Editorial

Smuggling biological materials and illegal laboratories – implications for biosecurity and potential biological attacks

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The United States Attorney's Office released a statement to the press on June 3, 2025 [1], regarding two Chinese nationals who were allegedly involved in transporting biological samples containing Fusarium graminearum into the United States, through Detroit Metropolitan Airport, for their work at a University of Michigan laboratory without properly declaring them in July of the previous year [2]. They face charges of conspiracy, smuggling, making false statements, and visa fraud. On June 9, 2025, a new statement [3] was released revealing that a third Chinese national was allegedly implicated in the transport of concealed biological materials (plasmids and culture media [4,5]) for the growth and modification of roundworms, via packages shipped from China to the same university in the US, in 2024 and this year [5]. The contents were declared to be plastic cups [4], and there was no indication on the label regarding the biological materials inside.

Fusarium graminearum may have emerged as a lineage in North America before the introduction of wheat and barley in the past 400 years [6]. *F. gerlachii* and *F. graminearum* species were initially found on symptomless wild grasses in Minnesota, USA, before being identified as Fusarium head blight pathogens on wheat and other cultivated grasses [6]. *F. graminearum* disease is well known in North America by the common names "gib", "scab" or "head blight". Grain crop infections are most severe during wet weather, particularly in no-till or reduced-till fields, and typically occur during the flowering season [7]. Affected crops can be identified by the presence of pink-red discolouration [7]. This condition reduces both grain yield and quality, leading to billions of dollars in economic losses worldwide [7]. They produce toxins, including deoxynivalenol, a "vomitoxin" which causes gastrointestinal upset in animals, and zearalenone, which impacts animal reproduction [7]. In humans, these mycotoxins can cause symptoms of food poisoning, including abdominal pain and diarrhoea, as well as liver problems and neurological symptoms like headaches [1,8]. Due to these issues, crops and animal feed are routinely checked for contamination [7]. Fungicides have been developed to tackle the issue [7]. Studying this important pathogen is crucial for understanding how it causes disease, what we can do to develop novel [9] and safer fungicides and how to find strategies to mitigate its virulence and toxic effects [10]. However, this work must be conducted under carefully controlled conditions to prevent the accidental or intentional release of more problematic strains into the environment. Some have argued that *Fusarium sp.* would make clumsy weapons [11] however little is known about the properties of the isolates seized, and changes in the "chemotype" [7] of the toxins, the quantities of toxin produced, resistance to fungicides, and the ability to infect fungus-resistant genetically modified crops could turn this farm problem into an agricultural disaster.

Roundworms (Ascaris sp.) are a diverse group of animals that include beneficial species, playing an important role in the nutrient cycle and aiding plants and agriculture [12]. However, approximately 15% are parasitic, and various species can affect plants, animals, and humans [12]. Plant roundworm parasites include root-knot, cyst, root-lesion, lance, dagger, needle, stubby-root, stunt, ring, spiral, pin, stem, bulb, bud, and leaf nematodes [12]. Cattle are impacted by worms, leading to three main clinical syndromes: gastrointestinal (e.g., brown stomach worm, *Ostertagia ostertagi* [13]), respiratory (e.g., bovine lungworm, *Dictyocaulus viviparus* [14]), and other syndromes (e.g., cattle eyeworm, *Thelazia gulosa* [15]). Poultry can also be affected by roundworms such as *Ascaridia galli* [16]. Some roundworms, such as *Trichinella spiralis* [17], *Toxocara canis* [18], and *Thelazia gulosa* [19], can directly cause infections in humans. However, the major impacts of worm infestations are poor growth of crops and animals, leading to food insecurity, suffering due to symptoms, and economic losses [20]. Controlling roundworms in plants primarily involves preventive measures such as maintaining sanitation and plant health, selecting resistant plant varieties, practising fallowing and crop rotation, and utilising solar heat to raise the soil temperature [21]. However, these techniques mainly impact the upper layers of soil, resulting in only temporary effects on nematode populations [21]. Some techniques may also reduce beneficial nematode populations. This means that if a new species is released, control would be complicated, and the impact could be severe. In animals, growth is monitored, and medications are used when necessary to control roundworms, as their ongoing use can promote drug resistance [22]. Once again, very little is known about the samples being concealed. However, the introduction of roundworms that may possess novel properties, such as increased lifespan [23], faster growth and reproduction rates [24], enhanced drug resistance [25], or higher invasiveness, could severely disrupt ecosystems and result in catastrophic losses of cattle or crops. Species that are better adapted to infect humans could result in significant disease outbreaks. Roundworm eggs are quite easy to store and transport, as they can survive for long periods outside the body, for example, in soil, making them a surprisingly favourable candidate for agroterrorism, even though they are not categorised as such.

In 1988, Hashemi Rafsanjani, then the speaker of the Iranian parliament, referred to chemical and biological weapons as "the poor man's atomic bomb." This is likely because these weapons are easier to obtain compared to nuclear arms and can result in significant casualties [26]. Whilst there may not have been intent for a biological attack behind these recent incidents, they demonstrate the potential for a covert attack in any country, where biological weapons might be secretly shipped via postal services or produced locally under the guise of a legitimate business. These cases also highlight the potential for insider threats and the role of Dual-Use Research of Concern.

Some methods to intercept such material are already in use, such as those for detecting anthrax in real-time, as employed by the US Postal Service [27]. Other techniques used globally include visual and manual screening [28], examination by dogs [29], irradiation [30], and X-ray screening [31]. These may, however, miss examples of smuggling, such as the current cases, because the range of agents to be identified and the methods by which they may be concealed or protected during transport are diverse, necessitating broader strategies. More comprehensive requirements for declaring organic materials transported in packages, luggage, or on a person, not just those known to pose bioterrorism threats, may be necessary. Any that may be transported in a latent or asymptomatic incubation state in a person, animal, or crop may be very difficult to intercept.

Insider threat and espionage in universities are well recognised as a threat [32]. Two separate smuggling cases involving foreign nationals who failed to declare biological materials at the same US university raise red flags, as these cases indicate, and US authorities will undoubtedly investigate ("distribution of perpetrators" [33] and "insider threat" [32]). More broadly, this raises concerns about insufficient oversight of international biological research collaborations.

The recent incidents highlight the broad range of threats that must be considered to prevent agroterrorism or bioterrorism through Trojan Horse methods. A higher index of suspicion and a lower threshold for investigation are needed to prevent or prosecute bioterrorism involving pathogens that could be introduced without raising suspicion, where similar organisms to the recent the case could also potentially be found locally.

Prioritising public and environmental safety by improving the oversight of research programs in microbiology, especially dual-use research of concern (DURC) [34], is essential. The processes for detecting unsanctioned or illegal activity connected to universities and other laboratories, along with legislation to swiftly halt operations and remove individuals considered to be an "insider threat", are inadequate in many jurisdictions. Research institutions are not adequately equipped to detect insider threats, nor can they deal with them without specialist help. Insider threats may arise from the recruitment of domestic staff by foreign countries [35], or the infiltration of labs by students and staff from foreign nations [36,37].

Two past cases also illustrate the challenges in identifying such activities. In the first case, two scientists transported viruses from Canada's sole BSL-4 laboratory to China and were fired in 2019, along with their PhD students, in a case that appears to involve espionage [37]. The second example illustrates the lengthy process and ongoing risk of insider threat. In 2001, during the anthrax attack investigation in the United States, it took seven years, involved 25 to 30 full-time investigators, and required hundreds of thousands of hours of effort to pinpoint the main suspect, an employee at the U.S. Army Medical

Research Institute of Infectious Diseases (USAMRIID) located in Fort Detrick, Maryland [38]. The investigation needed to proceed slowly to ensure due diligence and follow necessary processes; however, this slow pace does not eliminate threats quickly enough, as a bioweapon could disperse globally within weeks. Considering the potential rapid spread of biological agents, precautionary measures should be implemented even before all facts are fully understood, as these considerations must prioritise public safety.

The cases recently reported in Michigan were linked to a university lab; however, private labs and illegal labs also pose a risk, and there are no systematic means for detecting these. In 2022, an illegal laboratory was accidentally discovered in Reedley, California [39], owned by a Chinese biotech company that allegedly manufactured COVID-19 rapid antigen tests and other testing products. Their warehouse was discovered to contain freezers and fridges holding various vials labelled “HIV”, “Ebola” and other viruses, along with nearly a thousand humanised mice. In this case, the response from authorities was slow, and apparently, all materials were destroyed instead of being tested [40]. The Reedley incident highlights the threat posed by illegal labs, many of which may be flying under the radar, and illustrates how poorly equipped we are to respond to such discoveries.

Genetic engineering and other technologies for creating biological agents with potential as weapons are now inexpensive (the price has dropped 250-fold in the past decade) and readily available [34, 41]. Do-it-yourself biology lab-in-a-box kits are available for purchase online [42]. In the meantime, our systems for regulating the risks have not kept pace. In Canada, horsepox—an extinct *Orthopox* virus closely related to smallpox —has been recreated in the laboratory, highlighting the risk of synthetic biology, which could equally be used to reconstruct smallpox or other pathogens [41]. Individuals or groups involved in creating bioweapons may already possess highly skilled expertise or access to specialised laboratories in addition to makeshift facilities. Genetic codes for many organisms are freely available online, including those for smallpox, which were available to buy through mail order in segments as recently as 2006 [43]. Subsequently, the weaknesses in detecting these pathogens during transit, as mentioned earlier, could be exploited by individuals or groups, whether domestic or international, to deploy them.

Considering the difficulties in intercepting packages, detecting both inside and outside threats, and locating and regulating illegal laboratories, it is essential to develop the expertise to recognise patterns that may indicate a deliberate introduction of a pathogen from both external and “insider” sources [34]. Detecting unnatural outbreaks arising from accidental or deliberate events presents a challenge, as health agencies are often reluctant to consider unnatural origins of epidemics [34]. The routine use of risk analysis tools to evaluate epidemics for potential unnatural origin is lacking in epidemic response. However, the use of artificial intelligence and extensive datasets to develop multifactorial risk algorithms may improve the capacity to red-flag potential unnatural outbreaks [44]. Furthermore, leveraging artificial intelligence [44] for outbreak detection and analysis could accelerate the process and counter the inclination to disregard this possibility [34].

The legal frameworks for defining responsibilities and regulating biological agents that may pose a threat are complex and fraught with difficulties. The Biological Weapons Convention (BWC) focuses on biological agents and toxins for hostile purposes, stating that parties (nation states) must develop domestic laws to prohibit such activities. There is an effort to provide an all-encompassing framework, as it states that parties undertake to
“never in any circumstances to develop, produce, stockpile or otherwise acquire or retain:

1. microbial or other biological agents, or toxins, whatever their origin or method of production, of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes;
2. weapons, equipment or means of delivery designed to use such agents or toxins for hostile purposes or in armed conflict.” [45]

However, the BWC is unenforceable, and countries suspected of breaching it cannot be audited. Further, the focus on nation states misses a possibly greater threat, that of non-state actors such as terrorists and multi-national groups.

The Cartagena Protocol on Biosafety is similarly broad and includes risk assessments of living genetically modified organisms, biosafety standards and security, and building capacity to do this in lower-income countries.

"The Parties shall ensure that the development, handling, transport, use, transfer and release of any living modified organisms are undertaken in a manner that prevents or reduces the risks to biological diversity, taking also into account risks to human health."[46]

The International Health Regulations provide a legal framework for responding to health emergencies, including bioterrorism, based on similar principles. However, they primarily focus on natural outbreaks and the obligation to report significant events that may cross international borders. [47]

These international laws, along with local laws developed to regulate gene technology, do not sufficiently address the types of biological threats we may face in scenarios involving individual actors, terrorist groups and insider threats. For example, it was noted that the "Select Agent Rule" in the United States lists specific agents that must not be possessed or moved without proper authorisation. As this does not entirely cover novel threats (that may be based on common organisms), further amendments have been made to shift the burden of proof to the defendant to demonstrate that the possession of biological material was justified and for peaceful purposes [48].

These recent changes begin to address the ambiguity surrounding what constitutes a threat, especially in the context of potentially ingenious and rapidly developing new threats, as illustrated by the recent smuggling cases. Nevertheless, challenges in enforcement persist, and both under-detection and overreach may occur. A lack of funding for lower-income countries poses a significant problem, and political issues may take precedence over timely reporting, both of which result in challenges for outbreak control. In a fast-moving world, where only the tip of the iceberg of this issue is visible, legislation, awareness and funding to tackle the problem must race to catch up.

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