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Subcommittee on Terrorism, Nonproliferation and Trade and
Subcommittee on Asia and the Pacific

"More Than a Nuclear Threat: North Korea's Chemical, Biological and Conventional Weapons"

A Testimony by:

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Introduction and Main Points

North Korean development of biological weapons both poses a serious potential threat to the United States and its strategic partners, and illustrates the broader dangers of proliferation. Biological weapons pose dangers that are growing steadily with the proliferation of the civil, dual-use, and military technologies that can be used to develop and manufacture biological weapons – such as genetic engineering and drones.

Figures One to **Three** show that some estimates indicate that Cold War biological weapons could be even more lethal that nuclear weapons, and they have always far cheaper. Such weapons can also substitute for nuclear proliferation. They also do not require and high cost delivery systems like large ballistic missiles that are relatively easy to detect and locate, although they can supplement them. Moreover, they can act as a powerful threat and deterrent on their own, or act as compensation for inferiority in nuclear forces.

In theory, North Korea has rejected the development of biological weapons and advocates a "nuclear, chemical, and biological weapons free zone" in the Korean Peninsula. North Korea acceded to the Biological Weapons Convention on March 13, 1987, and has consistently denied that it has biological weapons ever since. It has accused the United States of using biological weapons in the Korean War, and more recently of sending Anthrax to South Korea as part of such an effort, proving “that the United States is a group of gangsters threatening human existence.” North Korea has also clearly developed nuclear weapons, however, and has long possessed large stocks of chemical weapons. Its restraint in any area of military activity seems dubious at best.

This means that the United States must plan for the possibility that North Korea has biological weapons and will continue to develop more sophisticated weapons over time. There also is a significant amount of reporting that it does have ongoing biological weapons programs, and even the mere possibility that North Korean -- or any other set of threat -- biological weapons exist already presents major problems for U.S. military planning, and already gives North Korean deterrent and strategic leverage.

Such weapons present major problems for intelligence collection and analysis in both peacetime and war. This is true at both the strategic level – which is illustrated at the end of this testimony – and the operational level. For example, they present unique challenges in attributing and characterizing attacks – particularly if they are used on distant targets, mirror natural disease, and are used at a time when no major crisis and period of tension exists with North Korea.

At the same time, even the best open source efforts present serious problems in terms of access to accurate data on North Korea and in estimating the ability to characterize the real-world effectiveness of current and future weapons programs, and these challenges may limit even the best intelligence efforts. So do key technical uncertainties. Serious questions exist about the ease of developing and producing truly effective biological weapons with predictable and controllable effects. Such questions also exist about the ways in which biotechnology will evolve new threats over the coming decade, and over the risk tolerance of the developer and user.

Accordingly, there are several priorities that this Committee should address in dealing with the issue of North Korea's biological weapons programs.

- The first is the need to ensure that the United States has given the right priority to developing the best possible data at the classified level and that we provide enough reliable unclassified data to properly define and examine the North Korean biological threat.
- The second is to look beyond estimates of the threat based on Cold War technologies and the current state of the art technologies, and examine how a North Korean threat could evolve over the next ten to fifteen years.
- The third is to look beyond more conventional ways that North Korea might use such weapons and examine the full range of ways in which North Korea might use biological weapons in a conflict.

Giving the Right Priority to Developing the Best Possible Data for U.S. Defense Planning

Any testimony on North Korea's biological weapons capabilities should begin with a critical caveat, and one that should govern the work of both this Committee and the overall U.S. Government approach to this issue. Much of the unclassified literature on North Korean biological weapons efforts either downplays the threat or makes estimates based on the capabilities of other countries and/or unverified reports from various Korean media sources and defectors.

The resulting data and analysis is often contradictory both in detail and in estimating the overall seriousness of the threat. Some analysts view North Korea as lacking modern public health facilities and medical progress -- which would limit its capability to use such weapons and make it highly vulnerable to a counter-BW attack. Others feel that its military is funded at levels which allow it to make advanced progress in military technology, and point out that public U.S. intelligence efforts have underestimated North Korea’s progress in other high technology areas like nuclear weapons, ballistic missiles, and cyberwarfare.

The ability to analyze the biological weapons aspect of the North Korean threat is further complicated by the fact that much of the open source literature on the development and lethality of biological weapons – like the data in **Figure One, Figure Two**, and **Figure Three** – is theoretical, estimated by people with a technical background but who have not actually worked on biological weapons and their defenses, or draws on Russian assessments of Russian progress during the Cold War – assessments which came from developers with potential motives to exaggerate their progress and the threat.

Many of the models used to estimate casualties or risks of the kind shown in the tables at the end of this testimony seem to represent worst cases for a given disease or toxin. At best, they are estimates where the estimated lethality/effect and coverage is *possible*, but where the lack of actual use in war or large-scale human testing makes it impossible to assign a clear probability.

At the same time, most such weapons lethality, characteristics, and effects data predate advances in the biosciences that increase the ability to genetically engineer or otherwise improve such weapons. Much of the open source material that does touch upon genetic engineering and the modern biosciences is necessarily speculative, and rarely seems to come from experts who have actually worked on future options for offense and defense using such weapons.

Possible North Korean Weapons Efforts

There are indicators that North Korea has a biological weapons program well underway. Several DPRK defectors have claimed that the North tested biological and/or chemical weapons on mentally or physically deficient children and concentration camp prisoners.[i] More officially, South Korean Ministry of National Defense's biennial defense white papers have reported on possible North Korean biological weapons programs since at least 2000. Its 2000 paper stated that, "The North is also suspected of maintaining numerous facilities for cultivating and producing the bacteria of anthrax and other forms of biological weapons." The 2006 paper stated that North Korea "is able to produce biological weapons such as the bacteria of anthrax, smallpox, and cholera."[ii] Its 2010 paper stated that North Korea could "independently cultivate and produce biological weapons, including anthrax, smallpox, and cholera."[iii] Its 2016 paper, however, was more cautious: "It appears that the North can independently cultivate and produce such biological weapons as the bacteria of anthrax, smallpox and pest." [iv]

Other South Korean reports have not been so cautious. From 2002 to 2015, South Korean sources like a ROK Parliamentary Audit reported that North Korea had 13 types of biological weapons, and either has stockpiles or the capability to rapidly cultivate and weaponize them. In 2015, for example, an audit reported that, "North Korea has 13 types of biological weapons in the form of agents, and it can cultivate and weaponize them within ten days. In an emergency, it is likely that the North would prioritize using anthrax which is highly fatal and smallpox which is highly contagious. Special forces, airplanes, and contaminated carcasses are the potential delivery means. It appears that the North has not developed missile warheads with BW payload." A joint working group with a U.S. institute stated that same year that, "North Korea is assumed to have 13 types of biological agents including anthrax and the plague, and it is possible that it would use them in bioterrorism or in an all-out war."[v]

IHS Jane's has also listed recent South Korean MoD states in its November 2017 analysis of the North Korean biological threat,[vi]

> …on 17 June (2015), the RoK MND issued a report that stated North Korea possesses an assortment of biological agents - including anthrax and smallpox - and the ability to weaponize them within 10 days. The report also stated that the North did not yet possess warheads to employ bioweapons.
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> …during June 2015 North Korea announced that it has created a vaccine, known as Kumdang-2, that could treat Ebola, HIV, "a number of cancers", and MERS. Kumdang-2 was reportedly manufactured from ginseng grown in fertilizer made from "rare-earth elements" and "micro-quantities of gold and platinum". Most serious researchers have significant reservations concerning these claims.
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> … In the aftermath of Kim Jong-nam's death in February 2017 due to toxic nerve agent VX, South Korea's MND was quoted by Yonhap News Agency as saying that North Korea's military is probably operating a regiment-level biochemical weapons unit.

The credibility of such reporting is uncertain since the number thirteen seems to have been borrowed from the number of biological weapons the FSU developed before the end of the Cold War. Some South Korean media reports, for example, claim the ROK has estimated that half of the DPRK's long-range missiles and 30% of its artillery were able to deliver biological or chemical weapons, though it was unknown if the North was able to equip missiles/artillery in a way that would allow the biological payloads to survive and effectively disperse.[vii]

U.S. intelligence has not reported publicly in any depth on North Korean biological weapons programs since 2012.[viii] However, U.S. intelligence reported in 2005 that,"North Korea has the

scientists and facilities for producing biological products and microorganisms, and has the ability to produce traditional infectious biological warfare agents or toxins. Pyongyang's resources presently include a rudimentary biotechnology infrastructure. In 2004, Pyongyang acquired dual-use bio-technical equipment, supplies, and reagents that could be used to support a BW program. North Korea possesses a conventional munitions production infrastructure that could be used to weaponize BW agents."

From 2006-2008, it reported annually that, "Pyongyang's resources presently include a rudimentary biotechnology infrastructure. North Korea has the scientists and facilities for producing biological products and microorganisms, and has the ability to produce traditional infectious BW agents or toxins. North Korea produces conventional munitions that could be used to deliver BW agents. In 2005, North Korea requested, but was subsequently denied, a preventive vaccine manufacturing facility from South Korea. U.S. intelligence also reported annually in 2009-2012 that, North Korea has a biotechnology infrastructure that could support the production of various BW agents. We judge that North Korea possesses a conventional munitions production infrastructure that could be used to weaponize BW agents."[ix]

Moreover, a DNI report issued in late 2011, noted that "North Korea has a biotechnology infrastructure that could support the production of various BW agents... There is not enough open source information to determine whether Pyongyang has progressed beyond the research and development stage and actually has created piles of actual biological weapons, delivery systems, and doctrine for the use of such weapons. Some reports indicate it has."[x]

The Nuclear Threat Initiative (NTI) website (http://www.nti.org) reports that South Korea's Ministry of National Defense issued a paper in April 2012, entitled "Research on Verification Measures for North Korea's Biological Weapons." It said that North Korea was capable of equipping its field artillery rocket launchers and mortars with biological weapons. The ministry indicated that anthrax, botulinum toxins, and smallpox pathogens were the most likely to be weaponized. It said that North Korea established a chemical defense Brigade and platoon under the guidance of its Nuclear Chemical Defense Bureau.[xi]

Such weapons are reportedly cultured in both civilian and military-related research institutes in the DPRK. **Figure Four** provides a possible list of North Korean agents and toxins, but there are no reliable reports to base any list upon. A number of experts, however, cite pathogens that have possible utility for BW, and that may be developed and weaponized by the DPRK. The most common include: Bacillus anthracis (anthrax), Clostridium botulinum (botulism), Mycobacterium tuberculosis (tuberculosis), Rickettsia prowazekii (typhus), Salmonella typhi (typhoid), Vibrio cholerae 01 (cholera), Yersinia pestis (plague), Korean hemorrhagic fever, Variola major (smallpox), Yellow fever virus (yellow fever), Dysentery, Brucellosis, Staphylococcus aureus, and Yellow Rain (T-2 Micro Toxins), and tetrodotoxin. Other sources indicate that North Korea has sought cultures from a range of source – including the Ebola outbreak in Africa.

Possible North Korean Facilities

What is clear is that even if the DPRK does not possess ready-to-use weapons – which present a range of technical and safety problems, it has the equipment and technical abilities to produce them. A variety of reports have warned over the years that North Korea could conceal a bioweapons research effort and possibly a major production and stockpile effort. Some also warn

that North Korea has dual-use facilities that could be used to produce biological agents and has a munitions industry that could be used to weaponize such agents.

Such reports are often highly speculative, and are no more reliable than the reports that list the diseases and toxins that North Korea *may* have weaponized. They do, however, indicate that North Korea has long had the potential to produce and weaponize biological agents.

Media sources reported in in 2001 that the that the ROK Ministry of National Defense (MND) estimated DPRK maintains at least three possible BW production facilities and six BW or BW-related research centers, including the No. 25 Factory in Chongju, the Central Biological Weapons Research Institute in Pyongyang and a plant in the City of Munchon, Kangwon Province. One ROK newspaper reported the existence of more than 10 facilities.

According to GlobalSecurity.org, Pyongyang's resources presently include a rudimentary (by Western standards) biotechnology infrastructure that is sufficient to support the production of limited quantities of toxins as well as viral and bacterial biological warfare agents.[xii] Other sources had estimated by 2012 that a number of DPRK facilities might be linked to ongoing work in biological weapons research, development, and manufacture.

The NTI has reported a number of facilities in addition to the No. 25 Factory in a report dating back to 2012. It listed:[xiii]

- The Research Institute of the Armed Forces Ministry (synonymous with the Bacterium Research Institute, Second Academy of Natural Sciences), responsible for developing biological weapons.
- A Biological research facility located in Songch'on County, South P'yongan Province, adjacent to the Onjong-ni chemical weapons facility; growth media is allegedly supplied (approximately 200 tons per year) by a facility in Munchon, Kangwon Province.
- A germ-producing facility known as the 25 February Plant (also known as the 25 Plant), located in Chongju, North Pyongan Province.
- The National Defense Research Institute and Medical Academy (NDRIMA), which conducts studies on disease pathogens such as the bacteria and viruses that cause anthrax, cholera, bubonic plague, smallpox, yellow fever, and others.

Some key possibilities dating back to this period are shown in the list in **Figure Five** and the map in **Figure Six.** These lists, however, have been expanded in more recent reports**.**

One such source, IHS Jane's, warns that data on suspect facilities in its November 2017 report are uncertain:

> Little is known about the facilities and organizations engaged in BW research, development, and production. Researchers from the Academy of Sciences' Microbiology Institute are known to study and conduct research abroad, most significantly in China (for example, the Chinese Academy of Sciences' Key Laboratory of Pathogenic Microbiology and Immunology and Institute of Microbiology in Beijing). A December 2001 South Korean press report claimed that the DPRK's Biological Research Institute had succeeded in developing BWs "thanks to a major role played by Russian experts who the institute invited early in the 1990s when they were made jobless in the wake of the collapse of the Soviet Union". Academic papers and reports published during 2011-16 indicate that North Korean scientists and researchers are actively conducting research into a wide range of dual-use technologies that could have direct applications in the development of BWs.

At the same time, IHS Jane's also listed 18 suspect facilities by name and location and the possible location of another.

Another expert, Joseph H. Bermudez, also warns about such uncertainties, but has also developed a relatively long lists of the facilities that might be connected with a biological weapons program – a recent 2017 study listed a total of 20 in all.[xiv] He also concludes that, [xv]

> As with all North Korea's NBC infrastructures, there are presently no detailed and accurate estimates of the number of personnel or organizations involved in the research, development, testing or employment of biological weapons. A rough order-of-magnitude estimate, however, suggests that there are 25-50 entities and 1,500-3,000 personnel directly involved in various aspects of the BW program.

Figure Seven combines the expanded lists shown in these two sources, but it is important to note that it scarcely exhausts the possibilities. North Korea could also follow in Saddam Hussein's footsteps and convert current dual use facilities to weapons R&D or production facilities – or design them in advance for rapid conversion. The DRPK possesses a number of dual-use biotechnology facilities that could be used to research biological weapons agents and produce militarily significant quantities of biological agents.[xvi] Both the Jane's and Bermudez lists of suspect facilities already include medical facilities, highlighting the fact that there is no clear line between biological offense and defense, and between medical/ scientific research and weaponization.

Bermudez notes that,[xvii]

> In its simplest form, the organization for the BW program is similar to the overall NBC program, with some specific modifications. Subordinate to the Cabinet, it is believed that the Ministries of Agriculture and Public Health provide some level of theoretical and practical research and information that inform the BW program. The Academies of Science and Medical Sciences reportedly provide theoretical and practical research and information, train personnel and conduct specific BW-related research and development. The KWP's Civil Defense Department coordinates with the KPA General Staff Department's Civil Defense Bureau and both have a defensive responsibility in coordination with the Ministries of Agriculture and Public Health.
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> Components of the Munitions Industry Department's Academy of National Defense Sciences and Second Economic Committee have the primary research, development and production responsibilities for BW. Within the Academy of National Defense Sciences there are several research institutes and laboratories that are dedicated to BW development and these have reportedly operated several different test facilities...Within the Second Economic Committee the Third and Fifth Bureaus appear to have a leading role in BW development and production. Within the KPA, it appears that the primary BW defense responsibility resides with the Nuclear- Chemical Defense Bureau. This bureau, through its subordinate research, training and storage components, appears to also have a research and support role.
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> ... In addition to the above, the State Academy of Sciences, Academy of Agricultural Sciences and Academy of Medical Sciences possess a number of "branches" or "laboratories" that could provide either direct, or indirect, support to the development of biological weapons and defenses. For example, the State Academy of Science's Bioengineering Research Branch has at least 12 institutes and organizations, the Biology Branch has at least eight and the Unjong Branch at least one. There is concern that the laboratories of the Ponghwa Clinic (responsible among many things for the health and longevity of the Kim family) may be associated with the BW program. Moreover, there are a number of additional agricultural, pharmaceutical and scientific entities (some of which may be under the control of the State Academy of Sciences) that could immeasurably enhance its BW program if put to that use, including the, Aeguk Compound Microbe Center, Aoji Protein Factory, Hoeryong Koryo Medicine Factory, Hygienic and Anti-Epidemic Center, Kim Hyong Jik University of Education, Choson Pugang Pharmaceutic Co., Ltd., Jongsong Pharmaceutical General Factory, Pyongsong and Hyesan Beer Factories, Central Epizootic Prevention Center and the Virus Institute and Genetic Medicine Institute at the Kim Il Sung University.

The same is true of a number of types of chemical production. Fertilizer production and food processing facilities that are not on most suspect facility lists. For example, pictures depicting the Pyongyang Bio-technical Institute (which Kim Jong-un was visiting) were released by the North Korean media in 2015. An analysis of these picture and reports on the visit indicated that the site

could potentially be used to produce mass quantities of anthrax.[xviii] North Korea has denied this and even invited members of the U.S. Congress to visit.

A 2017 study of the North Korean biological threat by the Belfer Center at Harvard points out that,[xix]

> In March 2017, according to the Rodong Sinmun, North Korea built an organic fertilizer production complex that covers "thousands of square meters" in Gangnamgun, Pyongyang that is claimed to be capable of producing thousands of tons of organic fertilizers.12 North Korea intends to continue exponential increase in bio-pesticide production to achieve Kim Jong-Un's goal of producing "Juche fertilizer," named after North Korea's self-reliance ideology. Such emphasis on agricultural self-reliance suggests the legitimate use of pesticide facilities for civilian use only.
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> … a series of photos of the Pyongyang Bio-technical Institute released by the North Korean state media in 2015 raised concerns for dual-use. Analysis of these images revealed that the Pyongyang Bio-technical Institute could produce military-sized batches of BWs, specifically anthrax…. The modern equipment visible in these images also showed a violation of the Australia Group's dual-use items list, and showed that it is possible to convert the facility from pesticide to BW production.

A Lack of Current Official U.S. Reporting and Adequate Base for Open Source Analysis

As has already been mentioned, there has been little recent U.S. official unclassified reporting or testimony on North Korea per se, perhaps because of the concern with North Korean nuclear and missile testing and the clear emergence of a different kind of threat. Neither the DNI nor the Director of DIA chose to mention a North Korean biological warfare threat in the annual threat assessments they provided to Congress in 2016.

Testimony from DIA has previously touched upon the probability of North Korean biological weapons since at least 2006, but has done little to describe their possible use and effectiveness. There also is little open source material to hint at how closely intelligence analysts work with actual experts on biological weapons, and how much attention they give to unconventional options. There are at least some indications that there is a tendency to focus on using ballistic missiles to deliver biological weapons, rather than possible "line source" delivery by slow fliers like cruise missiles and UCAVs, or covert delivery options. In many ways, ballistic missiles are far less desirable options.

There are more recent outside studies of North Korean capabilities that do point out both the dangers of such programs and the uncertainties involved. Two excellent examples include work by Joseph Bermudez for the SAIS/USKI North Korea Instability Project: *Overview of North Korea's NBC Infrastructure,* June 2017; and by Hyun-Kyung Kim, Elizabeth Philipp, and Hattie Chung for the Belfer Center at Harvard, *North Korea's Biological Weapons Program, The Known and Unknown,* October 2017. These sources, however, make it clear that they are often forced to rely on uncertain technical estimates, unclassified Korean media and defector reports, and unverified South Korean parliamentary and MoD statements.

As a result, many analyses by think tanks, academic researchers, and other open source experts rely heavily on press reports – such as one that wrote about a South Korean MoD statement made in 2015, that "North Korea has 13 types of BW agents which it can weaponize within ten days, and anthrax and smallpox are the likely agents it would deploy." There is little reason to assume that such a statement is accurate -- both in terms of 10 days for all 13 agents (which is the number the FSU weaponized) -- and mixing a weapon that is not contagious with one of the most

contagious weapons possible.

About the one thing that is certain about the current level of analysis is that it is impossible for an outside expert to fully assess what the U.S. does and does not know about North Korea's biological weapons program, and the current and future capabilities of a U.S. intelligence and defense effort.

North Korea's Future Potential and Some Recent Indicators

At the same time, North Korea does send some overt signals. It is scarcely coincidental that Kim Jong-un conducted a press tour of the North Korean factory called the Pyongyang Biotechnical Institute in June 2015 that has been mentioned earlier. North Korea does not "leak" during such events. It uses information as a weapon. It was sending a clear public signal that outside efforts to control the most critical technologies for the large-scale production of biological weapons have not limited the DPRK's access to the critical equipment needed to weaponize.

As a December article by Joby Warwick in the *Washington Post* noted, the tour displayed "industrial-scale fermenters that can be used for growing bulk quantities of live microbes, and large dryers designed to turn billions of bacterial spores into a fine powder for easy dispersal."

All of these issues raise the need for the Committee to examine this issue at a classified level, and to examine the quality and depth of the analysis being carried out in the intelligence community, its links to the work being done by the Department of Defense and CDC in exploring the real-world options and lethality for biological weapons, and the level of U.S., Japanese, and South Korean contingency planning.

It is equally important that a much better understanding be developed of what genetic engineering and other advances in the biological sciences can do to both create more lethal weapons and better detection and defenses -- including deterrent military options. No one can assume in today's world that a country like North Korea cannot import and/or clone the equipment and technology necessary to develop and produce advances biological weapons.

Technologies and equipment that were once under at least close control as part of the Australia Group list are far less well controlled today. Used or surplus sensitive equipment is often sold without any control or record.[xx] The Australia Group describes more than 50 pages of dual use items in its handbook on biological weapons controls, and the current volume lists case after case where dual use equipment is available. It is close to being a "cook book" on some aspects of proliferation.

There is a clear need to communicate as much credible data as possible at the unclassified level, and this scarcely applies only to North Korea. Many of the same issues arise in dealing with threat assessments of Russia, China, and Iran. They affect countries that are not threats to the U.S., but have committed themselves to the use of nuclear weapons: India and Pakistan.

Iran has already shown that a nation can make effective use of third party forces that are non-state actors, and North Korea might use such options. As Aum Shinrikyo demonstrated in its Anthrax attack in 1993, the threat from terrorist and extremist groups is all too real -- although that attack failed. We cannot afford to focus on one part of the threat -- nuclear and ballistic missiles -- but the U.S. and its allies also cannot afford focusing on "worst cases" or the last generation of threats. Making the right decisions requires the best public base for understanding and debate that the U.S. intelligence and national security community can release in unclassified testimony, reports, and background briefings.

Looking beyond the "Rational Actor" Scenarios

There is an equal priority to look beyond the conventional Western approaches to deterrence, escalation, and scenario planning. Most such open source analysis tends to focus on the threat to the U.S. -- rather than a range of regional targets -- and on the assumption that North Korean behavior will largely comply with the "rational actor" approach to estimating military options and patterns in escalation. It is the tacit assumption that North Korea will approach the escalation ladder in using biological weapons with the same values and willingness to take risks in climbing from one level to another as the United States.

These assumptions may be correct, but North Korea has a wide range of potential targets to choose from, an authoritarian structure dictated largely by the choices and priorities of one individual, and a leadership whose extreme threats are a warning that its values and willingness to take risks and escalate may differ sharply from those of the U.S. North Korea has shown in the past that it is willing to suddenly escalate to violence, it has large intelligence and special forces elements, and its exercise reflect a potential willingness to escalate that differs from that of South Korea and the U.S.

This does not make Kim Jong-un "irrational." For all the critiques of his hardline rhetoric, threats, and sporadic low-level attacks and assassinations, it is important to note that he is the third generation of a family dynasty of dictators in a world where most dynasties end with the death or overthrow of the first dictator. He would also scarcely be the only hard line negotiator in the current world, or the only authoritarian leader to put his own survival above all other objectives and values.

The rational actor approach -- with its tacit assumption that "rational" is defined by moderate democratic states -- has never really fit the actual nature and history of war. If there is any lesson the U.S. needs to learn from its experience from the First Gulf War to the present, it is that we live in an era of unconventional warfare.

It is also a grim fact that the history of war is often one of "irrational scenarios" driven by unanticipated actions and consequences. The shift to "total war" that Sherman made during the civil war was scarcely the brief decisive battle that both sides anticipated at the start of the Civil War, nor was it a decision that President Lincoln made deliberately.

No one expected or wanted the level of escalation that led to the First World War. The bombing of civilian targets in World War II occurred without deliberate decisions to create a new form of war on either side, and the level of escalation that occurred in the battle of Stalingrad came without deliberate planning on either side.

In case of North Korea, and biological weapons, this raises several grim possibilities – some which may seem far more unconventional or extreme than others, but none of which seem totally outside the possible windows of North Korean planning and use of such weapons:

- **Creating a Phantom Threat**: North Korea's leader has already effectively signaled that North Korea has the technology to produce biological weapons. Disproving a negative is notoriously difficult, particularly since some commercial dual-use biological, medical, and food processing facilities can be converted relatively quickly, and intent is almost impossible to verify. Sending more specific false signals could not only give North Korea added leverage, but potentially drive the U.S. and its partners into a wide range of high cost defensive measures, and confront nuclear attack planning with the issue of combining nuclear and biological counterforce targeting.

- **Creating a Dual Nuclear-Biological Threat:** North Korea may not be able to create a major nuclear-armed ballistic missile threat to the U.S. for years, but developing a deterrent/strategic leverage strategy based on developing a parallel capacity to attack the U.S. or its partners with biological weapons could greatly undermine the credibility of U.S.-use of nuclear weapons and willingness to escalate.
- **Substituting Biological Weapons for Nuclear Weapons:** The cost and timelines for developing a strategy that sacrifice nuclear weapons for biological weapons could well be far cheaper, far harder to contain, and far harder to launch counterforce attacks against that a nuclear weapons strike – particularly if North Korea calculates it does not need intercontinental capabilities to attack the U.S. if it can attack key allies like Japan. It is also far from clear that any biological weapons control and inspection arrangements can be as effective as those for controlling nuclear weapons efforts.
- **Using Biological Weapons to Limit Escalation to Nuclear Weapons or as a Warning Signal of Intent:** A limited demonstrative use of biological weapons might take place in a major crisis as a signal that North Korea was actually prepared to use nuclear weapons, or respond to any number or all-out conventional attack by using them far more widely.
- **Covert and In-Place Attacks:** North Korea might smuggle in infectious agents, use simple low-cost delivery systems like UAVs or sprayers, or even create limited covert production facilities in South Korea, Japan, and the U.S. Even a phantom version of such a threat could take on a new impact. North Korean exercises using biological weapons covertly to attack the U.S. would also present a major challenge to the U.S. in creating effective defenses – particularly if they are exercised as "defensive" reactions to U.S. use of nuclear weapons.
- **Infectious Weapons:** Most studies assume that no leader or nation would risk using weapons whose spread could not be controlled and where using nation could not immunizes its own population and possibly that of its allies. North Korea's leader has already risked the equivalent of a "doomsday" scenario by going nuclear. Threatening – and actually using – a weapon that would present major control problems is at least a possibility. Attacking Japan, the U.S., or Guam might offer North Korea the equivalent of secure target areas, and so might the use of the DMZ as a barrier to movement by the infected population. Such control would be tenuous, but might be acceptable to North Korea's leader.
- **Use an "Unproven" or Uncertain Agent:** North Korea might weaponize. threaten to use, or actually use an agent whose lethality would not be proven reliably, taking a wide range of risks that its effects could be far smaller or greater than it could predict, whether infectious or non-infectious.
- **Create or Exploit a Biological Weapons Test or "Accident:"** A report of a suspicious death -- particularly from a weaponizable disease or one not found in North Korea -- could be used to signal North Korean capability and be the equivalent of a nuclear test, but would still be deniable.
- **Creating Truly Advanced Biological Weapons**: There are serious debates over the level of biotechnology in North Korea, and over how quickly such weapons can be developed and deployed. As work by the Jason Study made clear in the early 2000s, however, the

biosciences and applied technology are rapidly evolving to the point where at least six new types of bioweapons are now practical or will be relatively soon. They include binary biological weapons, designer genes, gene therapy as a weapon, stealth viruses, host-swapping diseases, and designer diseases.

A straight forward open-source summary of their potential by Lt. Colonel Joel O. Almosara for the USAF Non-Proliferation Center, issued in June 2010, is shown in **Figure Eight** that summarizes one estimate of their current major types and status.[xxi] An equally good additional summary is available in work done by Colonel Michael J. Ainscough, also of the USAF Non-Proliferation Center.[xxii] It should be noted, however, that other experts see the development of such weapons as more challenging and uncertain.[xxiii]

- **Ethnic/Racial/Sub-Group Weapons:** An outlier with today's weapons, but tailoring diseases to attack given races, ethnic groups, or subgroups by unique genetic characteristics. Being able to distinguish Japanese, U.S./Western forces, other nationalities or key subgroups.
- **Agricultural warfare:** Attacking crops or animals for longer-term economic and political effects.
- **BW Terrorist Attacks:** Using limited biological attacks to show the credibility of the North Korean BW threat, intimidate given countries or populations, escalate, target key facilities, or arm proxies, non-state actors, and third parties.
- **Non-Lethal and Incapacitating Attacks:** North Korea might use such attacks to incapacitate key parts of the economy, threaten or undermine a target, demonstrate the credibility of more lethal attacks, and limit the levels of U.S., South Korean, and Japanese response or escalation.
- **Infectious attacks with delayed effects:** Infectious agents can be used that take time to bring on the effects of disease while still being highly infectious – effectively use normal population movement as the main method of dissemination and delivery.
- **Use the DMZ as an attack line and attempt barrier to infection: Figure Nine** draws on an excellent CRS summary of the emerging North Korean nuclear threat to show just how vulnerable North Koreas population would be to even an artillery/multiple rocket launcher attack with biological weapons, and how close Chinese and Japanese populating centers are.[xxiv]
- **Carry Out Human Testing.** One of the key problems in biological weapons development is to determine the real-world effects of a given agent. IHS Jane's seems to rely on uncertain sources, but the character and past conduct of the regime makes the following reporting at least possible:

  Sporadic and inconsistent reports by defectors during 2003-04 and 2009 state that North Korea has conducted testing of biological agents on political prisoners. For example, "... tests are conducted on political prisoners by the College for Army Doctor and Military Officers and Kim Il-sung University Medical College". …During June 2013, Joanna Hosaniak, deputy director general of the Citizens Alliance for North Korean Human Rights, claimed that disabled children were being used by the DPRK for "medical tests such as dissection of body parts, as well as tests of biological and chemical weapons".

> … During July 2015 a curious report appeared that a North Korean scientist named only as "Mr Lee", who was reportedly involved in that nation's BW and CW programs in Kanggye, had defected and was residing in Finland. The report claimed that Mr Lee had brought with him a hard drive containing documents detailing not only those programs but the experimentation on humans.
>
> …Although all of these reports are difficult to confirm, they do conform to older reports of this nature that have occasionally appeared since the late 1970s. Taken as a whole, and within the context of what is currently known about the treatment of political prisoners within the country, such reports suggest a long-standing policy of low-level lethal testing of biological agents on unwilling human subjects.

- **Attack U.S. Bases on Islands to Isolate the Impact of Infectious or Highly Lethal Agents, or to Demonstrate Lethality and Risk to the U.S. of Further U.S. Escalation.** The map in **Figure Ten** draws on the same CRS study to show the vulnerability of U.S bases and facilities in South Korea and the broader region.
- **Use the Threat or Reality of Biological Warfare Escalation to Lever China, South Korea, Japan, and other Asian states.** North Korea has already shown that it can use its nuclear and missile threat to influence South Korea and Guam, and put pressure on China. The risk of escalating to use of biological weapons, the added problems in detection and defense, and the inability to predict North Korean restraint all combine to give North Korea potential leverage.
- **Cooperate with Iran and Other Non-Competing Threats to the United States:** This could involve North Korea sharing of technology, equipment, and agents and toxins with Iran and other strategic partners to cut costs, increase capability more quickly, and obtain critical technologies and equipment. As one unverified example, IHS Jane's reports that an Israeli researcher has claimed that North Korea has given update small power cultures to Syria Extending the range and scope of threat requires the U.S. to respond at considerable cost, and could undermine strategic partnerships because of allied fears. Creating widespread proliferation of true weapons of mass destruction as an international norm would also undermine efforts to limit both nuclear and biological proliferation.
- **Biological Attacks on Key Materials:** Tailor diseases to attack key components and materials.
- **"Doomsday Machine:"** Threaten or actually create a capability to launch a massive attack if North Korea faces nuclear retaliation or a successful invasion. Put agents in place, use infection weapons, and/or attack key South Korean population centers. Accept a high loss of life in North Korea as the price of such action.
- **Lash Out/Revenge/Gotterdammerung Attack**: Carry out a similar last response attack once the leader feels his defeat or overthrow is inevitable.

In short, the threat of North Korea's biological weapons presents two important corollaries to Santayana's statement that those who cannot remember the past are condemned to repeat it. First, one has to speculate about the future – since there is no way to remember it -- and those who remember the past repeat it anyway. Second, history repeatedly shows that the estimated probability of given actions is often more misleading than useful. Time and again, the actual probability of what are perceived to be low probability scenarios before the event turns out to be the eventual reality.

Addendum: South Korea's Civilian Vulnerabilities in War

The Broader Range of North Korean Threats

Any effort to look beyond North Korea's nuclear threat must address the fact that we live in an age of unconventional and asymmetric warfare, and one in which that warfare may take a political and/or economic form or be prolonged and a war of attrition. It must also consider the grim lessons of recent wars. The cost to civilians may go far beyond the number of dead and wounded from direct military attacks in some relatively brief, intense conflict. It may be economic, it may be the impact of being turned into refugees and displaced persons, and it may be a tremendous loss of national wealth, security, and the services that support modern urban life, education, and health.

We are also dealing with a threat in North Korea that has a long, proven track record of pushing massive threat and low-level attacks to the edge of war. It is sometimes called irrational for doing so, but in practice it has so far been able to achieve consistent benefits for its leaders – albeit at considerable cost to its people. Kim Jong-un does take serious risks, but it is important to note that he is one of the world's only third generation dictators, and builds on nearly 70 years of using serious military threats and actual military probes, tests, attacks, and assassinations that have kept his regime in power and given it political status and success.

The Committee should also consider the fact that the North Korea is organized for unconventional and asymmetric warfare, as well as for theater-level nuclear and conventional conflict. It can use weapons of mass destruction and focus on mass casualties. It can also use biological warfare in ways that may be as lethal as or more lethal than nuclear weapons, or in a wide range of scenarios that go from intimidation to limited attacks to joint use of nuclear and biological weapons. This is why I have prepared a statement for the record that focuses on the key risks and uncertainties involved, and the range of options that North Korea might exploit in using such weapons.

At the same time, North Korea can inflict major casualties using more conventional weapons like massed, sustained artillery fire because of Seoul's proximity to the DMZ, and intensely concentrated urban populations in other parts of the country. It could sharply increase such casualties by using chemical weapons – and possibly biological weapons as well—in a direct fire mode.

South Korea's Vulnerabilities

Most strategic analysis tends to focus on military balances, deterrence, and warfighting, and not the vulnerability and cost to civilian populations. When estimates are made of civilian casualties, many lack credible modeling and data and are little more than guesstimates. The fact remains, however, that South Korea is an ally with some unique vulnerabilities.

South Korea has a relatively large total population—some 51 million compared to only around 25 million for North Korea. This population compares with only around 21 million at the time of the Korean War, and one that was heavily agricultural and to some extent self-sustaining in rural areas. Today the population is over 80% urbanized—only about 5% of work force is in agriculture. Over 70% is in largely urban services, and most of the rest in manufacturing. Like most Americans, it is a population geared to modern life in a country with a $2 trillion dollar GDP in PPP terms, and $1.4 trillion in Market GDP terms. Peacetime living standards are high among global standards. South Korea has a GDP per capita of $38,000.

To put these figures in perspective, the CIA estimates that North Korea has a GDP of only $45-50 billion in PPP terms and $30 billion in market or foreign exchange terms, and a per capita income of only $1,700-1,800 per capita—with much of its wealth concentrated in its leaders, security forces, party members, and show piece capital.

South Korea also is extremely dependent on the constant flow of trade. South Korean exports total well over $500 million, and imports total over $400 million. Like Japan., South Korea is critically dependent on its seaports and airports for trade, but also for its energy supplies. It economy is also "fragile" in the sense that the secure flow of trade movement, and services is just as critical as in any major American city.

The Risks Inherent in a Major War Involving a Modern Urbanized Trading Nation

South Korea's population now lives in a country that is highly developed, but is also one where approximately 70% of the country is considered mountainous and it is concentrated in cities in the lowland areas, where the population density is very high in a limited number of target areas where displaced persons and refugees have few outside alternatives with any serious surplus capability to provide food, shelter, and services. Its population density also varies sharply in the areas nearest to North Korea. Gyeonggi Province in the northwest, which surrounds the capital of Seoul and contains the port of Incheon, is the most densely populated province. Gangwon in the northeast is the least populated.

The greater Seoul area alone has a population of over 25 million—close to half the 51 million population of the ROK and a far larger population than all of its other cities combined. More than 10 million people live in its city limits, and its core has a population density of well over 17,000 to people per square kilometer and 45,000 per square mile—twice the density of New York, four times that of Los Angeles, and eight times that of Rome. Just one of its 25 districts has 680,000 people. According to some sources, it is the largest single urban complex in the free world.

While Seoul is the key to the ROK's short range vulnerability, five other urban centers also define South Korea's broader vulnerabilities and ability to ride-out and recover from a major conflict. The CIA World Factbook lists the population of these cities as follows: Busan (Pusan) 3.216 million; Incheon (Inch'on) 2.685 million; Daegu (Taegu) 2.244 million; Daejon (Taejon) 1.564 million; and Gwangju (Kwangju) 1.536 million (2015). These cities do not have the sheer scale of urban sprawl of many American cities, and—coupled with South Korea's high levels of development– this adds to its urban and national vulnerability.

South Korea's need for secure maritime routes and ports and air traffic and airports also adds to its vulnerability. South Korea depends on secure maritime and land transit/access traffic to 7 seaport(s): Busan, Incheon, Gunsan, Kwangyang, Mokpo, Pohang, Ulsan, Yeosu. It depends on 3 major container port(s) (TEUs): Busan (19,469,000), Kwangyang (2,327,000), Incheon (2,368,000) (2015). It can conduct naval raids, use midget or other submarines, and use cargo ships to release floating mines—as Iran did in 1987-1988. It is unclear that it has smart mines, but—if it does—any ship with a false flag or submarine could release mines that rest on the bottom, can be set to activate at intervals, and rise up and strike given types of ships based on their sonic signature.

The CIA reports that current air traffic volume is 65+ million passengers a year and 11.2 billion metric tons-km. South Korea has 71 airports, but only 4 major airports, and up to 19 others that might handle some additional traffic. At least 40 are unpaved or unsuitable for long-range traffic. A few Man Portable SAM firings or airport killings could have a major impact in terms of wars of intimidation and threat and counter threats.

At a higher threshold of conflict, North Korea's current long-range conventional weapons seem to have sharp limits on their ability to strike point targets, but a number of reports make it clear that North Korea is developing a range of precision ballistic missiles, cruise missiles, and UCAVs and some reports indicate such capabilities may already exist.

Precision strikes with conventional warheads on South Korea's power grid, water purification and distribution facilities, sanitation facilities, key bridges and rail/road links, and key communications points could turn such weapons into "weapons of mass effectiveness." Sabotage, terrorism, or special forces raids could also have major impact.

The same is true of South Korea's energy situation. It gets 71% of its power from fossil fuels, and 21% from nuclear plants. It needs safe facilities to import 90%+ of its natural gas and around 3 MMB of crude oil plus 900,000 bpd in petroleum products. Moreover, *Oil & Gas Journal* (OGJ) and EIA reports that 3 of the 10 largest crude oil refineries in the world are located in South Korea, making it one of Asia's largest petroleum product exporters – as much as 1.3 mbpd. South Korea also depends heavily on imports from six LNG terminals: Incheon, Kwangyang, Pyeongtaek, Samcheok, Tongyeong, and Yeosu.

There are other areas of special vulnerability. South Korea is an "Internet society" with nearly 90% Internet access. There is no credible way to measure the cyber vulnerability of its economy and critical infrastructure, but it could be great. Some past estimates have downplayed North Korea's capabilities in these areas, but experts now question the extent to which North Korea has created an effective elite of attackers, and how difficult it is to create cadres that can exploit the weaknesses and vulnerabilities in civilian IT systems and networks. These are areas where there are severe open source limits to assessments of the capabilities of the KPA General Staff Department and Reconnaissance General Bureau (RGB), as well as the Ministry of State Security. Some South Korean sources claimed, however, in 2015 that North Korea had approximately 5,900 personnel engaged in cyber warfare.

War and the Greater Seoul Region

One truly successful nuclear or biological attack on Seoul alone could cripple South Korea's recovery capability for a decade, and create massive problems in the short term for the global economy that could severely restrict South Korea's ability to recover its markets and trade over time. Nuclear strikes on two to three cities would raise serious questions about South Korea's ability to recover over time, as would distributing infectious or highly lethal biological agents.

South Korea's very success, however, makes it highly vulnerable to a major conventional invasion and highly vulnerable to a range of unconventional attacks. A land war that swept down into Seoul and the eastern part of the DMZ area could have far worse displacement problems than the world has seen in Syria, Iraq, or Yemen – mountains, by sea, loss of key airport and possible ports. As other recent wars have shown, water, power, sanitation, food, medical services, shelter, and any form of security and education for children would all be critical issues.

As the fighting in Mosul and other Iraqi, Syrian, and Yemeni cities has recently shown, conventional warfare can all too easily ruin the security of millions, and kill or cripple thousands of others in the process that are never reported as casualties of war.

This is why so many studies of the North Korean warn of the threat posed by North Korean shelter artillery posts near the DMZ. These artillery positions can be as a close as 54 kilometers—33 miles from City center. North Korea, however, has a steadily increasing stock of multiple rocket launchers with much longer ranges, and some sources credit them with chemical and even biological warheads.

According to unclassified sources like IHS Janes, there are HARTS (hardened artillery shelters) all along DMZ tailored to region and topography. These hardened artillery sites are fortified fighting positions with gun emplacements, personnel shelters, fire direction centers, trenches for self-defense and communication, and protective cover for prime movers to alter weapons locations. Each weapon has its sheltered emplacement and ammunition supply with connecting passages and emplacements tailored to the local terrain and angles of fire. They are defended with wire and minefields. In many cases, it would take earth penetrators to destroy them and a delivery system with line-of-sight or imagery links to target therm.

To quote from a recent IHS Jane's report,

> North Korea possesses the largest rocket and ballistic missile force in the developing world. Within North Korea, ballistic missiles (i.e., Hwasong-6/-7, KN-02/-10, and KN-07/-08/-14) are controlled by the Strategic Force (see Strategic Weapon Systems), and artillery rockets are controlled by the General Staff and its Artillery Bureau.
>
> Since 2010, North Korea has developed and deployed (sometimes in very limited numbers) new versions of 122 mm, 240 mm and 300 mm MRL systems. The most significant of these is the eight-round (in two, four-round, pods) 300 mm system, which reportedly has a range in excess of 100 km and may employ a GPS guidance system.

Some estimates almost certainly sharply exaggerate the probable number of direct casualties from the conventional use of such weapons, but direct military deaths are scarcely the only measure of human suffering. Moreover, North Korea has two other methods of unconventional attack that merit serious examination, but where unclassified reporting has severe – if not critical– limits.

The casualty, panic, and disruption impacts of such attacks would also be far greater if North Korea used chemical and/or biological weapons. The open source reporting on such North Korean capabilities is highly questionable. These issues are discussed in detail for biological weapons in separate testimony.

Reports that North Korea has stockpiled as many as 20 different chemical agents seem to sharply exaggerate the threat. However, North Korea probably does have a substantial stockpile of artillery rounds, rockets, missiles and bombs that can deliver effective persistent area denial weapons like Mustard Gas that could kill many civilians as well, and both short-term and persistent versions of nerve agents. Even a few rounds of such weapons could easily produce massive panic, and a major barrage could be a truly horrifying killing mechanism.

Special Forces, DMZ Tunnel, and Intelligence Branch Attacks

Again, the details in open source data are questionable. However, the broad nature of the threat is not. IHS Janes also reports that North Korea has built approximately 20-25 such tunnels under the DMZ, and only four have been publicly identified and neutralized by South Korean/US forces.

One of the tunnels that has been discovered had a total length of 3,300 meters, and went 1,100 meters into South Korean territory. It was 50-150 meters deep, and two meters by two meters. Janes reports that as many as 8,000 troops an hour could move through them.

Sudden raids into the Seoul area might never come close to taking the city, but could have a massive disruptive effect. Moreover, such tunnels might be used to infiltrate large numbers of Special Forces who might be able to pass as civilians. According to IHS Janes and the IISS, North Korea is reported to have some 200,000 Special forces, organized into some 60,000 "storm" troops and 140,000 light infantries. IHS Janes quotes General Walter Sharp, who once commanded the South Korean-US Combined Forces Command as saying in 2014 that, "The havoc-raising potential of North Korea's special forces has grown as their numbers have increased and their training has shifted to terrorist tactics developed by insurgents in Iraq and Afghanistan...They are very capable, and they will employ these tactics." A major infiltration into the Seoul area might never succeed in classic military terms, but could be intensely disruptive and have a major civil impact.

There also serious questions as to whether North Korea has sleepers or trained infiltrators outside its special forces in organization like its KPA General Staff Department and Reconnaissance General Bureau. Again, to focus on open source material, HIS janes reports that the RGB is the primary organization tasked with collecting foreign tactical and strategic intelligence, and co-coordinating or conducting all external special operations. It also exercises operational control over agents engaged in military intelligence activities and oversees the training, maintenance, and deployment of guerrilla teams available for operation in the south.

Guarding a Strategic Partner and Ally

It should be apparent that this analysis does focus on "worst cases" to some degree. One of the grim realities of war, however, is that war after war has escalated to a real-world "worst case" that none of those who launched or planned for the conflict intended. It is also probably fair to say that all major wars have been "unconventional" in terms of the actual fighting relative to the plans and intentions of the actors that began them.

If nothing else, the risks described in this testimony, and that are the focus of this committee, should remind us that we all have a deep moral and ethical responsibility to South Korea and all of our strategic partners. We must not simply plan to deter, or to win at a tactical or kinetic level. We must plan to do everything we can to protect an ally or partner's civilians and living standards as well.

Figure One: Illustrative Estimate of Comparative Effects of Biological, Chemical, and Nuclear Weapons Delivered Against a Typical Urban Target

Using missile warheads: Assumes one Scud-sized warhead with a maximum payload of 1,000 kilograms. The study assumes that the biological agent would not make maximum use of this payload capability because this is inefficient. It is unclear this is realistic.

	Area Covered in Square Kilometers	Deaths Assuming 3,000-10,000 people Per Square Kilometer
Chemical: 300 kilograms of Sarin nerve gas with a density of 70 milligrams per cubic meter	0.22	60-200
Biological 30 kilograms of Anthrax spores with a density of 0.1 milligram per cubic meter	10	30,000-100,000
Nuclear: One 12.5 kiloton nuclear device achieving 5 pounds per cubic inch of over-pressure	7.8	23,000-80,000
One 1 megaton hydrogen bomb	190	570,000-1,900,000

Using one aircraft delivering 1,000 kilograms of Sarin nerve gas or 100 kilograms of Anthrax spores y. Assumes the aircraft flies in a straight line over the target at optimal altitude and dispensing the agent as an aerosol. The study assumes that the biological agent would not make maximum use of this payload capability because this is inefficient.

	Area Covered in Square Kilometers	Deaths Assuming 3,000-10,000 people Per Square Kilometer
Bright Sunny Day		
Sarin Nerve Gas	0.74	300-700
Anthrax Spores	46	130,000-460,000
Overcast day or night, moderate wind		
Sarin Nerve Gas	0.8	400-800
Anthrax Spores	140	420,000-1,400,000
Clear calm night		
Sarin Nerve Gas	7.8	3,000-8,000
Anthrax Spores	300	1,000,000-3,000,000

Source: Adapted by Anthony H. Cordesman from Office of Technology Assessment, Proliferation of Weapons of Mass Destruction: Assessing the Risks, US Congress OTA-ISC-559, Washington, August, 1993, pp. 53-54.

Figure Two: Lethality and Stability of FSU Biological Weapons in the Late 1990s

Weapons Type	Q_{50} in Open Air Deployment (liter or kilogram per square kilometer)	Stability
Liquid Plague	3.5-4.5	--1-2 hours in air
Dry Tularemia	3.0-4.0	--several hours to one day in air
Old Dry Anthrax	15-20	--days and weeks in the air, and
New Dry Anthrax	4.5-5.0	years on surfaces
Liquid Anthrax	5.0-5.5	
Dry Brucellosis	3.5-4.5	--up to 2 days in air
Liquid Glanders/Meliodosis	4.5-5.5	--several hours in air
Liquid Smallpox	3.5-4.0	--up to 24 hours in air
Dry Marburg	minus 1.0 dry	--30 minutes liquid in air and several hours
Q fever	-	-- to several days in air
Glanders	-	--several hours in air
Liquid Ebola	- dry	--30 minutes liquid in air and several hours
Coccidioidomycosis	-	--days and weeks in the air

Q_{50} = Amount of agent needed to infect 50% of the exposed population or troops evenly distributed over a square kilometer. These calculations are based on a lethal dose (LD_{50} of 10000-20000 spores for anthrax, 200-400 (up to 1,000?) bacterial cells for Brucellosis, 100-200 (up to 1,000?) bacterial cells for Glanders, 500-1500 bacterial cells for Plague, 10-100 bacterial cells for Tularemia, 1-3 cells for Q fever, 1-10 virons for Ebola, 1-10 virons for Marburg, 5-10 virons (up to 50?) for smallpox, and 10-100 arthospors for Coccidioidomycosis.
Source: adapted from Ken Alibek, "Biological Weapons/Bioterrorism Threat and Defense, - Past, Present, and Future," Paper prepared for the ETH international conference on "Meeting the Challenges of Bioterrorism: Assessing the Threat and Designing Biodefense Strategies, Furigen, Switzerland, April 22-23, 2005.

Figure Three: Area Coverage and Casualty Impact of Line Source Type of Biological Attack

Agent	Downwind Area Reach in Kilometers	Number of Casualties Dead	Incapacitated
Rift Valley Fever	1	400	35,000
Tick Borne Encephalitis	1	9,500	35,000
Typhus	5	19,000	85,000
Brucellosis	10	500	125,000
Q Fever	20+	150	125,000
Tularemia	20+	30,000	125,000
Anthrax	20+	95,000	125,000

Note: Assumes 50 kilograms of agent along a two-kilometer line upwind of a population center of 500,000.

Source: George Christopher et al, “Biological Warfare: A Historical Perspective,” Journal of the American Medical Association, 278, No. 5, August 6, 1997.

Figure Four: Possible Classic DPRK Biological Agents

TYPE	SYMPTOMS/CHARACTERISTICS	STATUS
Bacteria		
Bacillus anthracis (Anthrax)	Pulmonary (inhalation): difficulty breathing, exhaustion, toxemia, terminal shock. Cutaneous (skin): itching, small lesions and possible blood poisoning. Intestinal: nausea, fever, diarrhea. Mortality (if untreated): Pulmonary 80–95%; Cutaneous 5–20%; Intestinal 25–60%. Incubation period: Symptoms usually occur with 7 days. Not contagious.	Possibly weaponized, with delivery system
Vibrio cholera (Cholera)	Diarrhea, vomiting, and leg cramps. Rapid loss of body fluids, dehydration and shock. Mortality (if untreated): 5–10%. Death in 1–3 hours. Not contagious.	Unknown
Yersinia pestis (Plague)	Fever, headache, exhaustion, swollen lymph nodes, blood infection, and pneumonia. Mortality (if untreated): 50–60%. Incubation period: 1–3 days, death in 2–6 days. Contagious.	Unknown
Salmonella Typhi (Typhoid Fever)	Fever, malaise, chills, stomach pains, headache, loss of appetite, and rash. Mortality (if untreated): 12–30%. Contagious.	Unknown
Typhus	Fever, headache, chills, whole body rash, and general pains. Mortality (if untreated): 30–50%. Incubation Period: 6–12 days. Not contagious.	Unknown
Mycobacterium tuberculosis (tuberculosis)	Coughing, chest pain, fatigue, loss of appetite, chills, fever, and coughing blood. Mortality (if untreated): 30–50%. Incubation period: 14 days–1 year. Contagious.	--
Virus		
Hemorrhagic fever (Korean Strain)	Fever, fatigue, dizziness, muscle aches, exhaustion, internal bleeding, coma, delirium, and seizures. Mortality (if untreated): 5–15%. Incubation period: 7–17 days. Contagious.	Unknown
Variola (smallpox)	Fever, malaise, aches, rash, and crusting scabs. Mortality (if untreated): 30–40%. Incubation: 7–17 days. Contagious.	Unknown
Yellow Fever	High fever, chills, headache, muscle aches, and vomiting; can lead to shock, kidney, and liver failure. Mortality (if untreated): 5–40%. Incubation: 3–6 days. Not contagious.	--
Toxin		
Clostridium Botulinum (Botulism)	Nausea, weakness, vomiting, and respiratory paralysis. Mortality (if untreated): 60–90%. Incubation: 12–36 hours after inhalation. Death in 24–72 hours. Not contagious.	Unknown

Note: World Health Organization, http://www.who.int/csr/delibepidemics/en/annex3May03.pdf; NATO, *Handbook on the Medical Aspects of NBC Defensive Operations AmedP-6(B)*, http://www.fas.org/nuke/guide/usa/doctrine/dod/fm8-9/2toc.htm; and US Army Medical Research Institute of Infectious Diseases, *Medical Management of Biological Casualties Handbook*, http://www.usamriid.army.mil/education/bluebook.html; and Centers for Disease Control, http://www.cdc.gov.

Source: Nuclear Threat Initiative, "North Korea: Biological," http://www.nti.org/country-profiles/north-korea/biological/; Chipman, "North Korea's Chemical and Biological Weapons (CBW) Programs," *North Korea's Weapons Programs*, 50.

Figure Five: Some "Classic" Examples of Possible North Korean Biological Facilities

Aeguk Compound Microbe Center	R&D and production of microbial-based fertilizer supplements.
Aeguk Preventative Medicine Production Factory	Comprised ten laboratories and various workshops devoted to R&D and production of vaccines and medicines. The main product has been hepatitis B vaccine.
Branch Academy of Cell and Gene Engineering	One of nine research branches of the Academy of Sciences. Conducts research on cellular biology and genetic engineering.
National Sanitary and Anti-Epidemic Research Center	Administers quarantines and provides inoculations against various diseases.
Endocrinology Institute	Mainly diagnoses and treats diabetes.
Industrial Microbiology Institute	R&D and production of microbial cultures.
Munchon Agar Plant	Agar (growth media) production. As of 1992, the annual agar production capacity was 200 tons.
Pharmaceutical Institute of the Academy of Medical Sciences	R&D of medicaments. Reportedly located in Pyongyang.
Pyongyang Pharmaceutical Factory	As of August 2000, the factory produced seven drugs, including antibiotics and multivitamins. Has received raw materials and support from UNICEF and Diakonie Emergency Aid of Germany.
Synthetic Pharmaceutical Division, Hamhung Clinical Medicine Institute	R&D of medicaments and clinical diagnostics.
Taedonggang Reagent Company	R&D of vaccines. Previously known as the November 19 Institute.

Sources: NTI, "North Korea: Biological"; "DPRK's NAS Pursues Cultivation of Stock Bacteria for Microbial Fertilizers," Chungang Ilbo, January 17, 2000; "DPRK Korea Donor Update," UNICEF Emergency Programs, August 7, 2000, http://www.reliefweb.int; Chipman, "North Korea's Chemical and Biological Weapons (CBW) Programs," *North Korea's Weapons Programs*, 50.

Figure Six: Map of Possible North Korean Biological Facilities

Source: Chipman, "North Korea's Chemical and Biological Weapons (CBW) Programs," *North Korea's Weapons Programs*, 57.

Figure Seven: More Recent List of Suspected Facilities

1st Biological Research Institute	State Academy of Sciences	Pyongyang
25 Factory (also known as February 25 Factory)	State Academy of Sciences	Chongju
2nd Biological Research Institute	State Academy of Sciences	Hamhung
3rd Biological Research Institute	State Academy of Sciences	Haeju
Bio-engineering Branch	State Academy of Sciences	Pyongyang
Central Biological Research Institute (may be the same as the Medical Research Institute)	Second Academy of Defense Sciences	
Central Biology Institute (also known as Central Biological Institute, Central Germ Research Laboratory)	Academy of Sciences	
Chemical and Biological Defense Research Centre	Nuclear-Chemical Defense Bureau, Korean People's Army	Pyongyang
College for Army Doctor and Military Officers (also known as Armed Forces Medical College)	Ministry of People's Armed Forces	Pyongyang
Experimental Biology Institute, Biological Branch	State Academy of Sciences	Pyongyang[1]
Kim Hyong-chik University of Military Medicine (also known as University of Military Medicine)	Ministry of People's Armed Forces[1]	Pyongyang
Kim Il-sung University Medical College	State Academy of Sciences	Pyongyang
Hygienic and Anti-Epidemic Center		Pyongyang
Medical Biology Institute	State Academy of Medical Sciences	
Microbiology Institute (also known as Institute of Microbiological Diseases, Institute for Medical Science, Microbiological Laboratory)	Academy of Sciences	Pyongsong
No. 25 Factory (aka February 25th Factory)	State Academy of Sciences	Chongju
Ponghwa Clinic Laboratories	Ministry of Health	Pyongyang
Pyongyang Medical College (Pyongyang University of Medicine)	State Academy of Sciences	Pyongyang

Preventive Medicine Unit	Ministry of People's Armed Forces/ General Staff Department, Korean People's Army	
U/I agar production facility[2]	State Academy of Sciences (?)	Munch'on
Vaccination Institute of the Central Sanitary Quarantine Institute	State Academy of Sciences (?)	

Notes: One defector has stated that a test station for biological warfare exists in Yangdok-gun, P'yongan-namdo. However, this remains to be confirmed.

In October 2001, a member of the South Korean National Assembly National Defense Committee stated, "The fact that facilities for manufacturing biological and chemical weapons was newly built at the area of Chagang Province of North Korea in December last year was confirmed by the military authorities." The precise location of the biological facility is presently unknown.

Source: Joseph H. Bermudez, June 2017, *Overview of North Korea's NBC Infrastructure*, 38 North, The North Korean Instability Project, http://www.38north.org/wp-content/uploads/pdf/NKIP-Bermudez-Overview-of-NBC-061417.pdf, p. 121; Hyun-Kyung Kim, Elizabeth Philipp, and Hattie Chung for the Belfer Center at Harvard, *North Korea's Biological Weapons Program, The Known and Unknown,* October 2017; IHS Jane's, *"Biological Capabilities, North Korean Strategic Weapon Systems," Jane's Sentinel Security Assessment - China and Northeast Asia*, Posted: 29-Nov-2017

Figure Eight: Almosara Summary of Trends in Advanced Bioweapons

(Excerpted from Lt. Colonel Joel O. Almosara, *Biotechnology: Genetically Engineered Pathogens*, The Counterproliferation Papers, Future Warfare Series No. 53, USAF Non-Proliferation Center, June 2010)

Binary biological weapons: This bioweapon is made up of a two-component system with independent elements that are safe to handle separately but when mixed together form a lethal combination. This system consists of a virus and helper virus, or bacterial virulence plasmid. Hepatitis D is an example of a virus and B as the helper virus; a combination of both produces severe infection to the host. "Hepatitis D needs to infect cells simultaneously with the unrelated virus hepatitis B; both are primarily transmitted through sexual contact or by contaminated blood or needles. The D virus takes advantage of the proteins expressed by the larger B virus, and greatly increases the severity of disease caused by hepatitis B. Infection by hepatitis D alone is not possible."

Examples of bacterial virulence plasmids are the plague (Yersinia pestis), anthrax (Bacillus anthracis), dysentery (Shigella dysenteria), and E. coli (Escherichia coli)….State of the Bioweapon: Binary biological weapons are already in existence. The process of generating this potential bioweapon has been decoded as revealed by a former Soviet Union defector. In 1992, a defector from the former Soviet Union code-named "Temple Fortune," described his experience with binary biological weapons. He revealed that the former Soviet Union secretly continued research on a "new and improved super-plague" (Yersinia pestis) despite President Yeltsin's order to end their offensive biological warfare program. The defector explained that the super-plague "would not only be more resistant to multiple antibiotics but it would be made with a special new process…In its initial form, the plague would not be virulent – so it would be safe to handle and store…Russian Scientists had found a way to convert this non-toxic plague back into a deadly, antibiotic-resistant form as soon as it was needed for weaponization."

It could also be argued that nations who have the equipment, material, resources, and knowledge could very easily produce these genetically engineered pathogens. Binary biological weapons are good candidates for future use because of their benign properties making them easy to store and handle. Because the components are not independently dangerous or hazardous they can easily be transported requiring less signatures for manufacturers. This also makes tracking more difficult.

Because of its properties and ability to be stored in large volumes for a long period without causing any harm, it is presumed that Russia still maintains this bioweapon. Future Application: The binary biological weapons processes are already known and are here to stay. In the wrong hands, bioweapons are an impending and dangerous threat.

Designer Genes and Life Forms: The successful completion of the human genome project paved the way to understanding the nature and content of the complex genetic information that could be used to create new biological life forms. There are about 599 viruses, 205 naturally occurring plasmids, 31 bacteria, 1 fungus, 2 animals, and 1 plant genomic sequence known to date…. This wealth of information regarding human genomes could expand the life forms using synthetic genes, synthetic viruses, and synthetic organisms….

Using the technique called recombinant DNA technology (gene splicing), a single gene is inserted in an organism to alter its genetic properties. An example is the splicing of genes to produce insulin for diabetics. Genes responsible for generating insulin are spliced into plasmid DNA that can then infect bacteria. The infected bacteria will then multiply, and the product is a large amount of insulin for medicinal purposes. The designer genes have been one of the greatest breakthroughs in the field of biotechnology…

…Despite the benefits of this biotechnology, the perils cannot be overlooked because genes can be programmed into an infectious state that could easily be transformed into a bioweapon.
DNA shuffling—also known as multigene shuffling, gene shuffling, and directed in vitro molecular evolution—has allowed scientists to greatly improve the efficiency with which a wide diversity of genetic sequences can be derived. A quantum leap in the ability to generate new DNA sequences…can be used to produce large libraries of DNA that can then be subjected to screening or selection for a range of desired traits, such as improved protein function and /or greater protein production.

State of the Bioweapon: Designer genes could become the most lethal form of bioweapon of the future. Nations that are interested in developing lethal weapons can openly use the genomic sequence databases to choose the genes they

want to design. One assessment noted, "The ever-expanding microbial genome databases now provide a parts list of all potential genes involved in pathogenicity and virulence, adhesion and colonization of host cells, immune response evasion and antibiotic resistance, from which to pick and choose the most lethal combinations."

This biotechnology undoubtedly offers great opportunities for medical purposes, but it could also have a significant impact in the production of genetically engineered pathogens resistant to drugs or vaccines, and increase virulence well-suited for bioweapons…Imagine using synthetic viruses to recreate the Spanish Flu pandemic of 1918 that killed 20 million people; the worst ever in history. With this wealth of information, it would be possible to create diseases using synthetic viruses that could wipe out an entire population.

The scientific and technological breakthroughs in genetically engineered pathogens have already changed the future outlook of the biological weapons and its threat. In October 2004, the Spanish Flu strain of 1918 was partially reconstructed by researchers at the University of Wisconsin using reverse engineering techniques. The influenza A virus was fully sequenced and characterized the following year. Experts predicted that, "Although, the knowledge, facilities, and ingenuity to carry this sort of experiment are beyond the abilities of most non-experts at this time, this situation is likely to change over the next 5 to 10 years".

… This is the bioweapon to watch for in the next 25 years. This technology is highly complex and only nations or groups that have biotechnological capabilities will be able to develop these genetically engineered pathogens. Advancements will continue to increase as the scientific world keeps finding new and innovative ways to manipulate human genetics.

Gene Therapy as a Weapon: ...There are two classes of gene therapy: germline (reproductive) and somatic cell (therapeutic). The DNA changes in a germline cell give it the capability to correct a bad gene allowing this new fix to be passed on through generations. Somatic cell gene therapy is different in that it can only affect the individual who received it Gene therapy has already been used in both animal research and human clinical trials.

Numerous examples of successful gene therapy application have been published and shown to have promising results…Another significant gene therapy outcome was the mousepox virus experiment in Australia. Researchers inadvertently developed a lethal mousepox virus while attempting to prevent the plague, within the mice population. This genetically altered virus attacked the immune systems of the experimental mice; it killed all of them. Researchers also found that sixty percent of those mice previously vaccinated died within days of exposure.

Though the progress of gene therapy is significant, there are more questions to answer and techniques to refine before this therapy becomes a viable treatment for many types of diseases. Although this was unintentionally created, if the same modified virus was added to smallpox, it could present the same lethality for humans.

Gene therapy is expected to gain in popularity. It will continue to be improved upon and could unquestionably be chosen as a bioweapon. The rapid growth in biotechnology could trigger more opportunities to find new ways to fight diseases or create new ones. Nations who are equipped to handle biotechnology are likely to consider gene therapy a viable bioweapon. Groups or individuals without the resources or funding will find it difficult to produce this bioweapon.

Stealth Viruses: The basic concept of this potential bioweapon is to "produce a tightly regulated, cryptic viral infection that can enter and spread in human cells using vectors" (similar to the gene therapy) and then stay dormant for a period of time until triggered by an internal or external signal. The signal then could stimulate the virus to cause severe damage to the system. Stealth viruses could also be tailored to secretly infect a targeted population for an extended period using the threat of activation to blackmail the target.

…Stealth viruses just like the gene therapy, require a vector to be inserted in the body and lay dormant until a trigger mechanism is activated either internally or externally. Imagine having a cancer-causing virus enter a human cell and lay dormant until an external signal triggers the disease. When the signal gets activated the cells become abnormal and could rapidly generate abnormal cell growth leading to a tumor and ultimately, death. Now, apply this concept to a population where an HIV virus gets disseminated within a target population. At a specific time chosen by the perpetrator, the signal would be triggered to harm an entire population all at once. Although this bioweapon is futuristic it is not improbable and deserves to be examined.

… Stealth viruses could become a potential bioweapon in the year 2035. There is much more to learn about the timing of the triggering mechanism to make this a feasible bioweapon. However, with the rapid rise in biotechnology, nations who have the capabilities to conduct research and development could certainly attain that level of knowledge. It would be highly unlikely to see groups or individuals possessing this bioweapon.

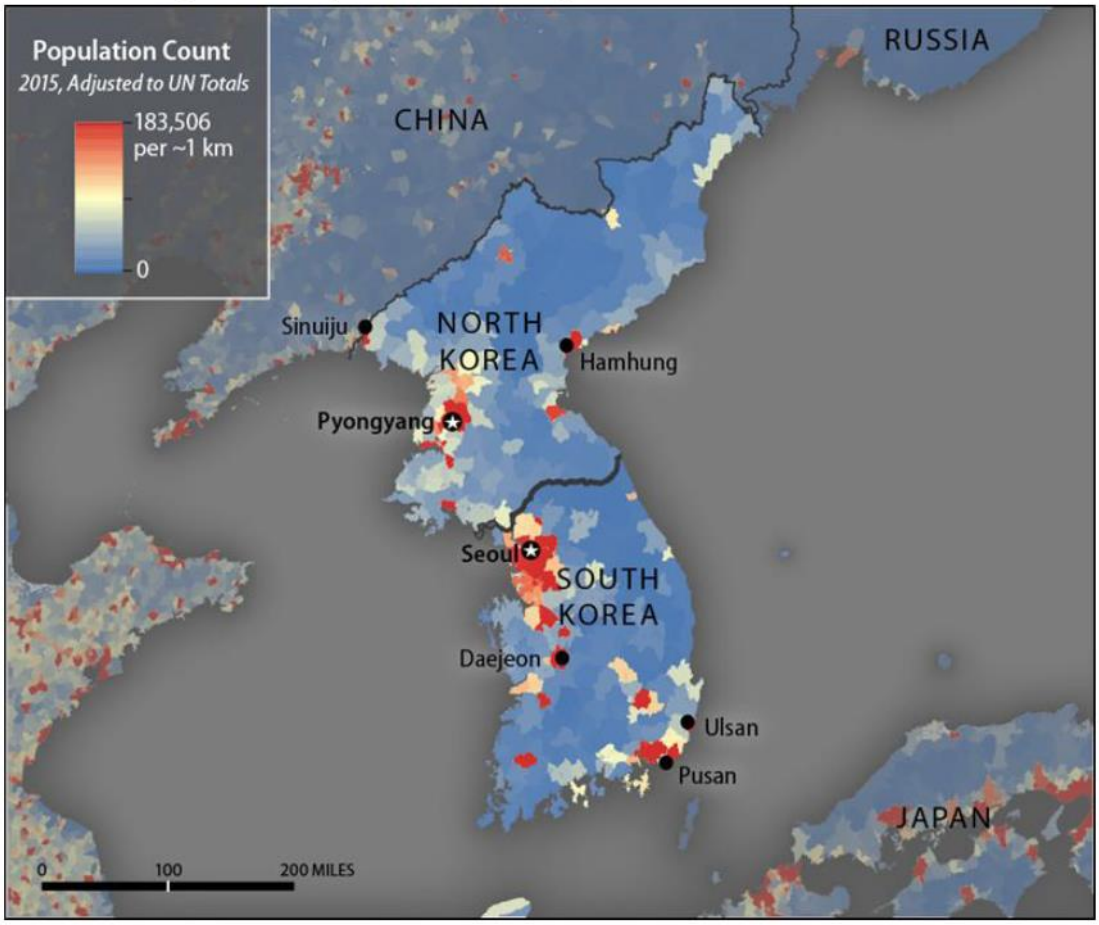
Host Swapping Diseases: Most viruses do not cause disease and are mainly considered parasites. They exist in evolutionary "equilibrium" with their host ranges, but if the "equilibrium" is disrupted, two things could happen; either the viruses become virulent or benign. Disruption of "equilibrium" occurs when a virus jumps out of its host range and transfers to a different host species where it could create another virus by mutating or picking up other genes by mistake. Animal viruses usually reside naturally in a "reservoir" or certain animal species and cause little to no damage to its host. Eastern equine encephalitis uses water fowl for its reservoir, rodents carry hantavirus, bats are the hosts for Ebola virus, and chimpanzees for the AIDS virus. When these viruses move out of their natural host reservoirs they eventually produce extremely lethal pathogens.

…The host swapping diseases are already an emerging biological warfare threat. They are also classified by the Center for Disease Control and Prevention as a Category A, meaning high-priority agent…. It could be argued that host swapping diseases as a bioweapon are already in existence. Nations, groups, and individuals could have fairly easy access to this bioweapon. With the rapid increase in biotechnology and with its dual-use nature, these genetically engineered pathogens can be extremely debilitating to a populace.

Designer Diseases: The knowledge of cellular and molecular biology has progressed nearly to a point where it may be possible to conceptually design a disease first and then create the pathogen to produce the desired effect of that disease. These designer diseases might work by attacking the immune system to affect the cells' natural ability to fight diseases (i.e., HIV virus causes AIDS), or it might reactivate dormant genes to cause destruction of cells (spread of cancer), or simply instruct cells to commit suicide and die (programmed cell death or "apoptosis"). Apoptosis can be useful in curing diseases like cancer. But, it can also be used to activate "death pathways" that could kill all cells at once…

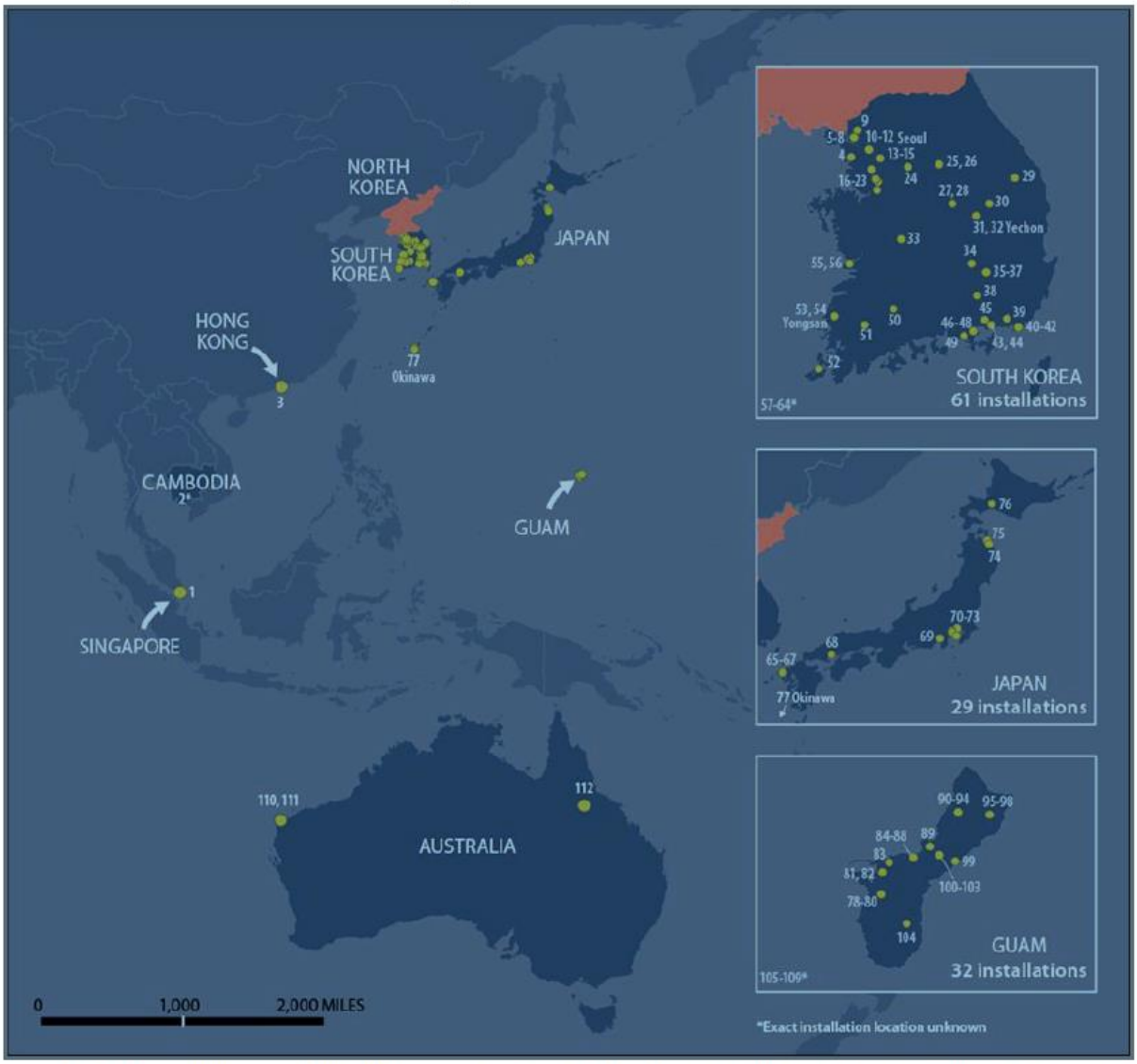
…The designer diseases are certainly a futuristic bioweapon but by no means inconceivable. Imagine designing a disease that could wipe out the whole population or a certain ethnic group? These bioweapons demand more investigation and research to fully understand their nature, properties, and potential harm….Designer diseases could be a viable candidate as a potential bioweapon in 2035. These bioweapons deserve to be further evaluated for future research. Nations who have the resources and capabilities to conduct research and development could certainly attain the knowledge to make this bioweapon a reality. It would be highly unlikely to see groups or individuals possessing this bioweapon.

Figure Nine: Short Range Vulnerability of South Korea's Population



Sources: Graphic created by CRS. Information generated by Hannah Fischer using data from the NASA Socioeconomic Data and Applications Center's Gridded Population of the Word, v4, with a UN-adjusted population count (2015), available at http://sedac.ciesin.columbia.edu/data/set/gpw-v4-population-count-adjusted-to-2015-unwpp-country-totals; Department of State (2015); Esri (2016); DeLorme (2016).

Figure Ten: Vulnerability of U.S. Bases in Asia and Possible Island Targets



Sources: Graphic created by CRS. Information generated by Hannah Fischer using data from the Department of Defense Base Structure Report, FY2015, available at https://www.acq.osd.mil/eie/Downloads/BSI/Base%20Structure%20Report%20FY15.pdf; Department of State (2015); Esri (2016).

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