

Threat Assessment of Chemical and Biological Warfare

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Executive summary: The weaponization of chemicals and biological agents have higher mortality rates and demoralizing effects than conventional weapons, and thus considered weapons of mass destruction (WMD). Since World War I, the use of chemical warfare has dominated the international stage. Multiple countries have conducted extensive biological R&D and acquired an advanced capability, however aside from toxins, there has been less actual deployment of biological weapons. Nevertheless, recent advances in biotechnology allow for more advanced weaponization of biological agents. After the proliferation and use of these unconventional weapons globally, the international community started to acknowledge the inhumane and demoralizing effects of them and as a result, security apparatuses to prevent proliferation and prohibit the use of them through international agreements, conventions and organizations. History shows that countries have violated international agreements. Countries with an extensive chemical and biological infrastructure, are considered potential actors to weaponize these materials, as many equipment, supplies, and facilities care considered dual-use in which they can be used for both peaceful and military purposes. Additionally, major difficulties arise in the verifying the use of these weapons and attributing blame as confirmation of allegations often takes time. Nevertheless, it is important to monitor countries who are likely to have capability and intentions to use these weapons such as Russia, Syria, North Korea, China and Iran.

Introduction

The current threat of chemical and biological warfare can be examined by first assessing countries that have or are seeking a chemical and biological weapons capability. Among the countries who have the capability, assessing the intention of countries and willingness to use these weapons in relation to their strategic objectives will help elucidate this particular threat. Additionally, the status and advancements of the biotechnology industry and each countries' infrastructure, the existing defense measures against current chemical and biological agents, and the effectiveness of the Conventions and the Australia Group (AG) also contribute to the assessment of this threat.

Biological warfare agents are deliberately released microorganisms or microorganism-based toxins, that cause diseases in humans, animals or plants⁴⁴⁰. A majority of biological agents that are used in warfare cause similar or indistinguishable conditions/symptoms from those of naturally occurring diseases, contributing to the difficulty of identifying a biological attack. The Center for Disease Control and Prevention (CDC) has separated biological agents into three categories based on its ease of dissemination and its mortality rate⁴⁴¹. Despite the plethora of naturally occurring bacteria, viruses and toxins, only a small number of these are effective as weapons in a military context. The utility of an agent is based on the ease of production, stability of the agent in storage and in weapon devices, and the infectivity or toxicity⁴⁴².

Chemical warfare agents are man-made, chemical substances that are deliberately used in order to cause major harm, incapacitate, or kill by

⁴⁴⁰ Duraipandian Thavaselvam and Rajagopalan Vijayaraghavan. "Biological Warfare Agents". *J Pharm Bioallied Sci*, Jul-Sep 2010: 179–188. doi: 10.4103/0975-7406.68499.

⁴⁴¹ "Preparedness Home: Biological Weapons", John Hopkins Bloomberg School of Public Health, accessed August 6, 2020, https://www.jhsph.edu/research/centers-and-institutes/johns-hopkins-center-for-public-health-preparedness/tips/topics/Biologic_Weapons/BioWeapons.html.

⁴⁴² Frederick R. Sidell, Ernest T. Takafuji, and David R. Franz. *Medical Aspects of Chemical and Biological Warfare*. Office of the Surgeon General, Department of the Army, United States of America, 1997. <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.470.8260&rep=rep1&type=pdf#page=24>.

its physiological effects⁴⁴³. Toxic substances have been characterized as chemical warfare agents based on characteristics such as high potency, high toxicity, and persistency⁴⁴⁴. Whether an agent is persistent or non-persistent is directly related to the volatility of the agent, in that agents with high volatility evaporate and disperse more rapidly⁴⁴⁵. The main categories of chemical agents are nerve agents, vesicants, choking agents, blood agents, and riot-control agents (incapacitants)^{446, 447}. Nerve agents affect the functionality of the human nervous system by inhibiting the enzyme acetylcholinesterase (AChE). Vesicants are agents that produce blisters (vesicles) on the skin in addition to potential effects on the upper respiratory tract and the eyes⁴⁴⁸. Blood agents disrupt the typical processes of our body tissues' oxygen consumption and inhibit particular enzymes⁴⁴⁹. Choking agents primarily cause damage to the respiratory tract, particularly the lungs, and asphyxiation⁴⁵⁰. Riot control agents cause incapacitation by irritating the eyes and upper respiratory tract but they do not have permanent effects⁴⁵¹. Chemical warfare agents are also found in the civilian sector as these chemicals are used industrially and manufactured for other peaceful purposes, and thus giving an opportunity for countries to effectively conceal harmful intent.

⁴⁴³ The Deputy Assistant to the Secretary of Defense for Chemical and Biological Defense. Chemical and Biological Defense Primer, Department of Defense, October 2001. Accessed August 6, 2020. <https://www.hsdl.org/?view&did=1504>.

⁴⁴⁴ K Ganesan, S.K. Raza, and R. Vijayaraghavan. "Chemical Warfare Agents". *J Pharm Bioallied Sci*, Jul-Sep 2010: 166–178. doi: 10.4103/0975-7406.68498.

⁴⁴⁵ Ganesan, Raza, Vijayaraghavan, "Chemical Warfare Agents".

⁴⁴⁶ Ibid.

⁴⁴⁷ Frederick R. Sidell, Ernest T. Takafuji, and David R. Franz. *Medical Aspects of Chemical and Biological Warfare*, 1997.

⁴⁴⁸ Ibid.

⁴⁴⁹ Ganesan, Raza, Vijayaraghavan, "Chemical Warfare Agents".

⁴⁵⁰ Ibid.

⁴⁵¹ Ibid.

History of Biological and Chemical Weapons

Although toxic chemical substances and bacteria/viruses have been weaponized for a long time, chemical and biological warfare between countries during World War I was a catalyst for the modern development and knowledge of these weapons. Table 1 expresses the presence of chemical or biological warfare in major international conflict. This table does not cover all conflicts or other isolated instances of chemical/biological weapon use. Throughout the assessment of chemical and biological warfare attacks, it can be difficult to confirm whether the malign effects were due to a natural or a deliberate source. Therefore, the term ‘alleged’ expresses that there is not absolute certainty that it was a chemical or biological weapon but there is either substantial or sufficient evidence to believe so.

Table 1. Chemical and Biological Weapon Presence in Major International Conflict

Conflict	Description	Aggressor: Agent	Impact of Agent	Validity (Alleged or Confirmed)
World War I ⁴⁵²	After the assassination of Archduke Franz Ferdinand, Austria declared war on Serbia. Due to alliances, Austria-Hungary, Germany and Italy (the Triple Alliance) opposed Great Britain, France, and Russia (the Triple Entente)	<ul style="list-style-type: none">• German: chlorine gas, phosgene, diphosgene, chloropicrin• British: chlorine• French: chlorine, hydrogen cyanide, cyanogen chloride, mustard	<ul style="list-style-type: none">• 1 million out of 26 million casualties suffered by all nations were from gas	Confirmed
Italian-Ethiopian War 1935 ⁴⁵³	Benito Mussolini launched invasion of Ethiopia	<ul style="list-style-type: none">• Italy: sulphur mustard bombs and sprayed from airplane tanks	<ul style="list-style-type: none">• Effective due to Ethiopian soldier’s open military uniform• Strategic effect on Italy’s success and demoralizing Ethiopian forces	Confirmed

⁴⁵² Frederick R. Sidell, Ernest T. Takafuji, and David R. Franz. *Medical Aspects of Chemical and Biological Warfare*, 1997.

⁴⁵³ Lina Grip and John Hart. *The use of chemical weapons in the 1935–36 Italo-Ethiopian War*. SIPRI Arms Control and Non-proliferation Programme, October 2009. Accessed August 8, 2020. <https://www.sipri.org/sites/default/files/Italo-Ethiopian-war.pdf>.

Sino-Japanese war 1937 ⁴⁵⁴	During Japan's large-scale invasion of China, the Japanese deployed chemical weapons and used bioagents in experiments on Chinese prisoners of war	<ul style="list-style-type: none"> • Japan: vomiting agents, blistering agents • -Japan: biological agents used in experiments with Unit 731 	<ul style="list-style-type: none"> • Helped achieve military objectives • Japan's Unit 731 experiments are considered a war crime 	Confirmed
Vietnam War ⁴⁵⁵	Conflict between communist North Vietnam and South Vietnam and their allies	US: Agent Orange (tactical herbicide) Vietnam: herbicides	<ul style="list-style-type: none"> • Immediate environmental effects/destroy food supply • Long-term health problems for Vietnamese people and US Veterans 	Confirmed
Egypt intervention in Yemeni civil war 1963 ⁴⁵⁶	Egyptian military support of the revolutionists that overthrew Yemen's monarch, Imam Muhammad al-Badr	Egypt: mustard gas, tear gas (CN), phosgene asphyxiant	<ul style="list-style-type: none"> • Egyptian President Gamal Abdel Nasser's military gas bombings allowed free reign in Yemen 	Confirmed
Iraq-Iran War ⁴⁵⁷	Iraq invaded Iran	Iraq: mixture of mustard gas and nerve agent tabun Iran: cyanide	<ul style="list-style-type: none"> • Significant element for Iraq in achieving tactical battlefield objectives 	Confirmed
Persian Gulf War ⁴⁵⁸	Iraq invasion of Kuwait. Coalition member countries involvement.	No use of unconventional weapons within the war. After the war: Khamsiyah Pit nerve agent release at low levels	Persian Gulf War syndrome – US soldiers who were deployed experienced wide ranging symptoms	Alleged

⁴⁵⁴ Ping Bu, "A research report on Japanese use of chemical weapons during the Second World War". Journal of Modern Chinese History, vol. 2, June 2010: 155–172. <https://doi.org/10.1080/17535650701677239>.

⁴⁵⁵ Greg Goebel, "A History of Chemical & Biological Warfare", Accessed August 11, 2020. https://www.cia.gov/library/abbottabad-compound/65/65A3FAC0A645BA2C3FAC8C187499C16D_the_history_of_chemical_war_fare.pdf.

⁴⁵⁶ Asher Orkaby "Forgotten Gas Attacks in Yemen Haunt Syria Crisis". Accessed August 11, 2020. <https://wcfia.harvard.edu/publications/forgotten-gas-attacks-yemen-haunt-syria-crisis>.

⁴⁵⁷ Javed Ali. "Chemical Weapons and the Iran-Iraq War: A Case Study in Noncompliance" The Nonproliferation Review/Spring, 2001, Accessed August 11, 2020. <https://www.nonproliferation.org/wp-content/uploads/npr/81ali.pdf>.

⁴⁵⁸ Persian Gulf War Illnesses Task Force. "Intelligence Update: Chemical Warfare Agent Issues During the Persian Gulf War". April 2002. Accessed August 11, 2020. <https://www.hsdil.org/?view&did=2796>.

Conflict	Description	Aggressor: Agent	Impact of Agent	Validity (Alleged or Confirmed)
Soviet Union in Afghanistan/Southeast Asia ⁴⁵⁹	Soviet Union provided chemical warfare agents to forces in Laos, Kampuchea, Afghanistan	<ul style="list-style-type: none"> Soviet backed Lao and Vietnamese forces: trichothecene mycotoxins Soviet forces in Afghanistan: lethal and nonlethal agents 	<ul style="list-style-type: none"> Effective way to demoralize and fight the resistance of anti-government forces 	Alleged but Substantive Evidence (Yellow rain controversy)
Syrian Civil War ⁴⁶⁰	President Bashar al-Assad fight against the insurgency, coalition efforts to defeat Islamic State	Syrian government: chlorine, sarin	<ul style="list-style-type: none"> Large number of civilian casualties 	Confirmed

The table shows a tendency for state actors to use chemical weapons rather than biological weapon use in warfare, aside from Soviet-supplemented toxins in Laos and Vietnam. This trend indicates that the development and exploitation of chemical weapons occurred much faster in comparison to biological weapons. Moreover, during the Persian Gulf War, Iraq did not use chemical weapons against opposing forces. However, many Gulf War veterans experienced a myriad of symptoms and conditions that have no source or explanation. Although there is no method to definitively identify the source of these symptoms, the Department of Defense (DoD) has concluded that these veterans might have been exposed to low-levels of nerve agents due to the demolition of chemical agents in Khamisiyah⁴⁶¹.

⁴⁵⁹ Alexander M. Haig. "Chemical Warfare in Southeast Asia and Afghanistan". United States Department of State, 1982. Accessed August 11, 2020. <https://www.cia.gov/library/readingroom/docs/CIA-RDP97M00248R000500010018-6.pdf>.

⁴⁶⁰ Gregory D. Koblentz. "Chemical-weapon use in Syria: atrocities, attribution, and accountability". *The Nonproliferation Review*, vol. 26, February 2020: 575–598. <https://doi.org/10.1080/10736700.2019.1718336>.

⁴⁶¹ U.S. Department of Veterans Affairs. "Chemical and Biological Weapons during Gulf War". Accessed August 12, 2020. <https://www.publichealth.va.gov/exposures/gulfwar/sources/chem-bio-weapons.asp>.

During WWI, Germans attempted to spread diseases such as anthrax, cholera and glanders in animals, but the attempts proved unsuccessful⁴⁶². Around the time of World War II, many countries were arguing over disputed claims of experimentation with biological warfare agents. Many of these allegations deal with Japanese use of biological agents against the Soviet Union and China⁴⁶³. Although not used in combat, during the entirety of WWII, Japan conducted extensive biological warfare experiments in multiple facilities, collectively known as Unit 731, in which thousands of prisoners of war were experimented on with biological agents⁴⁶⁴. Germany also conducted similar experiments on prisoners, but they diverged from Unit 731's great brutality⁴⁶⁵. The Japanese biological weapon research included agents causing plague, typhoid and typhus⁴⁶⁶. Although many allegations of biological weapon use existed during that time, a majority of them lacked sufficient scientific evidence to support it. Allegations involved countries with a biological weapon capability such as Great Britain, U.S., Germany and North Korea⁴⁶⁷.

In 1979, a Soviet Union facility that was openly used for industrial purposes, exploded and accidentally released anthrax, raising suspicion on previous Soviet claims of halting their offensive biological weapons program in the 1960s⁴⁶⁸. By 1989, it was revealed that an extensive biological warfare program, named Biopreparat, had been operating since 1973⁴⁶⁹.

⁴⁶² Frischknecht, Friedrich. "The history of biological warfare". *EMBO Rep*, June 2003: S47–S52. doi: 10.1038/sj.embor.embor849.

⁴⁶³ Frederick R. Sidell, Ernest T. Takafuji, and David R. Franz. *Medical Aspects of Chemical and Biological Warfare*, 1997.

⁴⁶⁴ Howard Brody et al. "U.S. responses to Japanese wartime inhuman experimentation after World War II". *Camb Q Healthc Ethics*, April 2014: 220–230. doi: 10.1017/S0963180113000753.

⁴⁶⁵ Ibid.

⁴⁶⁶ Frederick R. Sidell, Ernest T. Takafuji, and David R. Franz. *Medical Aspects of Chemical and Biological Warfare*, 1997.

⁴⁶⁷ Ibid.

⁴⁶⁸ Sahl, Jason W. et al. "A *Bacillus anthracis* Genome Sequence from the Sverdlovsk 1979 Autopsy Specimens. Accessed August 12, 2020. <https://mbio.asm.org/content/7/5/e01501-16>.

⁴⁶⁹ Hoffman, David E. "Cracking open the Soviet biological weapons system, 1990". The National Security Archive, 2009. Accessed August 12, 2020. <https://nsarchive2.gwu.edu/NSAEBB/NSAEBB315/index.htm>.

Soviet leaders initially attributed the anthrax outbreak to the ingestion of contaminated animal products until admitting its sinister background in 1992. The Soviet Union also provided technology to the Bulgarian state security in 1978 to aid in an assassination attempt of Georgi Markov, with a pellet that contained toxin ricin⁴⁷⁰. Moreover, although Saddam Hussein did not use biological or chemical weapons in the Persian Gulf War, Iraq had an extensive offensive biological warfare capability⁴⁷¹.

Conventions/Treaties and their Effectiveness

The use of chemical and biological weapons instigated international outcry in many instances due to their high communicability, high mortality, and demoralizing impact on troops. Therefore, after repeated major use in international conflict, various methods were implemented to control and monitor the production and use of chemical and biological weapons.

The “Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare”, known as the 1925 Geneva Protocol, was the first major international treaty that prohibits the use of chemical and biological weapons. Due to the large chemical use in World War I, the prohibition was initially addressed only for the use of toxic gases in war but was later extended to the use of “bacteriological methods of warfare”⁴⁷². The progression reflects the increased prominence of chemical warfare over biological warfare in history. Iraq violated the protocol during the Gulf War, and Italy violated it during the Italian-Ethiopian War, suggesting the treaty’s ineffectiveness⁴⁷³.

⁴⁷⁰ Nehring, Christopher. “Umbrella or pen? The murder of Georgi Markov. New facts and old questions”. *Journal of Intelligence History*, February 2016: 47–58. <https://doi.org/10.1080/16161262.2016.1258248>.

⁴⁷¹ Frederick R. Sidell, Ernest T. Takafuji, and David R. Franz. *Medical Aspects of Chemical and Biological Warfare*, 1997.

⁴⁷² Bureau of International Security and Nonproliferation. *Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare (Geneva Protocol)*, June 1925. Accessed August 13, 2020. <https://2009-2017.state.gov/t/isn/4784.htm#treaty>.

⁴⁷³ Frederick R. Sidell, Ernest T. Takafuji, and David R. Franz. *Medical Aspects of Chemical and Biological Warfare*, 1997.

To complement the Geneva Protocol, along with the increased research and development of biological weapons during World War II, the 1972 “Convention on the Prohibition of the Development, Production, and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction”, or the Biological Weapons Convention (BWC), went into effect in March 1975⁴⁷⁴. Parties within the Convention are prohibited from developing any biological agents or toxins in quantities beyond peaceful or civilian uses. The treaty also addresses that members should not aid anyone to produce these agents. The effectiveness of this convention is questioned due to the lack of verification methods to assure that countries are following the convention’s principles and the lack of compliance of certain countries (such as the Soviet Union)⁴⁷⁵. The Convention on the Prohibition of the Development, Production, Stockpiling, and Use of Chemical Weapons and on their Destruction, known as the 1993 Chemical Weapons Convention (CWC), is a treaty that prohibits developing, transferring, and use of chemical weapons⁴⁷⁶. The Organization for the Prohibition of Chemical Weapons (OPCW) implements the principles stated in the treaty and assesses members related activities and declarations. Due to the OPCW, the proliferation of chemical weapon use is likely more contained.

After the discovery of Biopreparat and Russia’s ability to keep it hidden for a long time, Russia agreed to a Trilateral Agreement with the US and UK in order to quell fear and worries about Russia’s dishonesty with dismantling its biological weapons programs⁴⁷⁷. However, Russia has failed to maintain this agreement, thus little concrete information exists about their current

⁴⁷⁴ U.S. Department of State. “Biological Weapons Convention”. Accessed August 13, 2020. <https://www.state.gov/biological-weapons-convention/>.

⁴⁷⁵ Rissanen, Jenni. “The Biological Weapons Convention”. Nuclear Threat Initiative, March 2003. Accessed August 13, 2020. <https://www.nti.org/analysis/articles/biological-weapons-convention/>.

⁴⁷⁶ Kimball, Daryl G. “The Chemical Weapons Convention (CWC) at a Glance”. Arms Control Association, April 2020. Accessed August 13, 2020. <https://www.armscontrol.org/factsheets/cwcglance>.

⁴⁷⁷ Moodie, Michael. “The Soviet Union, Russia, and the Biological and Toxin Weapons Convention”. *The Nonproliferation Review/Spring 2001*, Accessed August 13, 2020. <https://www.nonproliferation.org/wp-content/uploads/npr/81moodie.pdf>.

biological related facilities and organizations⁴⁷⁸. Due to the discovery that the international chemical industry largely contributed to Iran’s chemical warfare program (implemented in the Iran-Iraq war), The Australia Group (AG) was established in 1985 as an informal group of countries aimed to enforce export controls to prevent the proliferation of chemical and biological weapons⁴⁷⁹. The organization has a list of items to monitor including chemical weapon precursors, dual-use equipment for both types of weapons, and biological agents/organisms⁴⁸⁰.

The discovery of these two countries maintaining their offensive capabilities proves that these conventions and agreements have not been successful in completely deterring the use of these weapons, of which is also partly due to the fact that some countries in the world have never signed the agreement. The international community must work together to identify those violating the agreements and condemning or punishing those that use chemical and biological weapons.

Biological and Chemical Agents and Their Defense

Main Chemical Agents⁴⁸¹

Nerve Agents:	Tabun (GA), Sarin (GB), Soman (GD)
Vesicants:	sulfur mustard, lewisites
Blood agents:	Hydrogen cyanide (HCN), cyanogen chloride (CNCl)
Choking agents:	Chlorine, phosgene
Incapacitating:	BZ (3-quinuclidinyl benzilate)

⁴⁷⁸ Zilinskas, Raymond A. “The Soviet Biological Weapons Program and Its Legacy in Today’s Russia”. National Defense University, July 2016. Accessed August 14, 2020. https://inss.ndu.edu/Portals/68/Documents/occasional/cswmd/CSWMD_OccasionalPaper-11.pdf?ver=2016-07-18-144946-743.

⁴⁷⁹ Nuclear Threat Initiative. “Australia Group (GA)”. Accessed August 14, 2020. <https://www.nti.org/learn/treaties-and-regimes/australia-group-ag/>.

⁴⁸⁰ Ibid.

⁴⁸¹ Ganesan, Raza, Vijayaraghavan, “Chemical Warfare Agents”.

Main Biological Agents⁴⁸²

Bacteria:	<i>Bacillus anthracis</i> (anthrax), <i>Yersinia pestis</i> (plague), <i>Francisella tularensis</i> (tularemia), <i>Brucella</i> species (brucellosis) <i>Coxiella burnetti</i> (Q fever)
Viruses:	Variola virus (smallpox), Equine encephalitis viruses, virus-based hemorrhagic fevers
Toxins:	Staphylococcal enterotoxin B, Ricin, Botulinum toxins, Trichothecene mycotoxins

The Impact of the Biotechnology Industry

Due to the fact nearly all of the information, research facilities, and equipment/supplies necessary for biological weapons are also used in peaceful and civilian interests, countries with advanced biotechnology sectors have the potential to discreetly develop advanced biological weapon capability⁴⁸³. However not only do advancements in biotechnology provide greater opportunity for more lethal weapons, but it also allows advancements in defense countermeasure programs for these weapons.

After the mid-1970s, scientists began mastering the use of biotechnology and the manipulation of DNA to the extent to which the scientific community acquired the ability to sequence the entire human genome⁴⁸⁴. Following the natural progression cycle of new products, biotechnology started to become commercialized and has grown into a vast industry. The increased availability of biotechnology and advancements in knowledge in the industry also simultaneously increases the likelihood of this technology landing in the hands of a person with malevolent intentions. For example, through various experiments with these technologies, humans have gained the

⁴⁸² Frederick R. Sidell, Ernest T. Takafuji, and David R. Franz. *Medical Aspects of Chemical and Biological Warfare*, 1997.

⁴⁸³ Zilinskas, Raymond A. "Second-Tier Suppliers of Biological Warfare Technology, Equipment, and Materials: The Potential Roles of China, India, and Cuba". James Martin Center for Nonproliferation Studies, January 2008. Accessed August, 14, 2020. <https://www.hsdl.org/?view&did=716634>.

⁴⁸⁴ Gadagkar, Raghavendra. "Chapter: 4 The Biotechnology Revolution: Exploring New Territory Together". *Sciences Engineering Medicine*, 2016. Accessed August 14, 2020. <https://www.nap.edu/read/21810/chapter/7>.

ability to purposefully make pathogens more severe (virulent)⁴⁸⁵. Generally, understanding the capabilities offered by biotechnology to manipulate genes is important to help prepare for the different ways adversaries might enhance biological agents to cause more harm or defy current defense mechanisms.

Existing Defense Measures

The existence of effective and available medical countermeasures could potentially serve as a deterrent to use these weapons, in which the difficulties to stabilize and deploy the weapons is not worth the potential of an ineffective outcome. A defense capability against chemicals and toxins exist through physical countermeasures such as protective masks and clothing, decontamination, and vaccines⁴⁸⁶. Additionally, detection systems for chemical and biological agents exist such as handheld devices, bio surveillance and wide-area detection which immensely increase the likelihood for soldiers to avoid casualties⁴⁸⁷. Defense against an attack with these weapons is more effective when there is awareness of enemy intentions, training with the equipment, and sufficient amounts of equipment⁴⁸⁸. Although defense measures against these weapons exist, it is often hard to decipher an actors' intentions and the extent of their capability.

⁴⁸⁵ Raghavendra Gadagkar, "Chapter: 4 The Biotechnology Revolution: Exploring New Territory Together".

⁴⁸⁶ Frederick R. Sidell, Ernest T. Takafuji, and David R. Franz. *Medical Aspects of Chemical and Biological Warfare*, 1997.

⁴⁸⁷ United States Air Force Center for Unconventional Weapons Studies. *Chemical and Biological Warfare Overview*. Accessed August 14, 2020. <https://www.airuniversity.af.edu/Portals/10/CSDS/Books/cbwprimer2015.pdf>.

⁴⁸⁸ Ibid.

State Actors with Capability/Intentions

Russia

Due to the use of chemical weapons during World War I, the government in the former Soviet Union focused on growing a chemical industry for military and civilian purposes. By the late 1920's, leaders such as Yakov M. Fishman were focused on pursuing a biological capability⁴⁸⁹. After the creation of the first biological weapon laboratory called the Scientific Research Institute of Health led by Nikolay N. Ginsburg, many others were established to research other infectious diseases and develop vaccines against such diseases⁴⁹⁰. By World War II, the Soviet Union's offensive biological weapons programs was vast. Despite the United States' public dismantling of its offensive biological weapons program in 1969, and the Soviet's signing of the Biological Weapons Convention in 1972, the Soviet Union's offensive biological weapons programs continued—its existence was only disclosed publicly in 1989⁴⁹¹. The undisclosed nature of the Soviet's biological weapons capability was likely a part of the very reason why the Soviet's continued maintaining and advancing it, as it would serve as a major surprise in a potential future scenario. Thus, the Soviet Union had an extensive biotechnology industry intended to weaponize biological agents, often masked as civilian institutions such as Biopreparat⁴⁹².

Although Russia's former president Boris Yeltsin admitted the Soviet's violation of the Biological Weapons Convention throughout the Cold War in 1992, the current Russian president, Vladimir Putin, has reasserted that the Soviet offensive biological warfare capability never existed⁴⁹³. Putin's denial of the Soviet program suggests that Russia's current leaders also

⁴⁸⁹ Raymond A Zilinskas, "The Soviet Biological Weapons Program and Its Legacy in Today's Russia".

⁴⁹⁰ Ibid.

⁴⁹¹ Ibid.

⁴⁹² Ibid.

⁴⁹³ Trakimavicius, Lukas. "Is Russia Violating the Biological Weapons Convention". Atlantic Council, May 2018. <https://www.atlanticcouncil.org/blogs/new-atlanticist/is-russia-violating-the-biological-weapons-convention/>.

have a tendency to conceal the truth. After the failure of the Trilateral agreement between Russia, the U.S. and the U.K. in 1992, whether the Soviet program was actually dismantled, in which all pathogens have been destroyed, is unclear. Given a long history of secrecy and extensive capability, it is likely that Russia inherited much of the knowledge and weapons of the previous Soviet biological warfare program.

According to a 2012 article by Vladimir Putin in the *Rossiiskaya Gazeta*, Russia's military will develop weapons systems "based on new principles such as beam, geophysical, wave, genetic, psychophysical and other technology", proving that there is an interest in unconventional warfare weapons and tactics to achieve their strategic goals⁴⁹⁴. Particularly, President Putin's eagerness to create new weapons based on 'genetic' principles flashes warning signs of the production of biological weapons in violation of the BWC. Additionally, there has been no indication that Russia has reduced its biological facilities that were previously used for the Soviet offensive capability⁴⁹⁵. Therefore, although not proven, it is reasonable to assess that Russia likely has the ability to maintain an offensive biological weapons program and will be willing to use biological weapons in future war scenarios, if given the correct opportunity.

Regarding chemical weapons, Russia's production of chemical agents and weapons was the most extensive during World War II⁴⁹⁶. However, after becoming a member of the 1993 Chemical Weapons Convention, Russia committed to destroy all its declared chemical weapon stockpiles⁴⁹⁷. By October 2017, the OPCW declared that Russia had destroyed 39,967 metric tons of chemical weapons, which serves as 96.3 percent of its stockpiles⁴⁹⁸.

⁴⁹⁴ Putin, Vladimir. "Being strong: National security guarantees for Russia". *Rossiiskaya Gazeta*, February 2012. Accessed August 15, 2020. <http://archive.premier.gov.ru/eng/events/news/18185/>.

⁴⁹⁵ Raymond A Zilinskas, "Second-Tier Suppliers of Biological Warfare Technology, Equipment, and Materials: The Potential Roles of China, India, and Cuba".

⁴⁹⁶ Federation of American Scientists. "Chemical Weapons". Accessed August 15, 2020. <https://fas.org/nuke/guide/russia/cbw/cw.htm>.

⁴⁹⁷ Ibid.

⁴⁹⁸ OPCW News. "OPCW Marks Completion of Destruction of Russian Chemical Weapons Stockpile". October 2017. Accessed August 15, 2020. <https://www.opcw.org/media-centre/news/2017/10/opcw-marks-completion-destruction-russian-chemical-weapons-stockpile>.

However, in 2018, Russia used the nerve agent Novichok to attempt to assassinate a former Russian spy Sergei Skripal, demonstrating their violation of the CWC⁴⁹⁹. Therefore, it is uncertain whether Russia has truly dismantled their chemical weapon capability.

Syria

Syria focused on developing a chemical weapons program primarily due to the military aggression of Israel in the Middle East, exemplified in Israel's invasion of Lebanon in 1982⁵⁰⁰. Syria's chemical weapon capability serves as a deterrent tactic against the Israeli threat and provides a method to counterbalance the disparity between their militaries. Evidence exists that suggest that the Soviet Union and other countries aided in the development of their capability⁵⁰¹. Official U.S. assessments in 2013 indicated that Syria had 1,000 metrics tons of chemical agent stockpiles that consisted of mustard, sarin, and VX nerve agents⁵⁰². Due to the violence of the Syrian civil war starting in 2011, there have been many alleged chemical attacks between 2012–2013⁵⁰³. However, most of the early alleged incidences had low casualties, contrasting from the confirmed, large chemical attack against Ghouta using the sarin nerve agent⁵⁰⁴. Therefore, Syria is an example of a country in which the existence of their chemical weapons capability is rooted out of defense against aggressors (in the Middle East), yet they have been exercising it offensively without a 'first-use' from another country. Although the Syrian government used these agents against their own civilian population and not against another country, this type of warfare in general is unacceptable.

⁴⁹⁹ Coats, Daniel R. *Worldwide Threat Assessment of the US Intelligence Community*, Senate Select Committee on Intelligence, January 2019. Accessed August 15, 2020. <https://www.dni.gov/files/ODNI/documents/2019-ATA-SFR---SSCI.pdf>.

⁵⁰⁰ Mauroni, Albert J. *Eliminating Syria's Chemical Weapons*. US Air Force Center for Unconventional Weapons Studies, Future Warfare Series, No. 58. June 2017. Accessed August 16, 2020. <https://media.defense.gov/2019/Apr/11/2002115522/-1/-1/0/58ELIMINATINGSYRIACW.PDF>.

⁵⁰¹ Ibid.

⁵⁰² Ibid.

⁵⁰³ Ibid.

⁵⁰⁴ Ibid.

Due to pressure from the U.S., Syria acceded to the Chemical Weapons Convention and thereby committed to destroying its chemical weapons stockpiles. Despite the fact that the OPCW declaration of the destruction of all of Syria's declared chemical weapon stockpiles in 2015, there have been alleged Syrian military use of agents in 2016 and 2017⁵⁰⁵. Therefore, despite efforts from the international community, Syria has the capability and intent to use chemical weapons. Contrastingly, little information exists about Syria potentially having a biological weapons capability.

North Korea

North Korea's potential chemical and biological warfare capabilities have been disputed due to the fact that very little information is known about their programs or intentions, if any exist⁵⁰⁶. However, there is reason to believe that North Korea has a chemical weapons capability contrasting from their biological weapons capability, which remains largely unknown or unconfirmed. Recently in 2017, North Korea supported the murder of Kim Jong-Un's half-brother Kim Jong-Nam, with a form of VX nerve agent in an airport in Malaysia⁵⁰⁷. The fact that this assassination was in a public place such as an airport, indicates that the North Korea wanted a large audience to witness the assassination. Based on this incident, North Korea might have some sort of chemical weapons capability or knowledge about agents and is willing to use it to complete strategic objectives.

Based on the technical knowledge to develop its nuclear missile programs, it is possible for North Korea to create these other unconventional weapons⁵⁰⁸. Additionally, North Korea has a sufficient biotechnol-

⁵⁰⁵ Albert J Mauroni, *Eliminating Syria's Chemical Weapons*.

⁵⁰⁶ Parachini, John V. "North Korea's CBW Program: How to Contend with Imperfectly Understood Capabilities". RAND Santa Monica United States, 2018. Accessed August 16, 2020. <https://apps.dtic.mil/sti/pdfs/AD1056014.pdf>.

⁵⁰⁷ Daniel R Coats, *Worldwide Threat Assessment of the US Intelligence Community*, Senate Select Committee on Intelligence, January 2019.

⁵⁰⁸ Parachini, John V. "North Korea's CBW Program: How to Contend with Imperfectly Understood Capabilities".

ogy industry in order to maintain a biological weapons capability⁵⁰⁹. For example, the Pyongyang Bio-technical Institute, a pesticide production facility, has been scrutinized as a possible dual-use facility⁵¹⁰. Although this facility is operating under peaceful purposes, it is important to acknowledge that there is potential for biological weapon weapons to be produced there. South Korea's 2015 White Paper's have stated that North Korea has over thirteen types of biological agents and the capability to weaponize them⁵¹¹. These claims have not been substantiated by other sources, but the lack of confirmation of this information should not invite complacency by assuming that North Korea does not possess a capability. The international community should at least imagine the worst-case scenario and assess how to best prepare for such a scenario.

China

China's biological weapon's research and development activities abide by the Biological Weapons Convention, because it is ostensibly intended for defensive purposes⁵¹². Although China had created an active offensive biological weapons program in the mid 1970s, China became a member of the BWC in 1984.

However, suspicion of the existence of a Chinese offensive biological weapon program grew after assessing that the Chinese military controlled a few of the biological research centers intended for civilian purposes in 1993⁵¹³.

⁵⁰⁹ Coats, Daniel R. *Worldwide Threat Assessment of the US Intelligence Community*, Senate Select Committee on Intelligence, February 2018. Accessed August 16, 2020. <https://www.dni.gov/files/documents/Newsroom/Testimonies/2018-ATA---Unclassified-SSCI.pdf>.

⁵¹⁰ Kim, Hyun-Kyung, Elizabeth Philipp, and Hattie Chung. "North Korea's Biological Weapons Program: The Known and Unknown. *HARVARD Kennedy School, Belfer Center for Science and International Affairs*, October 2017. <https://www.belfercenter.org/sites/default/files/2017-10/North%20Korea%20Biological%20Weapons%20Program.pdf>.

⁵¹¹ Hyun-Kyung Kim, Elizabeth Philipp, and Hattie Chung. "North Korea's Biological Weapons Program: The Known and Unknown."

⁵¹² Shoham, Dany. "China's Biological Warfare Programme: An Integrative Study with Special Reference to Biological Weapons Capabilities". *Journal of Defence Studies*, 2015: 131–156. Accessed August 16, 2020. https://idsa.in/system/files/jds/jds_9_2_2015_DanyShoham.pdf.

⁵¹³ Dany Shoham, "China's Biological Warfare Programme: An Integrative Study with Special Reference to Biological Weapons Capabilities".

Additionally, a major facility for researching biotechnology and genetic engineering stopped publishing information in 2001 yet remained active as a facility⁵¹⁴. These activities suggest that China is trying to keep portions of their biological research/defense programs secretive. Based on the plethora of facilities that research biological products and other related activities that reside in China, and specifically those that are affiliated with the PLA or government-based defense organizations, China has the capability necessary to mass produce biological weapons and create an advanced offensive biological warfare program⁵¹⁵. China's massive biotechnology industry and infrastructure allows opportunity for the creation of a biological weapons capability that could be hidden from the international community due to the fact that facilities and research can be considered dual-use. Despite China's ability to obtain the weapons capability, China is likely to be cautious in using them in an international conflict as they hold status of major global power in the international community. However, based on history, China has no issue with violating human rights and going great lengths in order to reach their strategic goals.

After adhering to the CWC principles and dismantling their offensive chemical weapon capability, China has officially stated that they continue a chemical warfare program for defensive and protection purposes⁵¹⁶. Instead of participating in the AG, China has attempted to develop and implement its own export controls for chemical weapons, but implementation and reinforcement of this domestically run program has proven difficult⁵¹⁷. The fact that China's export controls is not under supervision of an outside source allows these activities to remain ambiguous and allows public knowledge of China's chemical-related exports to remain controlled and small.

China's defense programs for biological and chemical weapons requires research and knowledge of agents and their weaponization/dissemination,

⁵¹⁴ Ibid.

⁵¹⁵ Ibid.

⁵¹⁶ Nuclear Threat Initiative. "Countries: China". Accessed August 16, 2020. <https://www.nti.org/learn/countries/china/chemical/>.

⁵¹⁷ Ibid.

thus it is plausible to assess that China could harness an advanced capability in both areas if needed in a wartime contingency.

Iran

The Iraqi chemical weapon use in the Iraq-Iran War (1980–1988) prompted Iran to develop a chemical weapons capability⁵¹⁸. As Iran gained the ability to manufacture, weaponize and deploy chemical agents during the war, it became more difficult to identify the perpetrator of the different chemical attacks in the war⁵¹⁹. After the war, Iran claimed that its chemical weapon program was dismantled and joined the CWC in 1997⁵²⁰. However, there have been many allegations of Iran maintaining their chemical weapons capability. Countries such as India and China have sold significant amounts of chemical weapons materials to Iran and significantly advanced Iran's chemical weapon infrastructure⁵²¹. This prompted the U.S. to pass the Iran Nonproliferation Act and impose sanctions on these countries. Recent U.S. official documents express concern that Iran is not fulfilling its obligations under the CWC by continuing to develop offensive chemical agents and failing to declare all of its capabilities⁵²².

Iran's advanced civilian biotechnology sector has the potential use the dual-use supplies and equipment to contribute to offensive military purposes⁵²³. Iran has focused on researching and developing vaccines, researching agricultural biotechnology and different dissemination techniques

⁵¹⁸ Federation of American Scientists. "Iranian NBC Policy, Capabilities, and Employment Options". Denial and Jeopardy: Deterring Iranian Use of NBC Weapons. Accessed August 16, 2020. <https://fas.org/nuke/guide/iran/doctrine/dajd/ch5.html>.

⁵¹⁹ Iran Watch. "A History of Iran's Chemical Weapon-Related Efforts". Wisconsin Project on Nuclear Arms Control, November 2019. Accessed August 16, 2020. <https://www.iranwatch.org/our-publications/weapon-program-background-report/history-irans-chemical-weapon-related-efforts>.

⁵²⁰ Nuclear Threat Initiative. "Countries: Iran: Chemical". Accessed August 16, 2020. <https://www.nti.org/learn/countries/iran/chemical/>.

⁵²¹ Ibid.

⁵²² Daniel R Coats, *Worldwide Threat Assessment of the US Intelligence Community*, Senate Select Committee on Intelligence, January 2019.

⁵²³ Nuclear Threat Initiative. "Countries: Iran: Biological". Accessed August 16, 2020. <https://www.nti.org/learn/countries/iran/biological/>.

for plant pesticides⁵²⁴. Iran also continues to research into microbiology and genetic engineering at health research facilities, exemplifying their expertise and knowledge in the field. Overall, the dual-use nature of these facilities and this biological research, indicates that Iran is able to create a biological weapons capability effectively and quickly, if they do not have a clandestine one already.

Nonstate Actors – Biological and Chemical based Terrorism

Terrorists have acquired and deployed biological weapons on many accounts, of which primarily target civilians⁵²⁵. U.S. law enforcement prevented two attempts of infection with biological agents in America, including an attempt in 1972 by two college students in Chicago, and another attempt by the Bhagwan Shree Rajneesh followers in Oregon⁵²⁶. The perpetrators of these attempts show the broad spectrum of people that have sought to use these types of weapons.

More internationally recognized cases of bioterrorism include the Russia-sponsored Aum Shinrikyo Japanese religious group release of anthrax in Tokyo and the 2001 anthrax infested mail attacks against news media and US Congress⁵²⁷. Moreover, ISIS has used chemical weapons such as mustard and other toxic substances in Syria and Iraq multiple times throughout 2014–2017⁵²⁸. Due to increased availability and knowledge of chemical and biological weapons, terrorists are more likely to acquire this capability.

⁵²⁴ Ibid.

⁵²⁵ Williams, Mollie and Daniel C. Sizemore. "Biologic, Chemical, and Radiation Terrorism Review". *StatPearls [Internet]*, February 2020. Accessed August 16, 2020. <https://www.ncbi.nlm.nih.gov/books/NBK493217/>.

⁵²⁶ Ibid.

⁵²⁷ Ibid.

⁵²⁸ Daniel R Coats, *Worldwide Threat Assessment of the US Intelligence Community*, Senate Select Committee on Intelligence, January 2019.

Conclusion

Due to the proliferation of chemical and biological weapons and the intentions of the countries that possess these capabilities, the advancements in biotechnology and its dual-use nature of civilian and military purposes, and the decreased effectiveness of international treaties, chemical and biological warfare poses a prominent threat to the international community in the future. The monitoring of export controls, verifications of international agreements, potential sanctions of transporting biological/chemical materials, and advancing defense countermeasures will help deter countries or state actors from using these weapons.

The main countries that are underscored to either possess a biological and chemical weapons capability or possess intent to acquire and use them, include Russia, Syria, North Korea, China, and Iran. Although these countries have not publicly declared offensive capabilities and some of the allegations are not yet confirmed, the international community should not allow the lack of information to lead to the assumption that these countries completely do not have these capabilities. Complacency is dangerous because it increases the likelihood for a country to successfully execute a surprise attack and induce more casualties. Instead, the lack of information should incite the international community to continue to monitor these countries activities and increase its efforts to find more information about their intentions and capabilities.