The Pursuit and Use of Biological Weapons by States

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Summary

Biological weapons (BW) have been a fixture of warfare throughout history, although states did not have the capability of manufacturing BW arsenals until the 20th century. Few states had strategic objectives for BW production, but the fear of being outmatched by rivals produced arms races beginning in the 1920s. Both hegemonic and rogue states sought BW arsenals, although only Imperial Japan is known to have employed them. International agreements prohibiting BW have been ineffective, but normative, technical, and deterrent constraints have prevented the arms from being used.

BW remain undertheorized in the international studies literature and have not been part of the great debates within the field. The literature on BW has instead been far more technical than that for other categories of armaments. The main division among BW researchers is whether the select agents are likely to be spread by proliferation to rogue states, terrorists, or lone actors or whether the technical difficulties inherent in production mean that only states that have invested in advanced research will be able to harness them.

The biological weapons of the 21st century will be new technologies developed by great power militaries ranging from enhanced supersoldiers to genetic attacks that cause organ failure at the push of a button. These advancements raise difficult questions about Just War, military service, and domestic civil liberties. Just as the advent of nuclear weapons and drones preceded informed debate, military uses of biotechnology have already begun and require examination before they are deployed widely.

Keywords: biological weapons, military innovation, weapons of mass destruction, arms race, proliferation

Biological weapons (BW) have been a peripheral concern of international studies despite the weight given to their threat by policymakers, but there is reason to expect growth in the scholarship on this topic. Whereas BW have historically signified “germ warfare,” which have not been as operationally effective as conventional weapons or as strategically significant as nuclear weapons, BW increasingly mean a new category of arms and tools based on life sciences that have the potential to transform warfare. The great power states of the 21st century are all investing in next-generation BW that will require new ways of theory-building and analysis to describe their influence on international security.

Ashton Carter (2001, p. 157) argued, several years before becoming the U.S. Secretary of Defense, that “the biotechnology revolution will have implications for security that will probably exceed those of the nuclear and information revolutions that preceded it.” Similarly, in 2012 Russian President Vladimir Putin wrote that new categories of weapons in development, including genetic and psychophysical technologies, “will be comparable in effect to nuclear weapons but will be more ‘acceptable’ in terms of political and military ideology” (Zilinskas & Mauger, 2018, p. 1). Similarly, China, India, and the European Union are all known to be studying or pursuing novel BW research (Malet, 2016, p. 170). Each of these actors can plausibly argue that they are pursuing defensive research rather than seeking to establish an offensive capability because the unique nature of BW makes the pursuit of these objectives indistinguishable. It is therefore particularly important to understand the dynamics of BW arms races and limitation regimes as the most powerful states research capabilities to create new categories of novel BW.

International Studies and Biological Weapons

BW have been undertheorized in international relations. Although they have existed throughout recorded history, their deployment in modern times has been rare, and rarely consequential to the outcome of a conflict. Unlike the chemical weapons that are emblematic of the baleful and futile brutality of World War I, or the uncontestable nuclear weapons that ultimately ended World War II and ushered in decades of Cold War balance of terror, the third category of unconventional weapons of mass destruction (WMD) had no widely regarded defining turn during the major conflicts that shaped modern international studies (Koblentz, 2009, p. 4).

Definitions

There is no fixed definition of what falls within the scope of BW. Under the terms of the 1972 Biological Weapons and Toxins Convention (BWC), which is the cornerstone of global governance in BW arms control, signatories declare “never under any circumstance to develop, produce, stockpile or otherwise acquire or retain . . . 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” (Malet, 2016, p. 36). This categorization has proven problematic because many states have continued to pursue BW-related research in the name of developing defenses against BW or for ostensibly unrelated medical science (Dando, 2006, p. 22).

Zilinskas and Mauger (2018, pp. 7–8) define a biological weapon as a complete system of a payload of formulated pathogen, a munition that delivers the payload, and a mechanism for dispersion over a targeted population. However, this would only include weapons delivered by projectile munitions, and most of the BW that have been used by states to date were not delivered in this fashion. John Ellis van Courtland Moon states that “biological and toxin weapons are weapons charged with micro-organisms (bacteria, viruses, rickettsia, or fungi) or with poisonous chemical toxins (e.g., cobra venom) produced by living organisms” (Geissler & van Courtland Moon, 1999, p. 1). Some researchers who view pathogens as BW argue against including toxins in the category, whereas others argue for including bioregulators in the

definition, and in the BWC, because these naturally occurring biochemicals of the human body can be targeted by novel BW to produce direct effects on the human body within hours. Bioregulators include serotonin, endorphins, and insulin, which if caused to become imbalanced would disrupt not bodily functions but also mental functioning including mood (Koblentz, 2009, pp. 9–10; Maurer, 2009, pp. 106–107).

For select agents, whether disease pathogens, toxins, or substances affecting bioregulators, to be effective as BW in warfare, they would need to be (a) very toxic, (b) fast acting, (c) highly transmissible, (d) predictable in their effects, (e) able to survive in air and water long enough to cause widespread infections, (f) Not susceptible to common treatments for infection, (g) not readily destructible through purification methods, and (h) not easily susceptible to antidotes or prophylactics. Few naturally occurring infectious agents can be easily mass produced to meet these functional requirements (Utgoff, in Roberts, 1993, pp. 28–30).

Unlike chemical weapons, which are often lumped into a single category with BW as "biochemical weapons," contagious forms of BW do not require mass quantities of pathogens or toxins to cause mass destruction. Select agents such as viruses that can survive and reproduce outside laboratory conditions may even become uncontrollable in their growth if released. The potential for extremely small quantities for BW to be highly lethal, reproducible, and often naturally occurring, makes counterproliferation a far greater challenge for BW than other WMD (Preston, 2009, pp. 7–8).

Another challenge posed by BW is the "dual-use dilemma." Items used in the production of BW may also have legitimate commercial or medical research purposes. Moreover, any biodefense research against BW, which is permitted under the BWC, requires samples of the same select agents that would be used to produce weapons. BW therefore present the greatest challenge of any armaments for counterproliferation efforts. The problem of verification predates the BWC and is detectable in earlier international regimes against WMD, when scientists engaged in military BW research claimed they were only studying means of defense (Lepick, cited in Geissler & van Courtland Moon, 1999, p. 75).

Scholarly Assessment of BW

Despite the existence of national BW programs over the decades, there is little available research on state doctrines regarding their employment. Overall, it seems as though BW have been treated by states as a supplemental category of arms whose main purpose is to increase potential costs for adversaries (Preston, 2009, p. 5). Perhaps because BW have not been the basis for strategic military doctrine, they have been the subject of comparatively few strategic studies.

Research on nuclear weapons was the preeminent concern of security studies in the second half of the 20th century, and articles on the subject filled the most influential theoretically oriented journals of international relations. And the body of work was theoretical, imagining how nuclear arms influence state behavior, rather than presenting empirical data about the particulars of the weapons themselves or their devastating effects. Although a handful of prominent scholars, ranging from neorealist Charles L. Glaser to constructivist Jeffrey Checkel, had prior training as nuclear scientists, few researchers in a field dominated over its several decades of existence with concerns about preventing superpower nuclear war had or

were expected to have any working knowledge of nuclear weapons. Similarly, the smaller body of work on chemical weapons was largely based on how individual decision-makers were constrained by norms against their use. Imagine instead that scholarship on nuclear arms focused on the categories of weapons rather than their impact on the international system, or that chemical weapons scholarship provided analyses of chemical compounds and their effects on the human body.

The explanations for the fact that both categories of WMD had not been used since their initial major war deployment rested on explanations that they were seen as too terrible and too risky to consider, except perhaps as a final resort. But the literature on BW and the assessment of why it was rarely employed was very different.

> One common feature of the bioweapons literature is that many, if not most, of the authors have backgrounds in biological sciences and have worked in governmental or intergovernmental agencies responsible for biodefense or counter-proliferation. The bioweapons literature is therefore far more technical than perhaps any other subfield of international security, but it remains under-theorized.
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> (Malet, 2016, p. 4)

Rather than participate in the “great debates” of international relations, the literature on BW was empirical and often heavily descriptive about the armaments, and usually more so about the pathogens and their effects on the human body. With authors more interested in empirical and policy-relevant work, much of the most-cited literature on BW appears in books and was not required to fit into the theoretical silos of the international security literature. But this also meant that most of the work does not reference key theories that might explain state development of, and restraint in using, BW.

One key author, medical anthropologist Jeanne Guillemin (2005, p. viii), argued that BW programs were a “failed military innovation” that produced no armaments of strategic value or changes in military doctrine despite decades of investment by a number of major powers. Nobel Prize-winning economist Thomas Schelling, an early author in nuclear deterrence, dismissed them as “ridiculous weapons” (Koblentz, 2009, p. 32). Indeed, at the height of the Cold War, the United States proposed eliminating BW and the Soviet Union readily agreed, though it continued to develop them secretly, because superpowers viewed them as redundant to their more reliable nuclear deterrents (Guillemin, 2005, p. 11).

Unlike nuclear arms, BW can be effective force multipliers but are offense-oriented weapons that are “poorly suited to serve as strategic deterrents.” This is because they are not instant in their effects, so responses can be made against even the most lethal attacks, and because attacks are not necessarily indefensible, depending on the type of BW used (Koblentz, 2009, pp. 21, 40). BW are also different from nuclear weapons, and outside the logic of strategic deterrence, because it may be difficult to determine when a release has occurred, whether it was intentional, and who was responsible for it (Clunan, cited in Clunan et al., 2008, p. 4).

Yet states have continued to pursue, develop, and occasionally use BW, and multilateral nonproliferation efforts targeting both state and nonstate actors continue as well. As noted, senior leaders of major powers expect novel BW, including genetic manipulation of pathogens as well as the human body directly, to be the major challenges of 21st-century security. But

even traditional BW represent the potential for extreme disruption. The COVID-19 pandemic of 2020 demonstrated how even a novel pathogen with relatively low levels of transmissibility and lethality can completely disrupt international order. Although undertheorized in the international security literature to date, the potential for the deliberate release of an untreatable, potentially highly transmissible, and lethal pathogen presents an obvious source of concern for security practitioners.

Modern BW arsenals were initially developed during the interwar era, and military planners soon recognized that they had real limitations as strategic battlefield weapons, but could nonetheless be particularly effective as terror weapons, particularly against civilian population centers (Guillemin, 2005, p. 25; Koblentz, 2009, p. 37). On a psychological level, BW are effective because of the human horror of disease and fear of the unknown (Stern, 2002/2003, p. 104).

As the threat of nuclear war receded in the post-Cold War era, the potential use of BW by "rogue states" operating outside international norms or nonstate actors such as terrorists or religious cults became more prominent. One of the contributing factors in the 1991 Gulf War was Iraq's known pursuit of WMD including BW. At the conclusion of the conflict, Colin Powell, then Chairman of the Joint Chiefs of Staff of the U.S. Armed Forces, stated that the possibility of the use of BW against American troops on the field had been a more alarming possibility than the use of tactical nuclear weapons (Smith, 2011, p. 2). In 1996, the Pentagon Office of Counterproliferation and Chemical and Biological Defense noted, "BWs are the most problematic of the WMDs. They have the greatest potential for damage of any weapon. They are accessible to all countries, with few barriers to developing them with a modest level of effort" (Preston, 2009, p. 8).

Given the various security challenges connected to BW, it is understandable that even if there are no great theoretical or paradigmatic debates, the literature has several strands emphasizing different elements of the phenomenon. Indeed, there are substantial differences between authors of the most commonly cited works about whether BW are likely to be a major international security threat, but these are differences and not disagreements because the authors do not engage in these debates within their works. Therefore, the literature on BW is different from the literature on nuclear weapons, the literature from bioterrorism differs from other work on causes of terrorism, and so forth.

As noted, this is likely due to the heavily descriptive rather than theoretical nature of most of the work on BW. Many of the works on BW that emerged during the post-Cold War period in the 1990s and 2000s, when proliferation of Soviet BW to "rogue states" and nonstate actors was a driving concern, provided detailed descriptions of select agents and the harms they can cause, and histories of state BW programs and international arms control efforts (see Alibek, 1999; Dando, 2006; Guillemin, 2005; Koblentz, 2009; Smithson, 2011). Other works from this period turned a more critical eye on counterproliferation efforts, detailing how the United States, Russia, and other BWC signatories were violating their own rules (Klotz & Sylvester, 2009; Zilinskas & Mauger, 2018).

More recently, scholarship in the 2010s emphasized constraints on BW and biodefense doctrines caused by organizational culture and other psychosocial factors. Scholars have explored the importance of technical expertise, agency priorities, and the competition

between transmission of scientific knowledge versus political and ideological demands in some regimes attempting to develop BW (Ben Ouaghram-Gormley, 2014; Edwards, 2019; Smith, 2011; Vogel, 2012).

Other strands of the literature have examined novel biotechnologies and how they are being developed for military purposes (Huang & Kosal, 2008; Lin et al., 2013; Malet, 2015; Moreno, 2006). Some researchers focus on state biodefense programs and international cooperation in this area, including natural disease transmission and pandemic response along with BW (Enemark, 2007). Many works among these different strands address the pursuit of BW by nonstate actors as well as by states, but there are also works that focus entirely on bioterrorism, which is even more limited in scope than the BW programs created by states.

Military Competition and Biological Weapons

Hegemonic actors have employed BW throughout history, from Roman and Chinese use of toxins in antiquity to the inadvertent spread of smallpox through the New World by the Spanish Empire and then its intentional deployment against indigenous people by British forces once the germ theory of disease transmission was discovered (Malet, 2016, pp. 12–16, 20). But it was the advent of microbiology in the 19th century coinciding with the development of doctrines of total warfare that led to large-scale efforts to use BW in wartime.

Proliferation and Counterproliferation

During World War I, German “saboteurs attacked military livestock in the United States, Argentina, Romania, Norway, and perhaps Spain, slipping the animals disease-laden sugar cubes, painting their nostrils with contaminated material, and sticking them with infected needles” (Smithson, 2011, p. 230). When the director of a German pharmaceutical plant reportedly revealed to French inspectors after the war that work was continuing on bacteriological agents, France was persuaded to develop the largest BW program of the interwar period, including the development of aerial delivery of select agents (Guillemin, 2005, p. 24).

While some military thinkers of the time did believe that bacteriological warfare would be more “civilized” than using kinetic weapons, by the mid-1920s it was generally recognized that BW had little battlefield utility because, like chemical weapons, they were difficult to control and unpredictable in dispersion, but also because their effects would require days to be noticeable. Aerial delivery to infect civilian population centers and industries, causing terror and crippling war production, became the preferred strategy (Guillemin, 2005, pp. 6–7).

In keeping with the spirit of 1920s international peace agreements, the great powers of the interwar period signed arms control agreements to ban the use of BW. These were to prove no more effective than any other treaties of the time, and spurred one country to develop and use BW. The first effort was the 1922 Treaty of Washington, which banned the use in war of “asphyxiating, poisonous or other gases, and all analogous liquids, materials or devices,” but which never came into effect due to French objections. The United States, meanwhile, signed but never ratified the agreement, arguing that it was abiding by the provisions but would interpret them as it saw fit (Guillemin, 2005, p. 4).

Other states continued the push for an international agreement to ban the use of BW. These efforts succeeded with a push by Poland to add BW to the 1925 Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or other Gases, and of Bacteriological Methods of Warfare, generally referred to as the Geneva Protocol. There were, however, two significant shortcomings to the agreement: It only prohibited use and not possession of BW or research materials, and it included no mechanism for verification or enforcement (Klotz & Sylvester, 2009, p. 46).

Imperfect information and fear of disadvantage drove the BW arms race of the interwar years, just as it drives conventional and nuclear arms races. France feared German BW production and established its own program, which in turn drove BW research even by allies such as the United Kingdom. The Soviet Union began a BW program in the 1920s and this spurred Germany to begin its own research, which in turn became a major source of concern for the Allies and prompted the development of a large, shared BW infrastructure by the United Kingdom, Canada, and the United States. However, on the orders of Adolf Hitler, the BW program operated only for a time during the middle of World War II, focused largely on defensive measures, and was not to be used even for retaliation against a biological attack (Geissler, cited in Geissler & van Courtland Moon, 1999, pp. 91–99; Smithson, 2011, pp. 14–15).

However, Japan, deciding that BW must be potent weapons or other powers would not bother banning them, not only invested in production for strategic advantage but tested and used BW extensively against civilian populations in China in the 1930s and to a limited degree against Allied forces during World War II (Harris, cited in Geissler & van Courtland Moon, 1999, p. 131; Klotz & Sylvester, 2009, p. 47).

With limited and underreported use of BW during World War II, nuclear arms were the only unconventional WMD of major strategic concern during the postwar era. In fact, as states developed nuclear programs during the Cold War, they tended to abandon their BW programs (Guillemin, 2005, p. 11; Koblentz, 2009, pp. 17–18). By the end of the 1960s, the United States believed its BW arsenal to be redundant to its strategic nuclear arsenal. Facing international criticism for its use of chemical agents in Vietnam, President Richard Nixon announced in 1969 that the United States would cease to possess or develop BW, a move that Guillemin (2005, p. 129) describes as an unprecedented unilateral abandonment of a class of weapons. Nixon subsequently proposed expanding on the Geneva Protocol's ban on use of BW to an international treaty that would ban them entirely. The Soviet Union, after initial objections, agreed to support the effort in 1972, after which the BWC soon entered into force and has since been signed by nearly every country in the world (Guillemin, 2005, pp. 12–13, 127).

Still, the BWC is constrained by issues like those that hobbled the Geneva Protocol. It, too, has no mandatory provision for verification or compliance. Unlike the Chemical Weapons Convention or the International Atomic Energy Agency, which have formal organizations with international headquarters and hundreds of professionals to manage their regimes, the BWC rests on states requesting voluntary facility inspections. Second, whereas research on BW is prohibited, research on defense against BW is permissible. In practice, this means that states are free to continue to experiment with refining select agents and dispersal systems in the name of biodefense against potential attacks by enemies. The sponsoring superpowers that were the depository states for the BWC treaty did not pause their programs. In 1975, an

intelligence reform hearing revealed that the Central Intelligence Agency had retained stocks of bacteria, viruses, and toxins, which may have prompted Soviet distrust of the United States (Guillemin, 2005, pp. 125–127, 130).

However, the Soviets required little prompting to create a new, coordinated BW program, Biopreparat, while they began to promote the BWC. Under military urging, the Soviet Union had decided in 1971–1972, shortly before endorsing the BWC, that Biopreparat would employ newly developed techniques in genetic engineering to produce next-generation bioweapons on a greater scale than any other BW program of the 20th century (Leitenberg & Zilinskas, 2012, p. 59). Indeed, internal directives argued that some of the toxins and bioregulator influencers produced in bacteria by genetic engineering would be more acceptable because the BWC did not prohibit compounds that the human body produces. The United States and United Kingdom were apparently aware of Biopreparat work but ignored it in arms talks in favor of securing agreement on nuclear weapons reduction (Alibek, 1999, pp. 152–155).

Although Russia cooperated with the United States in the 1990s on WMD threat reduction programs, BW research and development have not been part of the various efforts to “reset” nuclear weapons agreements between Russia and the United States in the 21st century. President Vladimir Putin joined The Global Partnership in 2002, a post 9/11 multilateral forum to address catastrophic terrorism and WMD, but Russia opposed inclusion of biosecurity matters in its deliberations. Since then, Russia has regularly made allegations, often substantiated, that the United States is in violation of the BWC as justification for abrogating the agreement itself (Zilinskas & Mauger, 2018, pp. 273–274, 331).

Similarly, the use of chemical weapons during the Iran–Iraq War led to the creation in 1985 of the multilateral Australia Group dual-use technology transfer regime. What would eventually grow to a bloc of more than 40 states collaborated to harmonize export control licensing measures for biological and chemical select agents and send experts on verification inspections. Australia group inspections prevented Iraq from acquiring bulk fermenters, used since the 1950s to produce large quantities of slurry to grow anthrax spores and other pathogens, but Iraq’s efforts to pursue BW and other WMD continued (Klotz & Sylvester, 2009, pp. 501–502).

It is evident that a century of international arms control efforts had limited success in constraining proliferation of BW. However, fewer than 20 countries are known to have had BW programs despite the ease of obtaining samples and low costs of producing rudimentary arsenals. Although fear of retaliation and escalation, as well as norms against weaponizing disease, constrained the use of BW during World War II (Malet, 2016, pp. 20–27), the major powers of the 20th century all made some effort to develop BW programs. But only two stand out for the significance of their investment in BW (Imperial Japan and the Soviet Union), and only one verifiably used BW in war. For a sense of the scale of these programs, at its height the U.S. BW production program had “several hundred” staff. By contrast, the Japanese wartime program had 6,000 workers, and the Soviet Cold War-era program reportedly employed over 50,000 (Klotz & Sylvester, 2009, p. 107). These programs therefore deserve special attention for lessons on the pursuit and use of BW by states.

Japan

Japanese military strategists were convinced by international arms control efforts that BW must be effective or they would not be banned. The Kempeitai Political Department and Epidemic Prevention Research Laboratory, commonly referred to as Unit 731, was formed in 1932 under the command of General Shiro Ishii and began experimentation on prisoners and civilians in occupied China, particularly through contaminated food, causing major outbreaks of plague, typhus, and cholera in Harbin and Nanjing that Japan reported as natural outbreaks (Guillemin, 2005, pp. vii, 84; Preston, 2009, p. 278). Soviet estimates, based on captured research data, were that 3,000–10,000 Chinese civilians were killed by BW in prison camps and laboratories, with the total fatality rate across occupied China being perhaps a higher order of magnitude. When the war began, Unit 731 reportedly conducted BW tests on American, British, and Russian prisoners of war as well (Alibek, 1999, pp. 43, 48).

Japan's efforts to use BW on the battlefield appear to have been far less effective. In August 1939, the Soviet army routed Japan on the Mongolian–Manchurian border. The Japanese army left a suicide detachment behind to infect the local water supply with pathogens, but there are no reports that this was effective. In 1942, efforts to use aerosol weapons against the Red Army failed with a shift in the wind and resulted in the deaths of approximately 1,000 Japanese soldiers from unspecified disease, leading the military to dismiss Ishii from command (Guillemin, 2005, pp. 84–85). Perhaps because of this disruption, military calls to use BW against advancing American forces in the Pacific were not heeded even when it meant the fall of the empire. Japanese test data was ultimately captured by both superpowers at the end of the war, leading to knowledge transfers. Both superpowers would employ Unit 731 research and some of its scientists to build their BW programs in the early years of the Cold War (Guillemin, 2005, pp. 76–79).

Russia

Although Japan used BW against civilian and military targets far more than any other state, the Soviet Union would ultimately develop what was by far the largest BW program, and its successor continues to operate in Russia in the present era. Although the Soviet Union signed the Geneva Protocol, in 1928 the Revolutionary Military Council began work on typhus weapons, placed under the control of GRU military intelligence, which yielded a 40% fatality rate in those infected. By the mid-1930s, it was able to deliver the bacteria that produce typhus in both powder and aerosol form and it began working with Q fever, glanders, and other select agents. Some former Soviet BW personnel have attributed a suspicious outbreak of Q fever among German troops at Stalingrad in 1943 to the work of their predecessors (Alibek, 1999, pp. 33–36). Other contested reports claim that the Red Army used fungal mycotoxins against the mujahidin in 1980s Afghanistan (Katz, in Clunan et al., 2008, pp. 97–119, 72–115; Meselson & Robinson, in Clunan et al., 2008, pp. 72–96).

Ultimately, the Soviet program worked with at least 12 different pathogens as BW. Researchers have identified many BW programs where the projects are known only by codenames, so it is possible that the number of select agents is greater. Although it was

controlled by the ministry of defense, which operated three major research and development institutes and one open-air test site, Soviet BW development was disbursed across a number of facilities (Zilinskas & Mauger, 2018, pp. 8, 19–20).

To avoid the potential discovery and capture of its research by Germany, in 1941, the Soviet Union established its primary BW development facility far from the front lines in Central Asia, on Vozrozhdeniya (Rebirth) Island in the Aral Sea between Kazakhstan and Uzbekistan (due to the draining of the Aral Sea, the facility is no longer an island). The Soviet BW program was modeled on Japan's, although it far eclipsed it in scale. When the Red Army overran Manchuria, it captured the files of Unit 731 and followed the designs of the more-advanced Japanese program in building its own postwar production facilities (Alibek, 1999, pp. 36–37).

Based on available records, most Soviet and Russian biological research facilities, before and after the era of Biopreparat, were also subsequently located in Central Asia and Siberia. Outbreaks of plague, variola, smallpox, and other nonendemic diseases occurred in the region, indicating insufficient safety precautions (Guillemin, 2005, pp. 141–143; Zilinskas & Mauger, 2018, pp. 9, 14). Other biological facilities around the Soviet Union suffered similar mishaps, with the best-documented case occurring in 1979 in the city of Sverdlovsk, with the accidental release of anthrax. As with the Chernobyl nuclear accident several years later, Soviet authorities initially denied the outbreak of the disease that ultimately killed about 100 citizens, blaming it on tainted meat (Zilinskas & Mauger, 2018, p. 12).

The Soviet Union began developing its offensive capability to deliver its BW agents in the 1920s, with "scientists attached crop sprayers to low-flying planes. . . . After World War II, bombers armed with explosives were added to the arsenal." It conducted missile payload tests over the Pacific beginning in the 1960s. By the 1970s, BW payloads were on Soviet ICBMs, and by the late 1980s the Soviet BW program aimed to produce enough select agents to load the multiple warheads of MIRVs as well. The fact that it had already "stockpiled hundreds of tons of anthrax and dozens of tons of plague and smallpox" and more was required is indicative of the scale of the program (Alibek, 1999, pp. x, 5–6, 43).

Although the Soviet Union signed the BWC in 1972, within a year it had embarked on an ambitious program to create novel BW using the newly available biotechnology of genetic engineering. From that point forward, most of the advanced research conducted by Biopreparat focused on exotic pathogens like Ebola, using genetic engineering to combine toxins and pathogens, and making familiar diseases more difficult to identify and treat. Some of this research on toxins was obtained or stolen by the KGB and employed in assassinations during the remaining years of the Soviet Union. It continues to be used against targets of the Russian state (Zilinskas & Mauger, 2018, pp. 9, 17, 154–155).

In the latter years of the Soviet Union, reformist president Mikhail Gorbachev ordered BW research terminated, but this directive was opposed and ignored by the ministry of defense. After the fall of Communism, Russian Federation President Boris Yeltsin also ordered BW programs cut and slashed funding to them, but the programs were only scaled back. By 2000, the FSB domestic security services had requested $1 billion for "nontraditional" means of fighting terrorism, including biological agents. With the advent of the Putin regime, work continues at a multiplicity of facilities on novel BW to match the perceived capabilities of competitors like the United States (Alibek, 1999, p. x; Zilinskas & Mauger, 2018, pp. 11, 18, 19, 144–145).

Other Great Power BW Programs

There was no meaningful competition in BW development. Essentially the same states that explored or pursued nuclear programs during the 20th century also examined the prospects of biological pathogen arsenals. The largest programs, however, were legacies of interwar BW research.

The United Kingdom began BW research in 1936 with the establishment of a Ministry of Defense Subcommittee on Bacteriological Warfare. In 1940, it established the Biology Department at Porton Down to develop and test BW. In 1941, it incorporated the United States and Canada into the program to ensure interoperability. Although Prime Minister Winston Churchill stated that he would be willing to use BW against Germany and ordered the production of 500,000 anthrax-bearing cluster bombs, and five million linseed cakes laced with anthrax spores to feed German animals, these were never deployed. During World War II, most BW production relocated to Canada for the same reason that the Soviets pushed theirs to Asia, to prevent discovery and capture by German agents. British offense-based BW research would continue until 1959, while ostensibly defensive research continues to the present day at Porton Down under the Defense Evaluation and Research Agency (Guillemin, 2005, pp. 12, 44–55, 66, 113).

The United States joined the Allied BW development effort months before it formally entered the war, but both its political and military wartime leadership firmly opposed the use of BW on normative grounds as well as the fear that their use would invite a reciprocal response (Malet, 2016, p. 145). At the end of the war, data obtained from Unit 731 persuaded American military planners that only anthrax and plague-infected fleas had been effective. Nonetheless, the fear that the Soviets might have an effective BW capability led to an expansion in BW research and production. Upon learning that the Soviet stockpile was estimated to be 75% larger than the American one, President Dwight Eisenhower approved increasing production of incapacitating BW. President John Kennedy supported this expansion, believing that chemical and biological arms were useful tools for his policy of “flexible response” to the Soviet nuclear threat (Guillemin, 2005, pp. 59–60, 86, 113–114). The United States therefore expanded its wartime program and continued production until 1969. It built an industrial infrastructure for research and production to grow sufficient cultures to fill munitions with potentially lethal incapacitants including anthrax, botulinum toxin, tularemia, brucella, equine encephalitis, and staph. It is also known to have conducted research on smallpox and plague (Kortepeter & Parker, 1999, p. 524). Ostensibly defensive research continued past the BWC and into the 21st century on making pathogens including anthrax and Ebola more deadly (Ben Ouagrham-Gormley, 2014, p. 58).

Still, for all its production, the United States never developed a strategic doctrine on the use of BW and never developed delivery systems for the select agents it was producing. During the Berlin Blockade confrontation, the Air Force developed a BW plan for general war, which it maintained through the duration of the Korean War. Under a 1952 directive, all Strategic Air Command units were to have become BW operational within two years, but the directive was never carried out (Ben Ouagrham-Gormley, 2014, pp. 64, 82, 86). The same held true for defense. Although the United States promoted nuclear civil defense measures during the Cold War, it did not attempt to similarly prepare the public for a biological attack (Leitenberg & Zilinskas, 2012, p. 2).

Despite this, other countries that did not have BW programs at the time of World War II did seek to develop them. At least nine countries had documented agricultural bioweapons programs during some part of the 20th century (Canada, France, Germany, Iraq, Japan, South Africa, the United Kingdom, the United States, and the former Soviet Union). Four other countries—Egypt, North Korea, Rhodesia, and Syria—are believed to have or have had agricultural bioweapons programs as well (Congressional Research Service, 2007, p. 11).

Additionally, “the United States believes that China had an offensive BW program prior to 1984 when it became a Party to the BWC, and maintained an offensive BW program throughout most of the 1980s. The offensive BW program included the development, production, stockpiling or other acquisition or maintenance of BW agents” (United States Arms Control and Disarmament Agency, 1998). Guillemin (2005, pp. 151–152) also reported that Israel established a research program shortly after its independence.

“Rogue States”

With the end of the Cold War, the primary concern about BW by the international community became their proliferation to states that were prone to violating conventions and norms against development and use of WMD or that provided support to nonstate terrorist groups and could potentially disseminate illicit materials. Ben Ouagrham-Gormley (2014, p. 59) notes that foreign assistance with BW programs has been common historically, and both superpowers received assistance from other countries in developing theirs, so the concern was not unfounded.

As noted, Iraqi efforts to obtain WMD caused the formation of the Australia Group regime, and increasing focus turned to Iraq because of its refusal to clearly adhere to international sanctions and counterproliferation efforts in the wake of the 1991 Gulf War. Western-educated Iraqi scientists started the Iraqi BW program in 1984 and began production of armaments in 1988, using the same pathogens as those in great power programs and adding other pathogens including camel pox (Guillemin, 2005, pp. 153–154). After Iraq invaded Kuwait in 1990, President Saddam Hussein had bragged to other Middle Eastern leaders that he had BW agents that would stop the United States, and the American assessment was that he had no fear of any consequences for using them (Smithson, 2011, p. 16). Still, while Iraq fired tactical ballistic SCUD missiles at Israeli civilians and international coalition troops during the 1991 war, none of these were loaded with BW and the operation to dislodge Iraqi forces from Kuwait went far more easily than expected.

The United Nations Special Commission (UNSCOM) established after the Gulf War to end Iraqi WMD programs identified the Iraqi BW program, and although Iraq reported destroying its specimens in 1995, it subsequently acknowledged that it had already filled SCUD missiles with anthrax, botulinum, and aflatotoxin (Kortepeter & Parker, 1999, p. 523). Indeed, Hussein handed over his least modern stockpiles to inspectors and hid his best specimens (Smithson, 2011, p. 28). He ultimately ended his WMD programs after 1998 but continued to bluff that he possessed weapons to deter invasion. This strategy backfired in 2003 when an international coalition invaded Iraq because of its WMD threat. In this regard, the Iraqi BW program yielded even worse results than the interwar BW programs that provoked rival arms races.

Reports indicate that North Korea maintains dozens of BW production facilities as part of an arsenal that could be used in a deadly surprise attack or that could potentially be sold to terrorists (Cooper, 2009). Additionally, as several developing countries across the Global South open their own biological research facilities testing deadly pathogens, the potential for proliferation, theft, or leakage continues to rise (Vogel, 2012, p. 245).

In addition to Iraq, Imperial Japan, and the Soviet Union, one other state maintained an offensive BW development program until the end of its regime: apartheid-era South Africa. The White supremacist government declared in 1981 that it faced an existential threat from neighboring states where White colonial rule had recently been overthrown or where Communist insurgents were fighting against them. The Defense Department established Project Coast, a research program conducted by various universities and private companies, to work on deadly pathogens, hallucinogens, and sedatives that could be used to target domestic political enemies without signs of violence, and also genetic weapons that would only kill or sterilize Black Africans (Guillemin, 2005, pp. 11, 155–156). Like Biopreparat, Project Coast posed as a civilian drug company. Its research was ostensibly defensive in keeping with the BWC, and the regime told scientists that their work was being used against insurgents or to address overpopulation. Its director, Wouter Basson, maintained contact with White supremacist militias in the United States, and he was known to have consulted with Libya and Iran. Because of the fear of proliferation, the United States arranged for the post-apartheid government of Nelson Mandela to return Basson to its payroll to keep him employed (Klotz & Sylvester, 2009, pp. 51–55).

The United States made more strenuous efforts to keep post-Soviet WMD researchers from selling their expertise, and possibly samples of “loose nukes” or “loose bugs” to rogue states, terrorists, or organized crime. As part of its Defense Threat Reduction Initiative, more than $600 million went to fund commercial research to employ former Soviet bioweaponeers alone (Vogel, 2012, p. 107). One of them, Ken Alibek (1999, pp. 272–276), reported that several of his colleagues had gone to work for rogue states while he had been approached for his services by several other governments. Still other former Biopreparat employees were publishing advertisements as private research laboratories advertising their services and samples of pathogens and genetic material to the highest bidder.

Biodefense and Securitization

The degree of threat is probably the main point of division in the literature on BW. On the one hand, researchers point to the diffusion of technology and knowledge to private laboratories, and to private nonstate actors who can purchase samples and genetic sequencing equipment online, and who point to the dual-use dilemma of restricting access to material, much less to scientific knowledge. On the other hand, some researchers point to the specialized expertise required in BW production to explain why the absence of a robust military research and development infrastructure make the endeavor nearly impossible for other parties. With respect to state BW programs, the leakage of state-sponsored BW research by decentralized facilities is perhaps perceived as a greater threat than state military use of BW in the 21st century.

Biodefense, against state and nonstate BW threats, has been a pervasive but underexamined feature of international security efforts since the Cold War. In the decade after 2001, the United States spent $62 billion on biodefense, with an expected six or seven billion dollars continuing annually for the foreseeable future. The Department of State, in shifting to a global rather than post-Soviet paradigm after 9/11, has viewed individual lone scientists as potential proliferators and security threats. It has funded biosecurity programs in over a dozen countries, representing nearly half of its anti-threat reduction budget (Vogel, 2012, pp. 4, 109, 125).

Aside from potential foreign sources of BW proliferation, the United States has ample reason to view leakage from domestic military BW researchers as national security threats. In 2001, a domestic actor sent envelopes laced with refined anthrax spores (nicknamed “Amerithrax” in the FBI investigation) through the postal system to targets including two senators and the Department of State, resulting in five deaths, dozens of illnesses, and millions of dollars in decontamination costs. After several years of investigations, newly available genetic sequencing technology tied the samples used to Dr. Bruce Ivins, the lead anthrax defense researcher for the U.S. Army. Ivins committed suicide before his court arraignment, but, like his foreign counterparts, he was reportedly worried about whether his work would continue to be financed. He also had a history of severe psychological disturbance (Malet, 2016, pp. 112–121).

Additional research on the difficulties of BW production point to the likelihood that Ivins, or someone with his level of expertise, would be needed for such an attack. Ben Ouagrham-Gormley argues that biological weapons proliferation threats differ from nuclear weapons because the challenge to proliferators is not obtaining the materials but using them effectively. Bioweaponeering requires tacit knowledge gained from transmitted experience in a BW establishment that does not produce manuals on proper techniques. For example, only experience would teach researchers about how seasonal variation would cause nonreplicable variance in their virus samples. Additionally, research teams are highly dependent on the organizational culture of the broader institutions in which they operate. For example, no one at Biopreparat knew how to implement Moscow’s goals, but admitting this would mean a loss of resources. Open discussion of challenges, and the potential discovery of solutions, was similarly impeded (Ben Ouagrham-Gormley, 2014, pp. 3, 21, 37, 56–57). It is not clear that even if bioweaponeers went to work for a proliferation state, their specialized knowledge would be applicable or effective in their new workplace (Vogel, 2012, pp. 8–12, 63, 107).

Similar challenges can impede state biodefense programs. The United States put its Department of Health and Human Services in charge of biodefense rather than the Department of Defense, and the military, viewing biological agents as a health issue rather than a more conventional kinetic weapon, was happy to cede authority to health and emergency management agencies. At the same time, the federal Centers for Disease Control and Prevention (CDC) was inclined to only view outbreaks as human health issues and ignore security components, leading it to initially misidentify a domestic bioterrorist attack in 1984 (Smith, 2011). Subsequently, when the anthrax mailings became the second recorded successful domestic biological attack in the United States, the CDC lacked expertise on anthrax contaminations because it had never regarded them as a public health threat

(Guillemin, 2005, p. 173). The United States was forced to rely on the human experimentation data it had obtained from Unit 731 to model the outbreak and how to treat it (Malet, 2016, pp. 44, 113).

The dual-use nature of BW and biodefense research points to broader issues in biosecurity. New developments in science, such as commercially available genetic sequencers, mean that state biodefense programs must also focus on the possibility of lone scientists or a state BW program using synthetic genomes to recreate lethal pathogens such as smallpox or the especially virulent strain of plague, the Black Death (Edwards, 2019, p. 75; Vogel, 2012, p. 71).

Political and military leaders may also securitize biological threats for purposes of rallying support or passing policies. This may include expanding the definition of what constitutes a biosecurity threat. One example would be including deliberate disease transmission without traditional BW as a biosecurity issue, such as Zimbabwean soldiers deliberately spreading HIV in the Democratic Republic of Congo by using rape as a weapon of war (Enemark, 2007, pp. 5, 14). Biosecuritization may also include establishing a paradigm in which potentially any biotechnological development could be weaponized.

Biotechnology and Novel BW

Still, continuing technological advances mean that states will have to keep track of new forms of BW. Some of these new technologies are more akin to nuclear weapons than to germ warfare in that only the militaries of the richest, most advanced states with investments in research infrastructure will have access to these novel technologies that could change the nature of warfare. The great powers of the 21st century have already invested in novel biotechnologies and new generation BW based on genetic manipulation.

Rather than the historically prevalent biological weapons, new technologies and competition in the future are likely to center on “weaponized biology” that confers conventional power projection advantages that pathogen stocks never did. These include the application of synthetic biology, genetic engineering, and biomimetic technologies to increase war-fighting abilities of combat forces through physical and neurological enhancement of both warfighters and material. Examples that have already been trialed include cognitive and reflex enhancement for warfighters and drone pilots, materials engineered to mimic the processes of living organisms, such as the orb-weaving spider silk incorporated into bulletproof vests and gecko pad paddles that enable soldiers to scale glass walls, and the use of naturally occurring pheromones dispersed to make targets more compliant. None of these technologies are necessarily banned by the BWC, but all carry the strategic advantages and ethical dilemmas that advanced military powers face with all asymmetric technologies (Malet, 2016, pp. 50, 81–82, 93–94).

The biotechnology revolution began in 1973 with first successful recombinant gene engineering, in which resistance to penicillin was conferred upon a specimen of E. coli (Koblentz, 2009, p. 18). As noted, the Soviet Union moved immediately to use the technology to make its BW stocks deadlier and less treatable. Bioweaponeers also moved to exploit the use of genetic manipulation to affect human bioregulators, a type of biological warfare “not considered at the time of the BWC” (Gerstein, 2009, p. 41). Unlike traditional BW,

bioregulatory agents could have immediate effects (Preston, 2009, p. 245). Synthetic viruses could also be used to deliver other “direct effect weapons” that rewrite the human body’s genetic decoding of proteins. Proteomic weapons could cause rapid organ failure. Some Chinese military researchers have argued that victims could be treated and would even be grateful for this “more civilized” form of warfare—similar to the arguments made by proponents of BW a century earlier (Malet, 2016, pp. 91–92). The BWC makes no exception for nonlethal weapons (Zilinskas & Mauger, 2018, p. 67). But in the 21st century, security forces around the world use banned armaments that cause superfluous injuries like blinding, such as pepper sprays, against their own citizens in domestic disturbances (Lewer, 2002, pp. 1–3).

Another key area of research in the life sciences is one that would transform military personnel into BW, in some cases irrevocably. The field of human enhancement is being studied by the military research establishments of the great powers of the 21st century. In the United States, the Pentagon’s Defense Advanced Research Projects Agency (DARPA) funds “high risk, high payoff” research and development with military applications that is conducted by external researchers at corporations and universities. DARPA’s previous investments include the Internet and virtual reality, and it regularly issues press releases about novel technologies with military applications, including human enhancement. Its budget is not particularly large, but it fosters an open research culture praised by scientists; the opposite of the constraints faced by Soviet researchers in Biopreparat (Malet, 2016, p. 69; Moreno, 2006, pp. 13–14).

DARPA-funded projects include scanning and recording images from human brains (Moreno, 2006, p. 97), enhanced rates of cognition for warfighters, minimizing the effect of sleep loss, and controlling drones more quickly through neural prostheses (Huang & Kosal, 2008), and human strength and endurance programs with names such as “Metabolic Dominance” (Singer, 2010). Human enhancement experiments, although conducted with subject approval, may not be conducted under the medical ethics guidelines of benefit to the subject. They also raise significant questions about whether enhanced troops could be considered weapons and subject to regulation under the Geneva Protocol or the BWC. It also remains to be seen how they would affect cohesion with unenhanced troops with whom they serve (Lin et al., 2013, pp. 8–9, 17, 39).

Some of these technologies, including performance-enhancing drugs, advanced anticoagulants, and cybernetically controlled animals used for reconnaissance, have already been deployed, making these questions more than theoretical (Malet, 2016, p. ix). However, they continue apace in decentralized form with most research conducted by nonstate actors. Ashton Carter argued that the scope of bleeding-edge technological proficiency necessary to maintain a competitive advantage requires that the military engage with multiple private-sector partners and university laboratories. Carter did not realize his suggestion for a BW “university-affiliated government-owned laboratory” akin to those that research nuclear energy while he served as Secretary of Defense, but the decentralized public–private research arrangements coordinated by DARPA realize his vision in part (Carter, 2001, pp. 17, 157–158).

Chinese works on novel military biotechnology (e.g., Jiwei, 2010; Shibo, 2017) are among analyses of how emergent technologies such as CRISPR gene editing can be used to enhance combat troops (Kania & Vorndick, 2019). Other works by military-affiliated Chinese researchers have extolled the potential of “direct-effect” proteomic and genetic weapons to

disable organ functions in targeted populations and for “bloodless” victories and “merciful conquest.” These appeals to nonlethal modes of warfare as being more humane and therefore less likely to upset international norms of Just War echo claims made by Western states as they developed early biological and chemical weapons in the 19th and 20th centuries (Malet, 2016, pp. 92, 149).

In Russia, Biopreparat ended with the Soviet Union, but its BW research establishment continued despite a decade of effort to roll it back by Moscow and longer by the United States. Russia’s difficulty marshalling high-tech warfare in Georgia in 2008 led President Putin to call in election statements that year and in 2012 for a push to establish “new-generation weapons” including genetic weapons. Defense officials echoed his call, with some arguing BW would have the greatest impact of any new types of arms. Russian military planners anticipate adversaries to possess novel BW and launched biodefense programs to research genomics and proteomics. The modern Russian effort resembles both its Soviet predecessor in that state-owned companies involved in biodefense are ostensibly developing commercial products such as probiotics, but their funding comes from military institutes. It also resembles its American counterpart with contractors conducting work on behalf of an “analogue of DARPA” called the Advanced Research Foundation, whose mission is “to coordinate and provide beginning-to-end funding for high-risk innovative research projects with military applications.” Its subsidiary, the National Center for Technology Development and the Basic Elements of Robotics has promoted projects such as “Soldier of the Future” that include research on cognitive enhancement (Zilinskas & Mauger, 2018, pp. 1, 35–38, 54, 71–73, 95, 100, 127–128).

Based on the history of military BW programs, there is little incentive for states to reveal advances in BW because the arsenals lack the deterrent capability of nuclear arms, due to uncertainties about their effectiveness and because the effects are not immediate. Similarly, R&D loopholes in the BWC and the dual-use nature of biotechnology and its commercial applications also provide states with reasons not to develop the type of transparency-based regime governing nuclear energy. The proliferation of easily used gene-editing technologies, including splicing using CRISPR and interchangeable LEGO-like packets of Bio-Bricks, compounds potential security threats by increasing the potential number of BW states attempting to engineer pathogens or augment their conventional forces (Malet, 2016, pp. 51–52, 168–169).

Conclusion

The BW of the 21st century have the potential for a far greater impact than the previous generation of weapons created for World War I and World War II and the Cold War of the 20th century. Great powers of the international system advanced research in bacteriological weapons primarily because they were afraid of falling behind rivals and not because they had identified strategic doctrines for employing them. Much of the arms race in BW that resulted is directly attributable to imperfect information.

Except for Imperial Japan, no state with BW is known to have used them on the battlefield. Leaders were constrained by norms and deterred by the fear of reciprocal attacks, but even Japan found the weapons, like chemical weapons before them, to be as unreliable as a shift in

the wind. Despite the difficulty of containing and controlling select agents, the only state with a BW program known to have experienced significant leakage of deadly material was the Soviet Union, which suffered from multiple such incidents. In the United States, however, a leading biodefense researcher apparently used his select agents in a domestic terror attack.

With the use of BW having been fortunately limited, most research focuses on empirical characteristics of select agents, and to a lesser extent on the organizational culture of the BW programs that produce them. The biggest debates in the literature are over whether BW are susceptible to proliferation based on the technical feasibility of production. But the shift to new-generation novel bioweapons and increased interest in international biosecurity in the wake of the COVID-19 pandemic, raise the potential for new levels of interest and avenues of scholarship on state pursuit of BW.

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