Biological Threats and Deterrence by Denial

Tony Boyles
Georgia Institute of Technology
INTA 8803MK: Deterrence in the 21^{st} Century
Fall 2010
Prof. Margaret Kosal

Introduction (or How I Learned to Stop Worrying and Start Loving the Germ)

The Biological Weapons Convention of 1972 states in its preamble, "[…] that such use [of bioweaponry] would be repugnant to the conscience of mankind and that no effort should be spared to minimise this risk." Despite this noble sentiment, humans have employed biological agents in warfare and violence since the dawn of recorded history. The earliest uses were simplistic—adaptation of frog toxins for use on arrowheads by the indigenous populations in the Amazon. A growth in the sophistication of biological weapons did not occur until much later, with most biological attacks following the logic of the poisoned arrowheads: If I am exposed to a toxin, I become ill; therefore, if I expose an enemy to a toxin, he will become ill and (with luck) die.

In the 14th century, the Tartar army experienced an outbreak of the plague while besieging a town called Kaffa. They catapulted their deceased over the city's walls, hoping to spread the illness amidst the population of Kaffa (Christopher et al. 1997). Whether or not this action contributed to the plague in Kaffa is disputed[1], but the desired effect was realized. An outbreak of the plague within the city led to its capture, and subsequent trading with Kaffa is sometimes cited as one of the factors contributing to the pandemic across Europe (Derbes 1966).

More recently, in the 18th century, the commanding officer of British troops in North America ordered that smallpox-infected blankets and handkerchiefs be shared with the Native Americans. The subsequent outbreak of smallpox ravaged the nearby Native Americans tribes. This is, again, a case in which the causality of the human actions is disputed (Christopher et al

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[1] Alternative analyses argue that the flea-infested population of rats which followed the Tartar army may be the more plausible causal factor (Robertson and Robertson 1995). Regardless of what caused the plague outbreak at Kaffa, the act of depositing the bodies with the intent to spread the disease illustrates the point that the application of biological agents as a means to victory in warfare is historically well-established.

1997), but the underlying principle remains the same: exposing enemies to pathogens helps to reduce their number and ability to fight in combat.

We can see from these cases that the nature of biological warfare lends itself to studies of history and epidemiology. To date no one has constructed cohesive theoretical framework for examining biological weapons from an international relations perspective. That said, biological agents are a popular topic for current political discourse. Whenever most politicians decry the dangers of weapons of mass destruction, the terms nuclear, chemical, and *biological* are sure to follow. But does biological weaponry really merit the excitement with which it is met? Can the use of biological weapons be deterred? If so, what kinds of policy will deter actors from employing biological weapons? This paper seeks to examine these questions from a U.S. policy-centric vantage point.

The next section discusses some of the basic science underlying biological weapons. A brief discussion of deterrence theory follows. The paper concludes with a series of hypothetical situations in which deterrent policies are necessary responses to the threat of biological warfare.

The Science of Biological Warfare (or Bacteria, Viruses, and Toxins, Oh My!)

Before any argument can be made concerning the viability of biological warfare, one must first have a firm grounding in the underlying scientific background of the threat. Modern biological warfare is not as simple as casting bodies over a wall, or dipping bullets in toxins. There are different agents which can be employed for different attacks. Misunderstanding the variety of attack yields incorrect diagnoses, ineffectual treatments, and invites epidemic.

The CDC organizes pathogens in a hierarchical category system. Category A (i.e. the most dangerous) pathogens:

- can be easily disseminated or transmitted from person to person;
- result in high mortality rates and have the potential for major public health impact;
- might cause public panic and social disruption; and
- require special action for public health preparedness. (CDC)

To date, there are only six diseases which meet these specifications. They are listed in table 1, color coded by relative danger. Green indicates relatively low danger, yellow medium, and red high. These qualitative metrics are relative to the other entries on the table, noting that they are all extremely dangerous (as evidenced by the mere fact that the CDC classifies them as category A).

	Anthrax	Botulism	Plague	Smallpox	Tularemia	Hemorrhagic Fevers
Operative Agent	Bacteria	Bacterial Toxin	Bacteria	Virus	Bacteria	Virus(es)
Contagious?	No	No	Yes	Yes	No	Yes
Weaponized?	Yes	No	Yes	Yes	Yes	No

Table 1: The CDC Category A Pathogens

Bacteria are an attractive potential source of biological weapons. Bacteria, being ubiquitous, single-celled organisms, are easy to obtain and grow. They are a favorite topic in biological weapons discussions for a number of reasons. As seen above, of the six diseases identified by the CDC as category A, four are caused by bacteria or bacterial toxins: tularemia, botulism, plague, and most famously, anthrax.

Anthrax entered the public consciousness in 2001 following the September 11th attacks when Dr. Bruce Edward Ivins mailed at least four (and likely more) envelopes containing live anthrax spores. Titled the Amerithrax incident by the FBI, the targets of the envelopes were various news outlets and Senators' offices. The spores were included with letters praising al-Qaeda. The spores were not weaponized, so only those with very close contact to the letter were at risk (FBI). Five postal service employees died from exposure, dozens more were treated, and a much larger pool of those potentially exposed were treated preemptively with antibiotics (Cymet and Kerkvliet 2004).

Anthrax is non-contagious (i.e. cannot pass from an infected person to another person), but when weaponized will readily disperse in the air. The weaponization process is purported to be relatively easy, with some estimates indicating that it could be weaponized in a small laboratory with as little $10,000 USD (Dizer et al. 2004). Botulism, while caused by the most toxic substance known to humans, has proven difficult to aerosolize. Tularemia has also proven resistant to weaponization. They are both non-contagious as well. Because of the combination of these facts, the probability of seeing an attack driven by these agents is far lower than that of an anthrax attack. Additionally, response to a threat involving any of these agents should be localized—while quarantine is necessary until the area can be sterilized, a pandemic cannot break out.

Plague (caused the bacteria *Yersinia Pestis*) is unique amidst the category A bacterial diseases in that it *is* contagious. Because it could be transmitted between people, a weaponized strain would not necessarily need to be aerosolized. The Japanese army attempted to propagate the plague in the 1930's and 40's by dropping plague-infested fleas on Chinese populations. While some biological weapons programs have attempted to aerosolize the bacteria in order to circumvent the need for the fleas, a viable weaponization process may be much simpler: identify a strain which uniformly induces pneumonic plague and is resistant to antibiotic treatment. Such a strain may have already been identified in Madagascar, where 41% of the world's diagnosed cases are reported (Prentice and Rahalison 2007). Fortunately, viable approaches to an inoculation are being investigated presently (Kummer et al 2008), and a cure may be within the foreseeable future.

In contrast to all of the agents discussed thus far (which are bacterial), viruses are non-living. A virus is genetic material surrounded by a protective protein coat. It works by attaching to cell walls and injecting their genetic code into the cell. The cell, unable to distinguish between the rogue code and its own, begins to construct proteins and copies of the viral code, effectively replicating the virus at the cell's own expense. When the cell has exhausted its resources, it dies and the virus propagates in other cells (Campbell and Reese 2005).

Only two kinds of viruses fall into the CDC's category A classification: Smallpox and the family of hemorrhagic fevers. These are all contagious, and potentially the more dangerous of the category A maladies. Smallpox, in particular, attracts much attention from policymakers. The last known natural case occurred in Somalia in 1977. Because of the disease's eradication, inoculations have ceased. In the decades since, human immunity to the disease has diminished (the vaccinations are only certified for 10 years' immunity following administration), making smallpox an attractive agent for an actor interested in inciting a pandemic. Fortunately, the only known extant samples of the virus are safely stored away in laboratories run by the U.S. and Russian governments. (Huang 2004)

If, hypothetically, a smallpox epidemic were to break out, there exists a reasonable precedent for its spread. In 2003 Polio was nearly eradicated by an aggressive campaign of vaccination by the World Health Organization. The progress of this effort was abruptly halted at its last steps by the suspicions of some Nigerian clerics, who believed the campaign was actually a ploy for Westerners to infect patients with HIV, and to cause infertility. They ordered that all vaccinations in their states (which followed strict Islamic Sharia law) be stopped. An inconvenient outbreak of polio spread throughout the states, and then spread across Africa, into the Arabian Peninsula, and then as far away as Indonesia (Kosal and Terron 2009). The scope of the 2003 resurgence of Polio was much narrower than a world-wide smallpox pandemic, but the model stands. Were smallpox to break out into the modern population, it would likely spread world-wide very rapidly.

While viruses and bacteria are the traditional "germs" about which much of the literature on biological warfare is written, additional biological weapon agents may emerge from fungi or even plant or animal toxins. Ricin, for instance, is the toxic byproduct of the otherwise innocuous castor plant, which can easily be purchased[2]. Even more alarming may be the threat of so-called "subtle" biological weapons, which do not target human populations, but livestock, crops, and water supplies. Policymakers and public health officials should be cognizant of these threats, even if the CDC does not classify them as a comparable threat to the aforementioned agents.

Considering the excitement with which modern politicians meet questions about biological weapons engineered as tools for war, far too little credence has been paid to the most aggressive perpetrator of this offense: nature itself. Despite Dr. William J. Mayo's predictions about human progress against infectious diseases in 2011[3], according to the World Health Organization, infectious disease is still the plurality killer of humans. The over-perscription of

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[2] See, for example, http://www.amazon.com/Giant-Zanzibar-Castor-Seeds--Ricinus-/dp/B000RGZFEI/ref=sr_1_1?ie=UTF8&qid=1292529648&sr=8-1

[3] A New York Times 80th Birthday feature in 1931. Considering the timeliness and application of the prediction, I could not in good conscious exclude it: http://select.nytimes.com/gst/abstract.html?res=F40714FD3F591B728DDDAA0994D1405B818FF1D3&scp=1&sq=&st=p

antibiotics is breeding stronger bacteria in a perfect demonstration of Darwinian microevolution. New viruses like SARS-coronavirus and the H5N1 and H1N1 flu strains threaten human populations annually, and continuously mutate. It may only be a matter of time before the next Spanish Influenza is bred. We can easily imagine a rogue state or terrorist organization originating a weapons program to create Anthrax or antibiotic-resistant Yersinia Pestis, but what nature has in store for us is beyond imagining. Perhaps in this we have identified the true source of Sec. Def. Rumsfeld's "Unknown Unknowns." (DOD 2002) With this in mind, how are we supposed to combat a threat which we cannot predict?

Deterrence (or How to Stop Bad Things from Happening)

Deterrence is the coercive prevention of particular actions. It can be divided into two conceptual frameworks: *deterrence by denial*, and *deterrence by punishment*. The former is the most frequently employed, whereas the latter is the most frequently identified generically as deterrence. Stemming from second-wave deterrence theory of the 1950's, deterrence by punishment is predicated upon the threat of violence in response to particular actions. The textbook example is *mutually-assured destruction*. The United States promulgated the fact that if the Soviet Union attempted to use nuclear weapons against the United States or its allies, the United States would respond with nuclear force. The Soviets responded in kind. This concept drove U.S. political calculus throughout the cold war. With this promise of unacceptably severe carnage if either launched a nuclear attack, neither camp ever elected to perpetrate such an attack.

This variety of deterrence is logical, appealing, and entirely useless in asymmetric cases. Al-Qaeda, for example, has repeatedly stated that it would use nuclear weapons unconditionally

(Mowatt-Larssen 2010), given the opportunity to do so. Threatening to respond to a nuclear terrorist attack with a nuclear counter-strike will not deter a terrorist. The same holds true for biological attacks perpetrated by terrorists. There must therefore be another strategy to combat this variety of threat. This strategy is *deterrence by denial*.

Deterrence by denial is only a slightly newer idea than deterrence itself (the first recorded use of the term was in Snyder, 1960). Instead of seeking to prevent actions by promising punishment, deterrence by denial seeks to prevent certain actions by disallowing opposing parties the means to commit said actions. This is both a more secure and a more flexible approach to deterrence than deterrence by punishment. Threatening punishment will not (generally) deter an actor who is indifferent to his/her own survival. Threatening al-Qaeda with a biological response will not deter biological terrorist attacks. By applying a denial approach to deterrence, we widen the potential usefulness of deterrence, as seen in Table 1, which shows the available deterrence approaches for states, non-states, and nature.

Actor	State	Non-state	Nature
Deterrence Approaches	Punishment		
	Denial	Denial	Denial

Table 1: Comparison of Appropriate Deterrence Techniques for Different Actors

We can see that deterrence by denial is not just a more favorable approach for non-state actors—it is the only approach.

Deterrence by denial can be further broken down into two separate approaches. No terrorist can set off a biological attack if s/he cannot obtain a biological agent. Enacting policies to prevent acquisition of such an agent is referred to as *denial of acquisition*. If a terrorist does manage to gain access to a pathogenic agent, a civil safety net to capture the attacker and/or agent before it can be detonated also constitutes deterrence by denial. This second approach is here termed *denial of effect*.

In the case of non-state actors, the denial of acquisition has been the traditional approach to bio-deterrence. The Centers for Disease Control have locked away the last active samples of smallpox, in the hope that humanity will never again need to seek a cure. However, all biological agents originate in nature. Hoping to deny terrorists access to biological agents is a necessary approach, but placing all our faith in denial of access to agents is naïve. The Ames strain of Anthrax, for instance, is purported to be commonly found in the wild in east Texas (Chyba 2002). The hemorrhagic fevers are endemic in Africa and South Asia. The more appropriate route to deterrence by denial may therefore be to attempt to deny terrorists the equipment to weaponize these agents.

Denying terrorists access to equipment is both easy to claim and difficult to accomplish. The equipment to replicate pathogens is commonplace in the pharmaceutical, medical, biological research, and even beer brewing industries (Chyba 2002). In light of this fact, such equipment is unquestionably "dual-use" in nature, and therefore cannot be reliably kept from the hands of terrorists. How, then, can we possibly deter terrorists if we can keep neither agents nor the means to replicate them from terrorists?

In this situation, wherein it is nearly impossible to assure denial of acquisition to deter terrorists from making and using biological weapons, we must deny them the effectiveness of such weapons. Nature is very like a terrorist organization in this respect—threatening nature with punishment is akin to challenging God to a boxing match. If we cannot deter by punishment (because we can neither make a credible threat nor could nature appreciate it if we could), then we must pursue deterrence by denial. We lack the means to deny nature access to natural products, so attempting to enact a denial of acquisition policy against nature is nonsensical. We must therefore place our hope in the last variety of deterrence left—deterrence by denial of effect.

Biowarfare, Bioterrorism, Biodeterrence (and other Biostuff)

Most of the literature concerning biological warfare and bioterrorism originated in the late 1990's. Since then, the majority of the literature has called for a cohesive policy framework To address the threat of a biological attack on U.S. soil, but few have ventured to build or contribute to such a framework. Figure 1 is a diagram comparing the current human technical capabilities with regard to biological engineering.

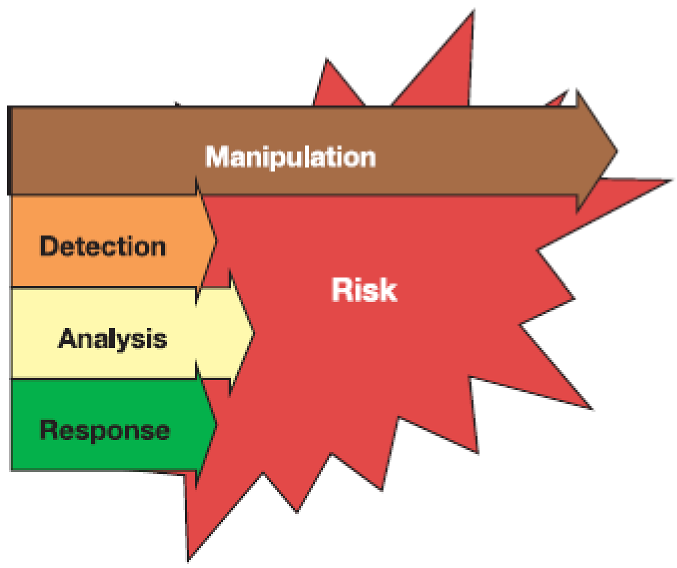

Figure 1: Classes of Biological Technology and Risk (taken from Endy 2005)

Our ability to manipulate nature and natural entities far exceeds our ability to detect, analyze and respond to biological threats. This is an understandably precarious situation in which to find ourselves. The lack of the latter three qualities leaves us exposed to natural pathogens like influenza and SARS, and the presence of the former further exposes us engineered threats. More-or-less luckily for us, nature far outpaces the current human ability drive evolution.

Noting the difficulty of bioengineering, terrorists without state (or large corporate) sponsorship will not likely be able to obtain the tools necessary to engineer a pathogen capable of dealing significant damage to the U.S. independently. While some states have a record of biological weapons development, (namely the U.S., Canada, France, Iraq, the former Soviet Union, and the U.K.), modern biological warfare programs are likely either disbanded or kept very secretive (Anthony and Cornish 2005). The probability of a modern state abandoning that secrecy to share cavalierly with a terrorist organization is low.

Terrorists have not gone without trying to establish biological weapons programs of their own. The Japanese terrorist organization Aum Shinrikio had an active bioweaponry program throughout the first half of the 1990's (Olsen 1999). Al Qaeda is also widely reported to have pursued or to be pursuing biological weaponry. However, the contrast between biological and chemical attacks is a contrast between failure and success. To date, no bioterrorist attack has (arguably) "succeeded," while chemical attacks by terrorists have been both successful and highly publicized. It seems that without deterrent, terrorists have done a fair job of keeping the public safe from biological attacks by failing to competently execute them. This, however, is a bit of luck the United States and world at large would do well not to rely upon.

If we are to practice deterrent policies, they must adhere to approaches which will be effective for the target. Consider for example a hypothetical case in which the United States uncovers intelligence suggesting that a pariah nation has started a biological weapons program. Policy options at that point are bleak: airstrikes, sanctions, invasion, and deterrence by punishment. While airstrikes have an established record of precedents (executed by Israel) and success in their goals, the United States has not implemented any policy akin to this. If Israel were unthreatened by the burgeoning program, it (the program) would go on, unscathed by air-to-surface missiles.

The more obvious response is sanctions, which the US would almost certainly pursue with vigor at the UN. But what about deterrence? Would the US attempt to deter by punishment? The 2010 Nuclear Posture review offers a clue: "The United States will not use or threaten to use nuclear weapons against non-nuclear weapons states that are party to the NPT and in compliance with their nuclear nonproliferation obligations." The U.S. cannot adhere to this posture and threaten nuclear retaliation for use of biological weapons. Likewise the U.S. cannot threaten symmetric response, not possessing an extant biological weapons arsenal. The question which remains is whether the US can deter with conventional force, the answer to which is almost unequivocally "yes." (Reynolds 2002)

This model works well for states, but can readily be augmented. What happens if deterrence by punishment fails, and the enemy state or terrorist organization launches a biological attack? A failure of deterrence by punishment would be particularly likely against a terrorist organization spreading a contagious agent. The best way to spread a contagion is to infect oneself with it, enter the country while the agent incubates, and then infect as many people as possible while you're still alive. The very fact that a terrorist organization pursued a contagious agent indicates that the operatives are indifferent to punishment.

The United States must possess a second deterrent to combat biological threats: deterrence by denial of effect. It is at this point that deterrent policy works equally for both terrorists and enemy states. Either would (hypothetically) launch an attack, indifferent to punitive U.S. response. If it were well-promulgated that the U.S. would not be affected by a biological attack because of advanced identification, response, and treatment technologies, then a rational would-be attacker would not waste resources trying to attack.

The most likely pathogen for such an attack is Anthrax. It is available naturally, feasibly weaponizable with low-technology, and deadly. In order to establish pre-emptive Anthrax immunity amongst the domestic population, a series of five vaccinations and an additional annual booster would be required for every American (Biothrax). This is inefficient, to say the least. Alternative solutions have proposed that the US government stockpile enough doses of post-hoc treatment vaccinations to protect the entirety of the U.S. population, insurance to protect from a worst-case scenario (Johnson et al. 2009). This is also a grossly inefficient solution. The probability that a terrorist organization could orchestrate an anthrax attack which threatened the entire U.S. population is so small that such an expense could never be justified.

Any action of the magnitude and coordination described above would require national support, which would undoubtedly attract publicity and international condemnation. For a group intending to attack the U.S. with a national sponsor (of sorts), it might be more efficient to build enough nuclear weapons and delivery systems to accomplish the desired destruction. Or better yet, pursue an attack mechanism which could self-propagate. By this measure, if you are looking to disrupt the affairs of the United States in the long-term, it would be a far superior strategy to pursue a contagious biological agent instead.

If the offending agent was Smallpox instead of Anthrax, mass panic might ensue. However, an attack of this sort is very much a double-edged sword. There is no reason a pandemic should decimate the United States and leave the rest of the world unfettered. Should an attack become an epidemic, it is likely that will spread world-wide, a point at which the U.S. public health infrastructure was likely better suited than the attacker’s to handle the outbreak.

More generically, when the discussion steps from toxins to contagions, then the measure of national immunization stockpiles becomes relevant.

Immunizing the entirety of the U.S. population may be inappropriate when the outbreak occurs in a particular location. Responses will vary between agents, but a combination of quarantine and empiric broad-spectrum antibiotic or antiretroviral therapy for those in immediate danger of contracting the disease with immunization to establish herd immunity in the surrounding vicinity should suffice. Attempting to spontaneously immunize for national immunity will only breed frustration, fear and dangerous public over-reaction. Unless careful attention is paid to the *vector* of the disease as well as the agent, the epidemiological challenges may last for a long time to come. For example, eliminating Y. Pestis by killing flea-ridden rats only intensifies flea feeding on humans. Therefore the epidemiologically optimal response to a plague outbreak is not to attack the visible rat, but the far less visible fleas (Keeling and Gilligan 2000).

All of these recommendations are secondary to the fact that making our biological defenses publically known deters enemies from using biological agents. Regardless of deterrent threats, why should an attacker expend the effort to generate a viable biological weapon, only to waste it on a target which is impervious to attack? Not that U.S. biological defenses are perfect, but as Kosal and Terron observe, “the robust nature of our public health system is a strategic asset.”

As a final note, establishing a powerful biological defense shield is equivalent to developing biological first-strike capability. Not that the U.S. is interested in launching a biological attack against anyone, but this comes with some other important properties. Because the U.S. will have less to fear from biological attacks, the rational terrorist will respond by targeting another ally nation. For this reason, it is critical that the U.S. public health infrastructure be prepared to offer support for victims of attacks elsewhere, particularly in Western Europe. In working with local authorities to build contingency plans of similar projected epidemiological success in other nations, the U.S. would build a sort of biological defense umbrella. When it becomes clear that no attractive target is a viable target, the use of biological weapons by terrorists will become an irrational prospect. The diplomatic and infrastructural construction of this umbrella will be a costly pursuit, but one which is highly necessary to realize a world in which biological weapons have no place.

Conclusion (or We have Nothing to Fear but Spent Tissues)

The variety of biological threats against the United States is limited, and until policymakers recognize that very little *can* threaten us, it is unlikely that any useful discourse on biological deterrence will surface. However, if and when such useful discourse does occur, the theoretical background for applying deterrence policy to biological threats is well-established. There are three points on the matter I would like to highlight in particular.

First, we must recognize that the greatest threats are still natural, and that the perfectly engineered biological weapon neither exists, nor will it exist in the foreseeable future. HIV, Malaria, and the seasonal flu each kill more people daily (on average) than all biological attacks and accidents combined. A broad-spectrum flu vaccine will save many more lives than grossly overstocked strategic reserve of anthrax and smallpox vaccines.

Second, we must understand that deterrence by denial of effect is the only approach which uniformly protects against attacks by states, terrorist groups, and natural epidemics. While the other varieties of deterrence have their places in keeping the U.S. safe, this one is both effective and our last line of defense against some enemies, and our only line of defense against some others.

Third, we must remember that our biological defenses are only an incentive to attack our allies if we do not extend our biological defense umbrella. It is my hope we can look forward to a day in which all infectious diseases have "gone the way of Smallpox," and that we achieve such a time without ever realizing a breakout of repugnant biological weapons.

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