assess biosecurity threat perceptions in the region, focusing on four categories of risk: (i) emerging/re-emerging infectious diseases (EIDs/REIDs); (ii) laboratory accidents; (iii) biotechnology/DURC; and (iv) deliberate misuse of biological materials/bioterrorism.

1. Assessing Biosecurity Risk Perceptions in Southeast Asian Countries

Table 1 provides an overview of how different categories of biosecurity risk are perceived in nine countries in Southeast Asia. The findings draw from field interviews with biosecurity experts in Cambodia, Indonesia, Malaysia, the Philippines, Singapore, Thailand and Vietnam conducted between March 2024 and January 2025. These are supplemented by a comprehensive literature review for Lao PDR and Myanmar as well as national statements delivered by the permanent representatives of AMS at United Nations-organised review conferences and meetings on the Biological Weapons Convention (BWC). Brunei Darussalam is considered as well but research is still ongoing. The risk perceptions are then ranked on a scale from 'high' (red fill) to 'moderate' (yellow fill) and 'low' (blue fill). (It must be noted that risks from bioterrorism and laboratory accidents are perceived to be low or moderate in some countries because of the presence of established health and security systems and regulations that can mitigate or prevent the risks, but that does not mean that these states completely disregard such risks.)

Table 1: Southeast Asia's Biosecurity Risk Perceptions

	i) EIDs/ REIDs	ii) Laboratory Accidents	iii) Biotech / DURC	iv) Deliberate misuse/ Bioterrorism
Cambodia	High	Low	Low	Low
Indonesia	High	Moderate	High	Low
Lao PDR	High	Moderate	Moderate	Low
Malaysia	High	High	Low	Moderate
Myanmar	High	Moderate	Low	Low
Philippines	High	High	Moderate	Moderate
Singapore	High	Low	Low	Moderate
Thailand	High	Low		Low
Vietnam	High	Low	Moderate	Low

DURC=dual-use research of concern; EID=emerging infectious disease; REID=re-emerging infectious disease

2. Understanding Risks from National Perspectives

(i) Emerging and Re-emerging Diseases

Reflecting the growing importance of EIDs and REIDs at the regional level, they are a significant concern in all seven Southeast Asian countries where interviews were conducted as well as in Lao PDR and Myanmar based on our literature review. In the archipelagic countries of Indonesia and the Philippines, the primary concern is monitoring the emergence and re-emergence of

diseases that may arise from their rich biodiversity or enter through sea or air travel routes. Within Indonesia, four new pathogens have crossed its borders over the past four years, primarily through international air and sea travel routes. These are COVID-19, African swine fever, foot-and-mouth disease and lumpy skin disease.[4]

Climate change plays an important role in zoonosis. Given that shifts in climate and weather patterns can trigger animal movements and habitat changes, greater attention has to be given to facing up to climate-induced zoonotic threats.[5] A recent study found that even in a below 2°C global warming scenario, there would still be more than 300,000 new interactions among different species of wildlife and 15,000 transmission events across species heading up to 2070.[6] This translates to 300 new transmission events per year, or between five and six per week. The faster rates of movement observed in bats is a key driver for new 'first encounters'.[7]

Another concern is illegal wildlife trafficking (IWT). A report by the Global Initiative against Transnational Crime has highlighted that IWT leads to 'fragile environments [being] placed under enormous pressure, and this intensifies the emergence and spread of zoonotic infections, as well as other biological threats'.[8] Areas with higher wildlife biodiversity, while attractive to traffickers, are also richer breeding grounds for EIDs.[9] From our field interviews, the movement of animals which can carry zoonotic diseases and migration of people that can bring imported viruses are a clear concern in Southeast Asia. In the case of Thailand, which shares borders with multiple countries (Cambodia, Lao PDR, Malaysia, Myanmar), the threat of land border entry of such diseases was highlighted.[10]

The risk of food-borne pathogens was highlighted as an important concern in Singapore, which imports more than 90 percent of its food supplies. The Singapore Food Agency conducts safety checks on imported food to guard against bacteria (e.g., *Salmonella*; *Listeria*; *Campylobacter*; gastroenteritis-causing bacteria, *E. coli*). In Indonesia, Malaysia and the Philippines, where agriculture is an economically significant sector, there is visible concern over plant products that could threaten the health of plants.

(ii) Laboratory Biosafety and Biosecurity

Most of the countries in Southeast Asia have been transparent with regard to the existence and operation of their national containment laboratories as well as their plans to build additional laboratories. Such national facilities, and their health security-related functions, are publicly reported. It is known that Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Thailand, the Philippines, Singapore and Vietnam operate Biosafety Level 3 (BSL-3) national containment laboratories as well as several BSL-1 and BSL-2 containment laboratories. (There is currently no BSL-4 laboratory in the region.) Also, in several countries in the region, top research-intensive universities could be seen operating well-managed, international/ISO-certified and highly secure BSL-3 laboratories. A majority of these are run by medical schools, tertiary hospitals and public health training institutions of these universities as well as by tropical medicine research institutes affiliated with government agencies such as the Ministry of Health. In Cambodia, Lao PDR and Vietnam, a not-for-profit organisation, Institut Pasteur, in cooperation with national agencies, also operates BSL-3 laboratories that play a major role in life sciences and health research against EIDs (human/animal).[11] BSL-3 laboratories in Southeast Asia are mostly heavily regulated. Most are certified by health ministries, with oversight of their activities by the IBCs of the medical/educational institutions that they are part of.

Experts have argued that the high-containment (i.e., BSL-3) research laboratories in the region would not be easy targets for terror groups or insiders seeking to steal biological agents as these facilities have established effective practices. Ordinary laboratories in hospitals as well as clinical and diagnostic laboratories (where virus research is not conducted) might be more vulnerable to the theft of biological samples due to lack of biosecurity awareness and lack of a security culture. Laboratory biorisk experts in the region, in our field interviews, have observed

that low-containment and ordinary laboratories across Southeast Asia may lack consistent enforcement of biosecurity regulations and guidelines.[12] One potential issue being considered in several countries in the region is insider threat, that is, when individuals within the organisation with authorised access to biological agents and toxins for research purposes misuse that access for malicious intent.[13]

Another emerging biological threat highlighted by Southeast Asian biosecurity experts that laboratories could be vulnerable to is cyberbiosecurity attacks.[14] Cyberbiosecurity aims to understand and address cyber risks engendered by the digitisation of biology. Such risks include, for example, embedding malware in DNA, corrupting gene-sequencing, manipulating biomedical materials, hacking and unauthorised access to the cyber system of BSL labs, stealing epidemiological data, or even developing biological weapons and spreading diseases. Currently, it is not yet in the official security threat or cybersecurity threat policy strategies of governments. Nevertheless, national biorisk associations like the Biorisk Association of Singapore and the Biorisk Association of the Philippines have started conducting awareness campaigns on cyberbiosecurity.

To address such threats, biosecurity training programmes and courses are needed. However, they remain inadequate, unable to cover all laboratory personnel and managers across Southeast Asia. Several non-governmental national biorisk organisations as well as biosecurity training institutions, with support from ASEAN dialogue partners, fill this gap by offering seminars and workshops to train laboratory personnel and managers.[15]

As noted, attention has been primarily directed toward naturally occurring and (re)emerging infectious diseases, insider threats and the intentional use of biological agents for the purpose of bioterrorism. Accidental leaks or releases from laboratories are deemed unlikely to occur, a perception that mainly stems from robust national and international biosafety regulation and the adoption of stringent due diligence measures. Nevertheless, the experts interviewed emphasise that there remains a need to strengthen the biosecurity culture in the laboratories and facilities handling biological samples.[16] Furthermore, given that there are different laboratory types – clinical diagnostic laboratory (primary, secondary and tertiary), academic research laboratory, industrial laboratory – it is beneficial to tailor policies to address the specific concerns and risks of these different labs.

(iii) Advances in Biotechnology and DURC

Emerging and new forms of biotechnology were identified by biosecurity experts from several countries in the region as a concern. In the early 1990s, Southeast Asia had focused solely on developing regulations on biotechnology, with particular attention to the use of genetically modified organisms (GMOs) in food production. The experts interviewed pointed out that GMOs could be a platform for bioterrorism and biocrime. The malicious genetic editing of seeds in agriculture can make them harmful, setting the stage for agro-bioterrorism through the unauthorised planting of GMO seeds with the intent to cause damage. Such unauthorised GMOs (UGMOs) are difficult to detect, which creates an entry point for the distribution of GMO-based weapons.

However, while GMOs remain a concern for most of the countries in the region, biotechnology is now a growing and diverse industry that uses living systems and organisms for healthcare and industrial purposes; it is no longer just about GMOs. Countries such as Indonesia, Singapore, Thailand and Vietnam are boosting biotechnology R&D, with state-led initiatives spearheaded by national science and technology research agencies, often in collaboration with industry partners.[17] Thus, governments are trying to institutionalise a more balanced regulatory climate for the biotechnology sector that encourages private sector innovations in a secure and responsible manner. The fear is that some of the rapid innovations may create loopholes, which may be exploited by dangerous people, damaging the environment and people's health; and

appropriate regulations would be needed.

Biotechnology-related biosecurity threats, particularly those associated with gene editing technologies like CRISPR, present significant challenges. One major issue is that it is not possible with current technologies to precisely trace molecular scars left by genetic modifications. This makes it difficult to determine whether an organism has been modified or is naturally occurring.

DURC Governance

DURC refers to research intended for beneficial purposes, but with the potential to be misapplied, thus posing a threat to the health of the public, animals and the environment.[18] Across Southeast Asia, interviewees have noted that some scholars had no inkling that their research may be classified as DURC.[19] The absence of comprehensive biosafety and biosecurity protocols and laws may be a factor in such lack of awareness. Another factor may be gaps in oversight of DURC, due to variances in the capacity of institutional biosafety committees (IBCs). IBCs are responsible for evaluating potential dual-use risks associated with research; if members of IBCs have comprehensive biosecurity training, they play a crucial role in managing biosecurity risks. Certainly, the experts interviewed noted that some universities and private entities lack established research protocols or oversight committees such as IBCs altogether.[20]

Table 2: IBC Regulations in Southeast Asia: Mandatory vs. Voluntary

	Mandatory	Voluntary	Governing Institutions/Ministries
Cambodia	✓		Institutional Committees, with members are selected from relevant ministries (Health; Agriculture; Forestry and Fisheries; Industry, Science, Technology and Innovation; and National Authority for the Prohibition of CBRN Weapons (NACW)
Indonesia		✓	
Lao PDR	✓		Committee for Biotechnology Safety Administration
Malaysia		✓	
Myanmar		N/A	
Philippines		✓	
Singapore	✓		Institutional Committees and the Genetic Modification Advisory Committee (GMAC)
Thailand	✓		Institutional Committees and the Ministry of Public Health
Vietnam	✓		Department of Preventive Medicine

(iv) Deliberate Misuse and Bioterrorism

In various meetings and conferences convened by the UN on disarmament of weapons of mass destruction (WMDs) and the BWC, AMS have strongly and repeatedly expressed their collective commitment to the BWC as well as their concerns over the development and possible use of biological weapons by non-state actors.[21] Bioterrorism is a shared concern among AMS, but

one that appears to be expressed within the security sector alone.[22] This concern is articulated during ASEAN meetings on chemical, biological, radiological and nuclear (CBRN) threats and WMDs as well as at the Conferences of States Parties to the BWC. While this concern appears unlikely to be shared by civilian agencies, AMS have nonetheless called for enhanced international cooperation and information sharing to prevent terrorists and other non-state actors from developing, obtaining and distributing biological weapons.[23]

While most Southeast Asian countries perceive bioterrorism as low-risk (Table 1) compared to traditional biological threats such as pandemics and EIDs/REIDs, experts in the region have argued that it must be considered a significant biosecurity threat requiring government attention. Exposure to designed or leaked pathogens could lead not only to deaths, but also have severe and far-reaching implications such as economic collapse and border closures. Dealing with bioterrorism can be challenging, however. The malicious intent behind such acts often remains hidden, making it more difficult to identify threats. Also, bioterrorism does not just involve lab-created or imported biological agents; naturally occurring toxins and other biological materials from natural environments could be misused as well.[24]

3. National Frameworks, Approaches and Practices

(i) Enhancing Policy Frameworks

Table 3 presents a snapshot of the biosecurity policies in place or pending/under discussion in the seven countries where experts were interviewed and three other countries (Brunei Darussalam, Lao PDR and Myanmar) for which future interviews are planned. It includes their comprehensive policies as well as other relevant frameworks applied at the national level. This list of national regulations and frameworks is non-exhaustive and will be further expanded in succeeding reports.

Table 3: Key Biosecurity Policies

Countries	Comprehensive	Other relevant frameworks
Brunei Darussalam	Biological Weapons Act 1983	Workplace Safety and Health Order 2009, Infectious Diseases Act 2003, Animal (Disease and Quarantine) Order 2021, Anti-Terrorism Order 2011, Part V of the Criminal Procedure Code and Section 17 of the Internal Security Act (for inspections)
Cambodia	2009 Law on the Prohibition of Chemical, Nuclear, Biological and Radiological Weapons	2008 Biosafety Law, National Medical Laboratory Biosafety Guidelines, Law on Preventive Measurement against the Spread of COVID-19 and Other Severe and Dangerous Contagious Diseases
Indonesia	Draft biosecurity/BWC bill (pending)	Ministry of Agriculture Decree No. 85/KPTS/HK.330/9/1997, Government Regulation No. 21 of 2005, 2019 Institution Biorisk Laboratory Manual
Lao PDR	No BWC implementing law/biosecurity framework	2019 National Biosafety Regulation (focusing mostly on lab biosafety) Regulation 1 on transportation and shipping of infectious materials, Regulations 9 and 10 on Cyberbiosecurity, the 2017 Law on Prevention and Control Communicable Diseases, 2014 Biotechnology Safety Law

Malaysia	Draft biosecurity/BWC bill (pending); a policy paper on BWC has been introduced	The Biosafety Act of 2007, Medical Act 1972, Prevention and Control of Infectious Disease Act 1988, National Security Council (NSC) Act Directive No. 20, Plant Quarantine Act, 2013 Malaysia Laboratory Biosafety and Biosecurity Policy and Guideline
Myanmar	No BWC implementing law/biosecurity framework	Counter-terrorism Law 2014, 2012 Environmental Conservation Law, 2011 Prevention and Control of Communicable Diseases Law, 1993 Animal Health and Development Law, 2012 Imports and Exports Law
Philippines	Draft biosecurity and biosafety bill (pending)	1991 Biosafety Guidelines, Executive Order No. 514, Joint Department Circulars 2016 (revised in 2021), Anti-Terrorism Act of 2020 Section 4(d), 2023 Manual of Laboratory Biosafety and Biosecurity Standards
Singapore	Biological Agents and Toxins Act 2005	Strategic Goods Act 2002, Singapore Standard: Biorisk Management for laboratories and other related organisations, Singapore Biorisk Code of Conduct for the Life Sciences Industry and Professionals
Thailand	Pathogen and Animal Toxins Act 2015 or PATA (focusing mostly on lab biosafety)	Communicable Diseases Act, Animal Epidemics Act, Plant Quarantine Act, 2019 Biodiversity Act (draft)
Vietnam	Draft biosecurity policy (3rd draft/pending)	Decree 103/2016/ND-CP on Biosafety, Circular No. 07/2016/TT- BNNPTNT, Circular No. 60/2009/TT-BNNPTNT on Agricultural Export and Import Control, Decision No. 80/2006/QD-BQP on Military Equipment Export and Import Control

BWC=Biological Weapons Convention

(ii) A One Health Systems Approach in Tracking Diseases

Processes for tracking the emergence/re-emergence of infectious diseases are critical, and this needs to be done across the different stages, from before a disease becomes zoonotic, until after it has started affecting humans. This could be done as part of a One Health approach, as seen in the national strategic/action plans of Brunei Darussalam,[25] Cambodia, Indonesia, Malaysia, Thailand, the Philippines, Singapore and Vietnam. That leaves only Lao PDR and Myanmar without One Health action plans.

Furthermore, most of the AMS have their respective national One Health university networks. These are part of the Southeast Asia One Health University Network, which aims to develop the next generation of skilful and competent One Health workforce by leveraging education, research and training developed in collaboration with university networks in Southeast Asia.[26]

(iii) Raising Biosecurity Awareness and Expertise among Policymakers and across Sectors

Disease surveillance requires raising awareness among policymakers and the general public alike as the effectiveness of even the most robust regulations is undermined if people lack the knowledge to implement them. The experts interviewed specifically highlighted the need for biosecurity training and education for the agricultural sector, in particular farmers. Such needs are demonstrated in, for example, Indonesia. Its large size and decentralised command structures make it challenging to ensure uniform knowledge of biosecurity across all levels of

society. This has meant that farmers may lack awareness of the potential pathogens that could enter through their livestock or of new or re-emerging plant-related diseases that could reduce crop yields.

Also, while biosafety is relatively familiar to scientists, medical professionals, the health security community, academics and laboratory personnel in the region, the concept of biosecurity is new to many of them. It is crucial to increase their awareness of biosecurity to be able to respond to related threats and incidents. The reason for the relatively high level of awareness and compliance with regard to biosafety has been mainly due to mandates by the government and IBCs. This suggests that there is substantial need for regulatory development in biosecurity; currently, there is no specific biosecurity provision in national regulations. However, for the most part, legislative bodies have yet to fully appreciate the importance of a comprehensive biosafety and biosecurity legal framework or a BWC national implementation bill.

(iv) Security–Health Sector Cooperation and Joint Training to Boost Enforcement

Even if countries have robust biosafety and biosecurity laws, lack of enforcement may prevent them from being followed consistently. A potential mechanism to strengthen enforcement is through engaging the security sector (the military, police, home affairs, etc.) in enforcing the health- and biosecurity-related agenda. Within Thailand, for instance, there are some siloed distinctions between ‘Ministry of Health jobs’ and ‘police jobs’. While there are sub-units within the police that could be involved in investigating health/biosecurity-related incidents, the perception by one of the experts interviewed is that they are focused on investigating top-line issues such as drug smuggling, animal smuggling and money laundering. The police will need guidance from the health sector, conveyed in language that is easier to operationalise, on the types of biosecurity-related incidents that the police should be tracking/monitoring.

It is also important to recognise that bioterrorists, or individuals involved in acts of bioterrorism, including insider threats, are hard to track. They are typically highly educated individuals with scientific expertise who are often indistinguishable from others in the organisation/society they belong to, until their ideological beliefs drive them to misuse their knowledge and skills to create or disseminate biological agents as weapons. As such, the security sector can also be tapped in the practical aspects of the enforcement of lab biosecurity, such as through regular inspections and staff training, even as the health sector communicates the consequences of non-compliance.

(v) Developing National Control Lists and Inventories of Pathogens, Toxins and Security-sensitive Biological Agents

Countries need to develop national control lists of dangerous pathogens and toxins and security-sensitive biological agents warranting specific monitoring regulations in order to mitigate potential health risks to humans, animals and the environment. The inventories of the pathogens, toxins and biological agents on these national control lists need to be consistently monitored across all human and animal health laboratories. This would require appropriate oversight mechanisms adapted to the specific requirements of different types of laboratories. The control of access to containment laboratories working with high-risk materials should also be well-regulated to reduce vulnerability to theft, diversion or misuse of dangerous pathogens. These steps are critical in ensuring strict and effective control over pathogens, toxins and security-sensitive biological agents, which will help maintain national security and prevent potential threats to society and the environment.

4. Recommendations for Enhanced Regional Cooperation

(i) Promote Harmonisation of Biosecurity Protocols through ASEAN Regional Networks

In 2024, ASEAN leaders declared their commitment to establishing the ASEAN Biosafety and Biosecurity Network to 'facilitate knowledge sharing, coordination, and cooperation among ASEAN Member States, partners and relevant stakeholders'.[27] Such a network could be built on existing regional networks and projects that separately address various biosecurity issues.

An example would be the Network of ASEAN Chemical, Biological and Radiological (CBR) Defence Experts, which was established in 2019. Experts within the CBR Network actively organise workshops, table-top exercises and regular exchange of visits to build country experts' capacity and nurture cooperation in areas where CBR defence awareness remains relatively low. This includes the ASEAN CBR Defence Experts Technical Meeting for Harmonisation of CBR Sampling and Analysis Reporting Protocol held in Singapore in August 2023.[28] Biodefence and biosecurity experts in the region could build on the initial success of this meeting by developing standardised protocols for CBR sampling, analysis and reporting across all member states. They may then conduct **regular reviews and updates of biosecurity-related protocols** to incorporate the latest advancements and best practices. The CBR Network can also consider joint reviews and initiatives with other related networks and institutions within the ASEAN system. The **mutual recognition of biosecurity measures** across different institutions and countries can be explored. By standardising and acknowledging each other's biosecurity protocols, organisations and nations can build trust, improve collaboration and create a more cohesive and effective regional defence against biological/biosecurity threats.

Another example is an initiative under the ASEAN Regional Forum (ARF) where the Philippines, in collaboration with the US State Department, hosted several workshops and table-top exercises on biological weapon risk mitigation measures.[29] To encourage more collaborative initiatives under the ARF, AMS and their dialogue partners in the broader Asia-Pacific region can explore the **creation of expert working groups** in collaboration with the Council for Security Cooperation in the Asia-Pacific (CSCAP) to tackle specific issues such as biological threat reduction, disease detection, preparedness for biological events and the peace and security impact of advances in biotechnology.

Further, to address EIDs, **capacity-building exercises through regional networks** will be needed to enable all AMS to achieve a minimum agreed level of surveillance, testing and monitoring to detect new pathogens. AMS face difficulties responding collectively to biosecurity threats because the resources available for different issues/threats vary across countries, and there is often no framework that allows for the effective use of these resources at the national level. The most cost-effective approach is to implement a framework at the regional level. Forward-looking and action-based discussions will be needed on how to promote further investments in surveillance systems to ensure that robust testing protocols are in place.

(ii) Conduct Workshops on Biosecurity

Countries in the region have set up workshops on the implementation of the BWC and other relevant biosecurity and biosafety conventions, treaties and guidance documents, including workshops organised in collaboration with ASEAN's external partners and UN bodies. Such workshops aim to deepen understanding of biosecurity, **share effective practices** related to the preparation of confidence-building measures (CBMs) as part of BWC requirements, and inform participants about the capacity-building opportunities available to strengthen biosafety and biosecurity.[61] These workshops are beneficial as countries can learn not only from their counterparts in the region but also from international partners such as the European Union CBRN Risk Mitigation Centres of Excellence Initiative (EU CBRN CoE).[30] These workshops may further **encourage countries to submit their CBM reports**, thus deepening their

understanding of their own biosecurity capacities, enhancing transparency and fostering greater trust and cooperation within the region.

From 2022 to 2023, for example, the Philippines, using its experience with CBMs, worked with Lao PDR in a country-to-country programme to raise awareness about CBMs and provide training on how to prepare CBM submissions. In July 2024, technical experts from eight countries in Southeast Asia gathered in Bangkok for a regional conference aimed at enhancing regional biosecurity measures, with attention given to addressing the dual-use nature of biological materials. And, in October 2024, Lao PDR co-hosted with China the First Regional Workshop on Implementing the Biological Weapons Convention and Promoting Biosafety and Biosecurity in Southeast Asia.

Regional workshops can also provide guidance on developing national frameworks that address naturally occurring as well as man-made biosecurity threats; advance better risk communication strategies (science diplomacy and diplomacy in science); and strengthen biosecurity threat-oriented intelligence work. These workshops can also be geared toward **developing a regional database to map, monitor and track biosecurity threats**. And they can promote mutual agreement and recognition of country-level biosecurity measures (as described in the previous recommendation) and improve the transparency of cross-country information exchange.

(iii) Develop Regional Networks for Knowledge Exchange

Information sharing on biosecurity issues among AMS still needs strengthening. Experts we interviewed disclosed that some countries in the region are concerned that their neighbours might be hesitant, for multiple reasons, to immediately share critical information about potential biosecurity incidents, especially disease outbreaks, that occur near their shared borders. A regional network for information exchange in Southeast Asia is therefore essential for enhancing biosecurity by facilitating the **timely detection of disease outbreaks, development of treatments and effective data sharing**, which would in turn allow for coordinated responses. Through joint research initiatives, experts across the region can collaborate on understanding pathogens, developing vaccines and creating strategies to mitigate biosecurity risks. To build confidence, foster information sharing and harmonise protocols, it is recommended that a network of high-containment laboratories be established in Southeast Asia. Sharing of biological samples, for instance, among these laboratories can be explored through this network.

Strengthening regional research networks and partnerships on biosecurity is key in balancing R&D, security and health. While some information exchange and technological sharing partnerships have been established, they are not happening at a pace that meets the biosecurity needs of the region. This type of cooperation could expand to regional sharing of information on EIDs and REIDs, and to developing a regularly updated list of controlled pathogens, toxins and security-sensitive biological agents.

Creating a list of biological agents unique to Southeast Asia or individual countries is a crucial step in strengthening regional biosecurity. This list would differ from global or other regional lists by focusing on organisms that are particularly prevalent or pose significant risks within Southeast Asia, such as tropical diseases, endemic pathogens or agricultural pests specific to the region. Identifying these organisms requires research and collaboration among countries in the region to ensure that the list accurately reflects the biological threats that most affect the region. Countries in the region can then develop targeted surveillance, prevention and response strategies, better safeguarding public health, agriculture and the environment against local biosecurity risks.

A further step is to **develop national and regional inventories of such pathogens**; the challenge however is that there is limited authority on the part of health agencies to mandate or implement inventory reporting. Even more fundamental, several countries in the region have yet

to even complete the first step of a national list of security-sensitive biological agents, toxins and pathogens, and it is unclear if those that have done so are continuously reviewing and updating their lists. There are efforts underway by the ASEAN health sector under the Mitigation of Biological Threats Programme to develop an inventory of high-risk pathogens. A feasibility study on establishing a biobank of high-risk pathogens in the ASEAN region is being conducted. At the national level, the biobanking landscape in each of the AMS is highly fragmented and that would need to be addressed, as fragmentation fosters the pre-conditions for risks in biosecurity.[31]

(iv) Encourage Security–Health Sector Cooperation

Cooperation between the health sector and the security sector in managing biosecurity threats is vital. Malaysia's use of the US model of **inter-agency biosecurity cooperation between law enforcement/security** (Federal Bureau of Investigation, or FBI) and the health sector (US Centers for Disease Control and Prevention, or CDC) presents a potential model to consider for ASEAN countries which have decentralised/sub-national levels of government. Each country will nonetheless need to determine which model suits it best. In Thailand, one suggestion was to establish a law enforcement unit within the Ministry of Public Health as the focal point for enforcement of the Pathogens and Toxins Act (PATA). In contrast, Singapore works with existing structures within a whole-of-government approach while encouraging greater collaboration among the health, security, veterinary, environment, food, water and trade sectors. In Cambodia, Malaysia, the Philippines and Thailand, one gap identified by biosecurity experts is the varying level of awareness of security sector bodies, public health agencies and other civilian agencies on biosecurity threats as they view such threats from different angles – from a CBRN perspective, WMD/non-proliferation perspective or a health security perspective. This is being addressed through inter-agency national meetings and national training workshops.[32]

At the regional level, to **strengthen cooperation in the health sector within the ADMM-Plus**, it is beneficial to follow the framework established by the security cluster, particularly in military medicine. Although the security sector tends to be reserved when discussing sensitive security issues, it is notably open and vocal about health and biosecurity matters. In contrast, the health cluster, which plays an equally or even more crucial role in biosecurity management, has been secretive with limited information sharing. Similarly, the education cluster requires significant improvement, as many discussions occur, but information is not being adequately shared, especially in areas like research and innovation in health. Given that multiple networks cover different types of biosecurity threats differently, such as biocrimes as opposed to naturally occurring diseases, a 'networking of networks' is required to enable synergies across these networks.

Sharing of best practices is also critical in light of the emergence of new types of threats. In the area of cyberbiosecurity, for example, potential cyber security risks and threats associated with digital lab data, and digital information about biological samples inside laboratories, may not be well understood. Also, in response to rising biotechnology-related risks, regional research networks should prioritise molecular epidemiology and create opportunities for effective collaboration. Increased research activity will lead to more regulation, so it is crucial to build trust, engage in joint research, and facilitate policy dialogues between researchers and policymakers to ensure mutual benefit. A regional network for information exchange would also facilitate knowledge sharing between the health sector and the security sector. Through **joint research initiatives, regional experts can collaborate** on understanding pathogens, developing vaccines and creating strategies to mitigate biosecurity risks. It is also important to engage all ASEAN pillars (political-security, economic and socio-cultural) to further improve biosecurity governance in Southeast Asia.

(v) Explore the One Health Approach to Preventing Biosecurity Threats

Given resource constraints, AMS commonly prioritise early detection and response to diseases or vaccine preparedness[33] once diseases have evolved into zoonotic forms that can infect humans. However, given the significant uncertainty over what kind of 'DiseaseX' (the next infectious disease with pandemic potential) will emerge, a disease-centric approach may be insufficient. A **systems-level One Health approach** is required in preparing for DiseaseX, with a focus on 'primary prevention', or tackling the systemic factors that lead to the occurrence of zoonosis, rather than 'secondary prevention', which focuses on early detection of the problem once it has emerged.

The starting point of primary prevention should be to **monitor and plan urban, ecological and land-use developments** in a manner that reduces the likelihood of new human-to-animal interactions, and in turn, animal-to-human spillover events in the future – in other words, a One Health approach. There is also a need to advocate for a One Health approach that not only accounts for the human–animal–environment health interactions, but also human-induced biosecurity threats. This is given that biological threats cut across multiple functions and sectors and go beyond the conventional silos of disease outbreaks (medical/health perspective) and bioterrorism (security perspective).

There is a need to **study approaches beyond preparedness and response**. Lessons learned from the past indicate the need to add layers to current policies and practices, which may include laboratory policies, environmental policies and engagement with civil society. While current efforts are heavily focused on preparedness and response, it is crucial to integrate these additional layers to enhance overall effectiveness. Strengthening laboratory policies can ensure safer handling of biological materials while environmental policies can mitigate the impact of degradation of ecosystems that may lead to biosecurity events. Involving civil society can improve community resilience and awareness, creating a more comprehensive approach to bioterrorism prevention and response.

(vi) Encourage the Development of Guidelines on Responsible DURC and Managed Cyberbiosecurity

The regulation of DURC and cyberbiosecurity represents a critical opportunity to safeguard scientific advancements while mitigating potential risks. DURC necessitates stringent oversight to prevent misuse of biological agents for bioterrorism or other nefarious activities. Given the digitalisation of biological information, cyberbiosecurity measures need to be integrated within both cybersecurity and biosecurity frameworks. By **implementing comprehensive regulatory frameworks**, AMS can ensure the responsible conduct of life sciences research, protect sensitive biological data from cyber threats and foster public trust in scientific innovation.

Such regulations, however, will need to **consider the delicate balance that needs to be maintained between safety and innovation**. If regulations are too strict, with onerous reporting or monitoring requirements for example, that could decrease researchers' or industries' motivation to conduct biotechnology research. Hence, regional forums are needed to discuss whether new laws or regulations are required, or if biosafety and biosecurity could be achieved within existing legal frameworks. A critical concern remains, though, on whether a new, separate agency would be better suited to providing monitoring and oversight of DURC.

A stakeholder analysis is therefore critical. Stakeholders in DURC, including principal investigators, researchers, students and IBCs, must have their expectations holistically studied to understand the messages they need, who will communicate with them and how to communicate effectively. Principal investigators, students and researchers require clear guidelines, detailed protocols and regular updates, typically communicated by IBCs and regulatory bodies. Additionally, industry stakeholders must be actively engaged through forums,

partnership meetings and collaborative initiatives to ensure awareness of DURC.

The World Health Organization (WHO) has issued in 2022 its own guidelines, titled 'Global guidance framework for the responsible use of the life sciences: Mitigating biorisks and governing dual-use research'.[34] A potential initiative for AMS is to **explore pathways to align with the WHO's global guidance framework**, such as by developing national guidelines that are adapted to unique local country contexts.

(vii) Establish National/Regional Supply Chain Security Framework

Supply chains are potential conduits for biosecurity threats from DURC as well as threats from imported commodities (whether food, animals or plants). By rigorously **monitoring vendors or primary sources of biological materials, maintaining a secure chain of custody and implementing physical and information security measures**, regulatory institutions can prevent unauthorised access, theft, accidental releases or misuse of sensitive materials. In light of the potential for invasive alien species and harmful products to be imported into ASEAN countries, which can pose threats to human, animal and plant health, it is important equally to explore measures that will allow countries to ban imports from selected high-risk countries. An ideal **Regional Supply Chain Security Framework** should encompass both traditional trade as well as digital trade/e-commerce, the latter being less regulated. Such approaches – even if they are more conservative in their approach to preventing threats to food safety such as poisoning or contamination – could potentially conflict with the World Trade Organization's (WTO) stance against non-tariff barriers to trade. Nonetheless, a balance must be struck between stringent security measures for food safety and adherence to global trade standards. In addition, given the potential of synthetic biology to be misused or weaponised, a supply chain security framework needs to **include genetic materials produced through synthetic biology** (e.g., gene editing/modification).

(viii) Promote and Institutionalise a Security Culture to Prevent Biosecurity Threats

Low biosecurity awareness and lack of a security culture create security challenges and vulnerabilities in ordinary laboratories (i.e., those not involved in research). Given the potential for insider threats, AMS will benefit from **promoting and developing strict personnel reliability standards** to be rolled out region-wide. The standards should include comprehensive screening of personnel and compulsory training and retraining of staff. Also important are fostering positive workplace cultures; enhancing biosecurity awareness among staff and managers; promoting adherence to security protocols; detecting potential issues early; and preventing accidental releases from labs. Maintaining such standards can promote greater accountability for laboratory-related biosecurity within borders and prevent incidents of transnational threats, thus contributing to regional biosecurity. Future research can explore how biosecurity efforts can be upped to increasingly recognise **the importance of integrating social and cultural approaches** to effectively manage biological risks. These approaches involve engaging local communities, respecting cultural practices and fostering public awareness about biosecurity threats.

NOTES

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