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RECEIVED 29 July 2025

ACCEPTED 01 October 2025

PUBLISHED 21 October 2025

CITATION

Cross GA and Carus WS (2025) Is a biological weapons arms race on the horizon: impact of scientific advances and strategic competition?

Front. Polit. Sci. 7:1675963.

doi: 10.3389/fpos.2025.1675963

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Is a biological weapons arms race on the horizon: impact of scientific advances and strategic competition?

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This article considers the impact of advances in the biological sciences and related fields on the international system by considering the prospects that such developments will induce countries to adopt biological weapons and spark a biological weapons arms race. As such, it considers the relative importance of technological factors compared with other considerations (such as military utility and bureaucratic factors) in determining weapons system adoption.

KEYWORDS

biological weapons, biological warfare, biological weapons proliferation, arms race dynamics, technological determinism

1 Introduction

This article examines whether advances in the life sciences and related fields will prompt states to pursue biological weapons (BW), thus triggering a BW arms race.¹ Some analysts have argued that revolutionary advances in the life sciences are making it possible to develop ever more dangerous BW. These advances, in turn, may make BW more attractive to at least some countries. Perceptions or fears that possible adversaries are developing BW could spur others to follow suit, leading to a BW arms race. Misperceptions about intentions over BW arise largely because the core technologies needed for BW are inherently dual-use. With dual-use technologies, differentiating between their peaceful and military applications is difficult. Because of this uncertainty over dual-use applications, it has been suggested that countries may feel compelled to adopt BW out of fear that potential adversaries are doing so, thereby initiating an arms race (Malet, 2021, pp. 7, 21; Emma et al., 2024, p. 169).

Here, we contend that such arguments are overly simplistic and do not adequately reflect what we know about the adoption of BW. Although scientific and technological advances have influenced perceptions of the utility of BW, understanding the reasons states adopt particular types of weapons is particularly important. We argue that the reason countries have failed to acquire and use BW in the past has resulted from two main factors, neither of which seems to

¹ Biological weapons here are defined as having two components. First is the weapons systems designed to disseminate pathogenic living organisms or replicating entities (such as bacteria, viruses, or fungi) or toxins (poisons derived from living organisms) to intentionally cause death, harm, or incapacitation to humans, animals, or plants. Second is the payload, which consists of the pathogenic organism or toxin (The convention on the prohibition of the development, production and stockpiling of bacteriological (biological) and toxin weapons and on their destruction, 1972; United Nations Office for Disarmament Affairs, n.d.).

have been significantly affected by recent scientific innovations. First, BW has shown limited military and strategic utility, as demonstrated by the small number of cases in which BW have been used.² Second, BW suffer from an unusual degree of opprobrium, as reflected in widely accepted international norms and agreements.

To develop these points, we set out the historical context behind known BW programs, highlighting some key features that distinguish BW from other weapons systems. We also discuss what is known about the intentions that motivated BW programs and the factors that influenced the formation of those intentions. These considerations are placed in the context of revolutionary developments in the life sciences and the convergence of biology with other transformative developments, such as artificial intelligence (AI). This background material provides a basis for rejecting claims that scientific and technological developments are the primary drivers for state development of BW capabilities. We conclude that, currently, there is little reason to believe that recent scientific advances will incite a BW arms race.

2 Context

In its April 2025 arms control compliance report, the US government states that Russia and North Korea possess offensive BW programs, Iran is assessed as retaining an intent to research and develop BW agents for offensive purposes, and China is reportedly conducting activities that raise compliance concerns (Department of State, 2025).

Based on the authors' research, both published and unpublished, only about two dozen countries have organized BW programs since the beginning of the 20th century. The largest number of offensive state BW programs active at any time numbered ten during the late 1970s. Between the two world wars, as tensions rose in Europe in the prelude to World War II, seven states pursued BW programs. Even if Iran and China were added to the roster of current BW programs, that number still would be historically low.³

Also worth noting is that almost all BW programs were small-scale, of limited duration, and relied on unsophisticated delivery systems.⁴ In this respect, the Soviet BW program, which employed tens of thousands of people, lasted for more than six decades, and is believed to have developed effective munitions, was anomalous. Most programs had fewer than 100 personnel and never possessed effective weaponry. Only the Soviet Union and the United States are known to have developed capabilities for large-scale dissemination of biological agents (Carus, 2017a, pp. 143–146). However, information of a Soviet

BW doctrine is so sparse as to raise questions whether the Soviets had developed a military doctrine for BW battlefield use (Leitenberg et al., 2012, pp. 709–710).

Perhaps even more significant is the apparent lack of utility assigned to BW. If BW had perceived military or strategic utility, the incentives should have led to its use in armed conflict. Yet, instances of biological warfare have been almost nonexistent. The only large-scale use of BW occurred during the Second World War when Japan used BW against the Chinese (Harris, 1999). Although other small-scale incidents of biological warfare have occurred, they have produced few or no results. As a result, there is no reason to believe that even those countries that explored BW found it to have military utility (Carus, 2017b).

What motivated the creation of past BW programs? Unfortunately, in most cases, we do not know precisely. As a result, it is not possible to assert with confidence that countries initiated programs in response to the perceived activity of hostile powers (Malet, 2021, p. 7). In some cases, intelligence reports probably influenced decisions to organize and sustain BW programs, but even in those cases, other factors may have been more significant. Thus, was Poland's BW program established in the 1930s to counter a suspected Soviet BW program, or was it designed to provide covert capabilities against an occupying enemy army (Carus, 2017a, apps. 83–84). Even when research and development were more obviously intended to provide retaliatory capabilities, it remains unclear to what extent such activity was motivated by often unreliable intelligence information. Thus, the US program also was influenced by leading scientific advisors who saw BW as a potential new form of warfare (Bernstein, 1988, pp. 293–294). In the US case, poorly sourced intelligence reports of German BW activity were accepted to justify the pursuit of BW, rather than actually driving the action.

The perceived lack of BW utility is likely the main driver in disincentivizing states' interest in BW. This disutility, in turn, encourages acceptance and adherence to international norms. States are more than willing to sign on to agreements outlawing categories of weapons that seem useless or at least marginally useful, especially if they gain political or diplomatic standing by doing so. Limited BW utility almost certainly outweighs the assertion that a BW taboo explains the lack of offensive state BW programs.⁵

The absence of any known BW use since the 2001 Amerithrax letter attacks also reinforces the judgment that states—and arguably non-state actors—have little interest in them. Although BW has occasionally been employed in very small-scale attacks, even such use has been extremely rare. Assassinations involving BW have invariably involved toxins, such as botulinum toxin, ricin, and curare (Cross and Beedham, 2025). Infectious agent use is known to have been considered in only one case (Natasha Shur, 1998). The uncontrolled and unpredictable global spread of COVID-19 and the pandemic's political, economic, and social impact likely further disincentivizes any large-scale, deliberate release of contagious pathogens (Ackerman et al., 2024).

² For a review of how limited information on state BW programs, doctrines, and incidents of use affects analysis of BW intent formation, decision-making in individual countries, doctrine and planning, and use cases, see Carus (2015).

³ Other countries have been credibly accused of possessing BW programs, such as Egypt and Israel, but the reporting is dated and there are no reliable reports that those countries continued that activity into the 21st century. For discussions of state BW programs, see Carus (2017a), Cross (2021), and Cross and Beedham (2025).

⁴ By the end of the 1960s, the US and all the Western BW programs had ended. The Rhodesian, South African, and Iraqi programs ended by the 1990s, largely as the result of regime change (Carus, 2017a, p. 139).

⁵ (Cross, 2024) On this point, we disagree with those who assert that a BW taboo explains the lack of interest in BW, as best articulated in (Bentley, 2024).

3 Factors influencing intent

Intent is the political will to establish and support the development of a BW capability and the political will to use such weapons. Intent typically is established at senior levels of government and communicated down through the organization, although it is possible for organizations to pursue BW capabilities without authorization or even in defiance of official policy.⁶ Intent is the result of a deliberative process by decision-makers, factoring in an assessment of BW utility in response to a perceived threat (Cross, 2020). Intent, thus, is highly contextual and liable to change as circumstances evolve. We assess that variables affecting intent can include changes in policymakers through changes in government (through elections, coups d'état, or revolutions), perceived changes in the threat environment, strategy shifts, reprioritization of resources, diplomatic pressure, or public exposure. Complicating matters, capabilities—including potential capabilities—can shape intent, even as intent shapes the rationales justifying their existence.

The calculation of whether to develop BW must weigh bureaucratic considerations, domestic politics, diplomatic relations, opportunity costs (the relative value of alternative weapons), the security environment, intelligence assessments of potential adversaries' intentions and capabilities, and the political cost of norm violations (Balmer, 2002). Thus, each nation's decision-making process and outcomes regarding BW are likely to differ. In most cases, we have no insight into these decisions. Thus, although we know Mussolini came to support Italy's BW program, our limited insight does not indicate whether he even knew of its initial organization (Di Feo, 2009, chap. 1). In the case of the Rhodesian BW effort, the political leaders went to great lengths to distance themselves from responsibility despite their complicity (Cross, 2017).

What motivates countries to acquire BW? Determining the reasons countries acquire and maintain BW programs is rarely easy, given the secrecy that surrounds them. In some cases, no deeply considered strategic rationale is apparent. However, based on what we know about past BW programs, several considerations seem to shape intent. These factors include: (a) perceived strategic and tactical utility, (b) bureaucratic and institutional drivers, and (c) internal and external threats. The weight of each of these factors likely varies from nation to nation and from time to time. Moreover, the rationale for creating a program may differ from those assigned to it as it acquires usable capabilities.

3.1 Utility

Of these factors, based on the historical record, utility probably has had the greatest weight. Recent history, especially Russian poison use in assassinations, suggests some national leaders value the capability to conduct covert, plausibly deniable attacks against regime opponents and perceived threats (Cross, 2021). Yet these attacks are not offensive BW use on a battlefield scale, nor have they resulted in

the adoption of BW by other nations. However, a covert BW capability could be employed to damage an enemy's economy through attacks on crops and livestock (Wheelis et al., 2002; Chalk, 2004) or to conduct sabotage of critical infrastructure (Cross, 2021). In present-day parlance, these attacks would be gray zone operations utilized to weaken an adversary short of open warfare (Gisselsson, 2022).

3.2 Bureaucratic and institutional factors

Bureaucratic and institutional factors, including internal political constituencies and budgetary considerations, may be more significant than often realized. Leadership politics, personal decision-making practices, and the influence of key advisors are crucial. We know that influential scientific advisors have played a decisive role in advocating for the creation of some BW programs, often through webs of advisory committees. Examples include Frederick Banting (Canada/UK), Paul Fildes (UK), Ishi Shiro (Japan), Robert Symington (Rhodesia), Wouter Basson (South Africa), and George Merck and Ira Baldwin (US) (Balmer, 2002; Guillemin, 2006). These advocates rarely had deep strategic or military rationales for their advocacy. Instead, they recognized that, in theory, biological agents could be made into weapons but had only vague notions about how possible applications would have military utility. Thus, in some instances, the programs sought a military rationale rather than having been created with specific military objectives in mind.

3.3 Internal threats

Internal threats to regime security motivated several state BW programs. These programs, housed in intelligence and security services, focused on the covert assassination of regime opponents, including opposition political leaders, dissidents, journalists, defectors, as well as leaders of religious and trade union organizations. Targets have also included insurgent, anticolonial, and emerging communist leaders (Cross and Beedham, 2025). Use of covert BW to combat internal security threats usually has gone undetected, as shown by the Rhodesian and South African use of biological agents against hostile guerrilla groups, and is unlikely to result in BW competitions.⁷

External threats, specifically feared possession of BW by adversary nations, have motivated the acquisition of BW, especially before the Biological Weapons Convention (BWC) came into force (1975). Allied BW programs during World War II were organized to provide a retaliatory response to feared German BW use. Large offensive military BW programs post-WWII are notable exceptions, given that most BW programs after WWII have belonged to intelligence and security services and focused on assassinations. The few large offensive military programs (those of the Soviet Union/Russia, the United States,

⁶ As Erhard Geissler has noted, the SS pursued offensive BW in defiance of explicit orders from Hitler forbidding such activity (see, Geissler, 1999, pp. 103–104, 108–109).

⁷ Arguably, the covert use of BW in assassinations may have gone undetected, being what the French describe as *mort silencieuse* (silent death) (Nouzille, 2015). Those covert uses of BW made public largely are the result of disclosures made years after the events.

China, and North Korea) primarily were driven by internal political and bureaucratic factors and threat perceptions.

3.4 Political considerations

Political signaling and national prestige almost certainly are not factors in motivating states to adopt offensive BW programs. BW programs are among a country's most closely guarded secrets. They are not made public for fear of the political costs of violating the prohibitive norms. The intense secrecy surrounding state BW programs and the cost of norm violation limit the value of any signaling of a BW capability.⁸ The almost universal desire of countries to hide their BW programs suggests that international norms and agreements are important influences on perceptions of BW. Arguments that BW possession might confer national prestige are likewise untenable.

Norms play an important role in supporting BW disarmament; however, they do not explain the lack of historical BW use or the fact that fewer nations are now assessed as possessing BW. BW's lack of utility as a battlefield weapon better explains both the historical record and the current trend toward fewer state BW programs (Cross, 2024). Arguably, the norms prohibiting BW development, production, and possession have come under increasing challenge, yet if norms have weakened or eroded, no corresponding increase in the number of state BW programs has been observed (Cross, 2025). This observation reinforces the conclusion that the norms themselves are not the chief factor limiting state BW programs.

3.5 Limitations of intelligence

BW programs have always been highly secretive and pose extremely difficult intelligence challenges. Most states never discuss the subject, even restricting access to information about former BW programs. Only two countries (the United States and Egypt) have ever made public disclosures of their existing BW capabilities (Carus, 2017a, p. 147).

Determining intent and the dual-use nature of the life sciences complicate the intelligence challenges when assessing whether a nation has a BW program. The challenges associated with identifying state BW programs starkly contrast with nuclear weapons programs, which are often matters of public record; nuclear tests are visible demonstrations of capability, and nuclear weapons technology is unambiguously weapons-related. Thus, although numerous reports mention that Taiwan had, or may have had, a BW program in the 1970s and 1980s, no details are available. In contrast, considerable information exists about Taiwan's equally secretive nuclear weapons program.⁹

Further complicating matters is that intelligence assessments, too often based on faulty information or unfounded assumptions, frequently have been wrong. The historical record of intelligence on BW programs suggests that security organizations often exaggerate or underestimate their opponents' BW activities. For instance, the Allies assessed that the Germans had more advanced capabilities than was actually the case during WWII. In contrast, Western authorities seem to have had no idea of the extent of the Japanese BW program. Similarly, US intelligence grossly underestimated the extent of Soviet BW activities as the end of the Cold War neared (Carus, 2017a, pp. 148–149). Indeed, a former director of the US National Intelligence Council once described the failure to accurately assess the Soviet BW program as the most significant US intelligence failure of the Cold War.¹⁰

Even today, adversarial states are unlikely to uncover conclusive evidence of another nation's offensive BW program. Intelligence methods are largely incapable of detecting covert BW programs, especially if small-scale. Intelligence collection capabilities focus on observables, such as imagery or activities. BW research and development (R&D) is almost indistinguishable from legitimate civilian scientific research and therefore unobservable. Large overt military programs are more likely to have discernible footprints. Unique weapons signatures, dedicated military units, BW-related training and exercises, as well as doctrinal documents, all give observable indications of BW programs.¹¹

4 BW and technological determinism

Some experts have argued that bioconvergence—the synthesis of revolutionary advances in diverse fields, such as biotechnology, artificial intelligence, robotics, biochemistry, big data, and the growth of computational capabilities—can incentivize state and non-state actors to develop BW (Brockmann et al., 2019; Yassif et al., 2023, pp. 259–260). The underlying assumption underpinning these concerns is that new technologies will enhance the attractiveness of BW by making it easier to acquire such capabilities and also making them more effective.

Such arguments are a form of technological determinism—the belief that technology or technological capabilities drive the adoption independent of political, economic, bureaucratic, or societal inputs (Smith and Marx, 1994). As Kathleen Vogel describes it, “Technologically deterministic thinking often incorporates a technological imperative, which assumes that technological developments, once set in motion, are unstoppable” (Vogel, 2013a).

Despite the evident logic in such arguments, there is a danger in overemphasizing technological capability as a driver of BW development. James Revill and John Borrie caution against the acceptance of technological determinism. Technology itself does not drive the development of BW; organizational factors must also be considered.

⁸ Only Egypt and the United States ever admitted to possessing a BW capability while their programs were active. Yeltsin's 1992 statement admitted to the existence of a Soviet BW program and provided reassurances that the program had been terminated.

⁹ The limited amount of information on Taiwan's alleged BW program is summarized in Poor Toulabi (2021, pp. 201–202). On Taiwan's nuclear ambitions, see Mitchell (2004).

¹⁰ This comment was made at a workshop around 2005.

¹¹ Roffey (2004) and Fångmark and Norlander (2005).

Biological weapons programs useful for military purposes still require a sophisticated organization, including funding, contracts, equipment, facilities, and considerable experience. Such programs are not available to most non-state actors and require state support (Revill and Borrie, 2020).

Other commentators have criticized a focus on technology to the exclusion of social and institutional factors. Sonia Ben Ouagrham-Gormley has long argued that BW are difficult to develop and produce, and their production faces challenging endogenous and exogenous variables (Ben Ouagrham-Gormley, 2014). Kathleen Vogel has suggested that social factors influence the development and application of technology (Vogel, 2013b). Moreover, tacit knowledge and institutional factors within scientific institutions likely hinder the possibility of misuse (Vogel, 2006; Ouagrham-Gormley, 2012; Jefferson et al., 2014).¹²

Controversy over the impact of AI remains.¹³ As researchers at the University of Cambridge's Centre for the Study of Existential Risk concluded,

Conversely, some stages of biological weapons development may be more amenable to "barrier lowering" through AI than others. As previous attempts by States and Non-States to develop biological weapons have shown us, the process is a complex one, and the utility of AI in the different stages will depend on the stage, the actor(s) involved, their existing capabilities, and their absorptive capacity. Moreover, while many assessments have looked in particular at the 'design' stage (and this is where AI could likely have an impact), you cannot get away from the need for iterative testing 'in the real world'. And the transition to the physical world is a significant pinch point (Norwood, 2025).

In summary, the impact of AI and bioconvergence on the potential BW threat, particularly from novice and intermediate-skilled actors, remains untested and unproven.¹⁴ Arguments that scientific and technical developments related to the life sciences will inevitably motivate interest in BW seem untenable. As noted, many factors play a role in decisions to adopt BW, and a reductionist, deterministic approach fails to account for the complex individual and institutional interactions that occur in forming intent.

¹² A contrary perspective is given in Brent and McKelvey (2025).

¹³ A skeptical view is given by Mouton et al. (2024). For arguments that the effectiveness of security measures implemented by AI firms and the role of tacit knowledge in mitigating the AI threat have been exaggerated, see Brent and McKelvey (2025) and Luckey et al. (2025).

¹⁴ Efforts to explore AI's potential misuse to develop, produce, and disseminate a biological weapon have consisted of expert panels, workshops, and red team exercises, as well as use of prompts to test AI system responses (i.e., whether the AI platform provides accurate and useful detailed instructions on BW development). No publicly available information exists as to whether any of these efforts have attempted to use AI information in any practical setting. For a discussion of the limitations on the study of AI-generated BW threats, see Drexel and Withers (2024).

5 The prospect of a biological weapons arms race

Some argue that technological developments will impel some countries to acquire BW, raising fears that other countries could do the same in response, thus leading to a biological arms race. Are such fears reasonable? Might states embark on offensive BW programs, covertly or overtly, to exploit the potential military applications of emerging BW capabilities? Would the pursuit of BW by one state lead other countries to follow suit? Could this result in a full-fledged BW arms race? Assessing the prospect of a BW arms race has been little studied and, for reasons discussed below, is challenging. Nevertheless, while the answers to these questions are complex and necessarily speculative, the historical record and the nature of BW offer some clues.

Historically, arms races have involved large, complex military weapons systems that are difficult to disguise, highly observable, and easily distinguishable from civilian activities. Some historical examples of arms races include the mid-19th-century Anglo-French naval competition, the late 19th-to-early 20th-century Anglo-German Dreadnought race, and the mid-20th-century US-Soviet bomber and missile "gaps" (Huntington, 1958; Kennedy, 1984). Little agreement exists on the causes and consequences of arms races or the dynamics of these competitions. Commentators are divided over whether domestic or external pressures cause them. What is not in dispute is that arms races are complex phenomena poorly understood in theory (Glaser, 2000, pp. 251, 263).

5.1 The security dilemma

Arms races often are attributed to what has been called the security dilemma, in which one state, attempting to strengthen its security through the acquisition of new armaments, thereby threatens the security of other states. Its competitors attempt to bolster their security by also acquiring more armaments. The states in such competitions perceive that their adversaries are seeking an offensive advantage rather than just enhancing capabilities to resist their enemies. Such competition occurs among adversarial (or at least competing) states. Arms races, therefore, do not take place between allies or partners. Uncertainty, which gives rise to fear over an adversary's intentions, is a necessary but insufficient condition for the emergence of the security dilemma (Jervis, 1978; Glaser, 2000; Lupovici, 2021).

This argument is sometimes advanced by those who fear that technological advances will lead to a BW arms race. Does the security dilemma explain the rationales behind historical BW programs? Little evidence exists to support such a hypothesis. As discussed above, even when there are indications that a country is reacting to the activities of a potential enemy, it is not evident that the need to develop a comparable capability is the primary reason for initiating a BW program.

For the past decade, the Russian Federation has mounted a Russian disinformation campaign intended to generate suspicion and fear of alleged BW programs organized by the United States and others (Leitenberg, 2020). In the security dilemma model, such allegations would lead adversaries to respond competitively (i.e., to develop offensive or defensive BW capabilities). However, no evidence exists

to suggest that Russian disinformation has triggered other countries to develop BW.

5.2 Uniqueness of BW

Past arms races have involved weapons systems thought to define core military capabilities, most recently nuclear arsenals and missile delivery systems. BW, however, are so different from such weapons that applying approaches used to explain Cold War arms races is untenable. Although BW commonly are referred to as the “poor man’s nuclear bomb,” such assertions assume that BW are substitutes for nuclear weapons. In this argument, states that aspire to acquire nuclear weapons will rely on BW in the interim as they work toward building a nuclear arsenal. Studies of nuclear and BW proliferation do not support such claims (Poor Toulabi, 2023).

The reasons are clear. First, as previously suggested, the military effectiveness of BW is unproven. Second, no country has ever considered BW as its most important military capability. Indeed, some countries, including France, the United Kingdom, and the United States, abandoned BW in favor of relying on nuclear weapons for deterrence.

Third, BW does not confer national prestige as nuclear weapons do. BW programs have always been conducted behind a veil of secrecy. The motivation to keep such activity secret intensified after the negotiation of the Biological Weapons Convention. Because the possession of BW violates international norms and agreements, offensive BW activities are conducted in secret and are only used covertly (Carus, 2017a, pp. 147–148). The utility of BW, therefore, is in the difficulty in attributing use to an actor and in its plausible deniability.

Fourth, BW arsenals differ from those for any other weapon. Indeed, quantifying the real capabilities of a BW program is impossible. Countries rarely maintain stockpiles of BW. Rather, large BW programs tend to rely on mobilization facilities that produce and fill weapons when needed. Moreover, no clear metrics exist for a transparent assessment of relative capabilities in the BW arena. As a result, it is impossible to ascertain whether a country pursuing BW has acquired sufficient capability to match that of an adversary.

Finally, BW is ineffective as a strategic deterrent, unlike nuclear weapons (Malet, 2021, p. 4). Strategic deterrence would rely on announcements of BW possession and intent to use such weapons. These conditions are untenable given the near-universal accession to the BWC and widespread international acceptance of the prohibitory norms. Rather than substitute for nuclear weapons, BW are at best complementary.¹⁵ Additionally, BW provides covert or plausibly

deniable means of state action to achieve national goals short of open conflict.

5.3 Hidden intent

Rarely do we know why countries chose to create and sustain BW programs. They are not announced, decisions are secret, budgets are hidden, and no doctrine is evident. None of the activity is public, and little is observable even with the use of sophisticated intelligence collection tools and exhaustive efforts.

Assessing intent is as difficult as it is complex. Almost always, little to no data exists on whether intent to pursue BW exists. As mentioned above, decisions surrounding intent are almost always secret, and BW programs are cloaked in secrecy. Often, if evidence is uncovered of a concerning intent at one point in time, the often-erroneous assumption is that the intent continued uninterrupted to the present day. As described above, intent is likely fluid, shifting as conditions change. The rationale for creating state-level BW programs is often unclear. In many cases, BW lack any known strategic rationale. In some instances, the programs likely sought a military rationale after the fact rather than having been created with specific military objectives in mind. Often in the absence of intelligence on BW intent, the focus shifts to assumptions about intent, either assessing current intent from previous known intent or concluding that scientific programs infer an intent to develop BW. Both approaches attempt to fill intelligence gaps with unfounded suspicions. Yet, today, these suspicions are not fueling BW arms races.

5.4 The dual-use dilemma

BW development and production are almost indistinguishable from civilian scientific research and development. The technologies used in BW development are also highly integrated in the civilian sector. Indistinguishability and high integration place dual-use biotechnology in what Tristan Volpe has termed an arms control “dead zone” (Volpe, 2024, pp. 138–140). In this “dead zone,” the difficulty of detection necessitates a highly intrusive and costly verification regime that may not detect violations.¹⁶ Similar considerations led to a growing body of regulation to constrain biological research due to fears of bioterrorism.

5.5 Securitization of biology

The possible misuse of advances in the life sciences has raised fears over deliberate BW use, leading some observers to characterize BW—along with natural disease outbreaks and unintentional laboratory accidents—as global catastrophic biological threats. These calls are efforts to securitize potential biological threats and exaggerate the possible harm by merging three different phenomena into a single existential threat. Securitization theory argues that actors and

¹⁵ In cases where one weapons system is equivalent in effect to another, they are considered substitutes. In cases where weapons systems are used synergistically for greater effect, they are considered complementary. The complementary nature of BW is evident in the statements of former Soviet bioweaponer Ken Alibek. He differentiates nuclear weapons (weapons of mass destruction) from BW (mass-casualty weapons). Each weapons system produced different effects, therefore could not be substitutes, but those differences made them potentially complementary (see Tucker, 1999).

¹⁶ Exhaustive and sophisticated intelligence means also face challenges in detecting offensive BW activities under such conditions.

audiences socially construct existential threats through “speech acts” (Buzan et al., 1998). In essence, actors—whether states, non-governmental organizations, or super-empowered individuals—who work to securitize issues of concern do so by focusing attention, generating fear of existential risks, and calling for urgent, emergency action (Lupovici, 2014). Thierry Balzacq describes securitization in the following way.

... an articulated assemblage of practices whereby heuristic artefacts (metaphors, policy tools, image repertoires, analogies, stereotypes, emotions, etc.) are contextually mobilized by a securitizing actor, who works to prompt an audience to build a coherent network of implications (feelings, sensations, thoughts, and intuitions), about the critical vulnerability of a referent object, that concurs with the securitizing actor's reasons for choices and actions, by investing the referent subject with such an aura of unprecedented threatening complexion that a customized policy must be undertaken immediately to block its development (Balzacq, 2010).

In generating fear to elevate a topic of concern among competing national security priorities, securitizing actors often distort perceptions of the security environment, heighten uncertainties, and divert limited resources, all of which may result in unintended consequences.

The threat of biological agents, whether natural, accidental, or deliberate, is being securitized. Several actors are asserting that the deliberate use of BW poses an existential risk, labelling BW use as one of several “global catastrophic biological risks” (GCBR) (Cameron, 2017; Schoch-Spana et al., 2017; Lewis, n.d.). Efforts by securitizing actors to focus attention on GCBRs seem to have largely failed. The targeted audiences have not responded by pushing for far-reaching emergency measures. However, some limited movement has taken place in restructuring biosecurity activities and curtailing gain-of-function (GOF) research (Kupferschmidt, 2025; Improving the Safety and Security of Biological Research, 2025).

The Russian government's disinformation campaign targeting US and Ukrainian biological research cooperation can be seen as a securitization effort. Moscow's pronouncements clearly are intended to cause fear and push target audiences to support urgent, emergency actions aimed at halting US and Ukrainian activities. Again, apart from domestic Russian audiences and Moscow's allies, world opinion seems to have rejected Russian claims (Jakob et al., 2022; Robinson et al., 2022).

The seeming failure by several actors to securitize BW as an existential threat reinforces the conclusion that the large-scale intentional pathogen releases are improbable. A serious BW threat does exist, but it does not involve a massive deliberate release of a lethal pathogen. Apart from a hypothetical apocalyptic group, such a release is in no one's interest. In the wake of COVID, the unpredictable, uncontrollable, and indiscriminate effects of a pandemic agent would argue against its intentional use by any state actor. Such fears have long dissuaded countries from pursuing BW.

5.6 Avoiding technological determinism

Efforts need to set aside technological determinism and fears of BW arms races to focus on the more likely uses of BW, including assassinations, sabotage, regime security, political destabilization,

economic attacks, and disruptions to critical infrastructure. In these grey zone applications, BW likely would be used in combination with cyberattacks, disinformation, cognitive warfare, and currency manipulation.¹⁷ These operations are distinct from large-scale, large-area attacks conducted during conflict. A form of irregular warfare, subliminal zone operations are defined as conducted during the pre-conflict crisis period.¹⁸ These operations are covert or clandestine and designed to disrupt an adversary's ability or even will to engage in conflict. In this sense, these operations are distinct from more traditional concepts of biological warfare.

Amir Lupovici contends that insecurity is socially constructed by actors who highlight the threat posed by technologies. Labeling a technology as dual-use allows an actor to construct a threat around that technology, even if it was developed for peaceful and beneficial purposes. Casting dual-use technologies poses potential threats (securitizing dual-use technologies), which intensifies uncertainties and concerns about misuse. Lupovici adds that actors cannot know the intentions of those developing dual-use technologies.

This dilemma could raise uncertainties about intentions, and disinformation campaigns generate fear, prompting an international response. Yet this reaction has not occurred despite notable Russian efforts. Bioconvergence and emerging dual-use technologies have not prompted the BW arms race some have feared (Paxton, 2024). In general, the consensus is that even dual-use science holds far greater promise of benefits for humanity than potential for its destruction.

6 Conclusion

Considering all the factors described here, the prospects of a BW arms race are highly unlikely. BW lack strategic military utility, and international prohibitive norms so far remain intact. The number of state actors assessed to be pursuing BW now stands at an all-time low. The historical factors that incentivized states to pursue BW no longer drive BW development and use today. Despite recent allegations and accusations of BW development and production, no state potentially threatened by others' BW efforts has begun its own BW programs. There is no evidence that states see possession of their own offensive BW arsenal as an effective counter to an adversary's BW. The one exception to this general rule is the possible use of BW in assassinations and small-scale operations. Of non-state actors, only apocalyptic-millennarian groups are likely to pursue the use of BW to cause pandemic-level harm. Yet, exhaustive efforts to identify such groups today have been unsuccessful.

Arguments that scientific and technological advances have changed the equation are unconvincing because they typically ignore the factors that have historically limited the attractiveness of BW. Technological determinism as a driving force behind BW threats needs to be a cautionary tale. Despite the enormous recent strides made in the life sciences, the advent of bioconvergence, as well as the accelerating vertical and horizontal proliferation of technology and

¹⁷ For a description of BW use in subliminal, grey-zone operations such as sabotage, assassination, and small-scale special forces attacks, see Cross (2021).

¹⁸ David Kilcullen originated the concept of liminal warfare (Fox, 2020; Hybrid threats and liminal warfare with Dr. David Kilcullen, 2021).

expertise in the life sciences, we have not seen a corresponding rise in the number of state BW programs.¹⁹ The obvious conclusion is that capabilities are not being translated into intent.

Furthermore, BW do not fit the model established by historical arms races or by explanatory international relations theorists. The dynamics that fueled past arms races do not now exist to drive a BW arms race. The need for a BW capability to deter or respond to an adversary's BW threat does not now exist. Despite concerns over weakening prohibitory norms, the normative regimes remain intact, mainly due to the disutility of BW. Acting to further disincentivize BW programs, possession and use of BW today mark those pursuing BW as anathema.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Author contributions

GC: Writing – original draft, Writing – review & editing. WC: Writing – original draft, Writing – review & editing.

¹⁹ Vertical transmission refers to the transmission of expertise and capabilities (including access to technology and materials) from the most skilled to the less skilled or unskilled. Horizontal transmission refers to the transmission of knowledge and capabilities from development centers to other countries or regions (chiefly a reference to spread from the Global North to the Global South).

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Funding

The author(s) declare that no financial support was received for the research and/or publication of this article.

Conflict of interest

GC was employed by Crossbow Analytics LLC.

The remaining author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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