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The Combating Terrorism Center
Biodefense Report

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A makeshift emergency hospital set up at Camp Funston to care for victims of the 1918 influenza epidemic. (Courtesy, The Otis Historical Archives of the National Museum of Health and Medicine.)

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The Combating Terrorism Center

LTC Joseph Felter, Director, USMA Combating Terrorism Center

The Combating Terrorism Center at West Point is committed to arming current and future leaders with the intellectual tools they need to defeat and deter terrorist threats to our nation. We accomplish this through a robust interdisciplinary education, research, and policy analysis program integrating the wealth of academic expertise and operational experience of the faculty at the U.S. Military Academy.

When I was commissioned at the end of the Cold War, the threat posed by the biological weapons stockpiles and advanced research program of the Soviet Union was a constant that loomed on our horizon. This specter was somewhat mediated by the fact that we could engage the Soviets diplomatically, hold things they valued at risk, and engage their leadership in efforts to limit the production and proliferation of biological weapons.

Today, we face a new and in many ways more pernicious threat from biological weapons than we did during the Cold War-biological terrorism. Small groups -even individuals- with no state sponsorship can conduct devastating biological attacks.

"Terrorism forces us to make a choice. Don't be afraid. Be ready." This mantra - posted on the Department of Homeland Security's website - is especially relevant to how we must approach the threat of bioterrorism. Unbridled fear generated by the anticipated lethality of an effectively employed biological agent is difficult to mitigate and greatly exacerbated by our limited popular understanding of biological weapons and their employment considerations.

Biological weapons employment leverages cutting edge technology; maintaining advanced expertise in this area requires significant investment in training and education. Enhancing leader readiness and ability to respond to bioterrorism, however, can be achieved by making leaders more aware of risks and limitations of biological threats.

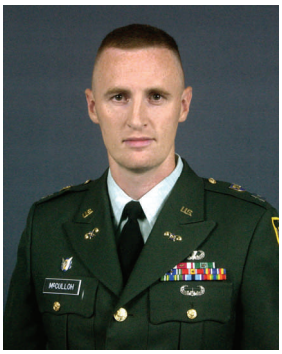
The CTC at West Point contributes to heightening our awareness of the bioterror threat in multiple ways. With the generous support of the Alfred P. Sloan Foundation, we are able to bring to bear the tremendous experience and subject matter expertise of Dr. David Franz, former Commander of the US Army Medical Research Institute of Infectious Diseases and veteran of multiple UN biological warfare inspection missions. Dr. Franz, along with CTC research associate Brian Fishman, planned and conducted two outstanding bioterror workshops this past academic year. The Fall workshop included sessions on bioterror's enabling technologies and barriers to bioterrorism. Our Spring workshop focused on public resilience to bioterrorism. These events bring together leading experts from the academic and scientific communities as well as insights from practitioners in biotechnology and related fields. Highlights of these workshops and conference reports are available at the CTC website.

Upcoming CTC bioterror related initiatives include continuing our semi-annual bioterror workshops, as well as developing a Terrorism and Weapons of Mass Destruction undergraduate course with significant attention devoted to the threats posed by bioterrorism and how we can best defend and respond to it. Dr. James Forest, CTC Director of Terrorism Studies, along with two CTC senior fellows are editing a textbook on WMD terrorism to support this initiative. Ideally, this course will serve as a model for undergraduate study of biological and other forms of WMD terrorism at other academic institutions.

We cannot make our cadets scientists, but we can support efforts to provide them with a broad knowledge of the bioterror threat, increase their comfort level in engaging with experts in the field, and better prepare them for the challenges and uncertainties that lie ahead. These leaders will make difficult decisions about issues such as force protection when deployed, and the first response to a bioterror incident at home or abroad.

Introducing the Biodefense Report

MAJ Ian McCulloh, Editor, Biodefense Report



I would like to take a moment to introduce you to the Biodefense Report. There are two primary goals of this publication. The first is to educate future military leaders and to heighten their awareness and their understanding of the threat of biological terrorism, and warfare. The second goal is to create a venue for cross-disciplinary collaborative discussion and research in the field of biological defense. Particular interest and priority is given to the threat of biological terrorism.

I have been an Army chemical officer for the last eleven and a half years. When I was selected to go to graduate school in preparation to teach in the Department of Mathematical Sciences at the U.S. Military Academy, I wanted to work on a Master's thesis that was related to Chemical Biological Radiological Nuclear (CBRN) defense. I contacted the only place I knew that conducted research in CBRN, the U.S. Army Chemical School. Unfortunately, they were not equipped to provide me a suitable research project and I ended up completing a more theoretical thesis. While serving in the Math Department at West Point, however, I have had the opportunity to conduct CBRN related research with a variety of different government agencies: DTRA, Edgewood Chemical Biological Center, Joint Combat Developer, JPEO-CB, JPM Decon, Joint Requirements Office, the Marine Corps, and the OSD. In addition, I have had the opportunity to meet a variety of other experts in the fields of biology and terrorism through the Combating Terrorism Center at the U.S. Military Academy.

While there is already a great deal of cooperation among these agencies, there is still room to improve. As a CBRN community, we need to better leverage people with military experience pursing academic research. Every year the military places officers who have an interest in CBRN defense in graduate schools. Cadets at the service academies look for research topics to satisfy their degree requirements. Junior faculty at the service academies look to conduct relevant defense related research.

It is my hope that this publication can provide a venue to bring the military and academic CBRN research communities together. This publication will feature research conducted by cadets at the nation's service academies; articles from faculty members; and interviews with experts in the field of Biological defense, such as the former Secretary of the Navy Dr. Richard Danzig. I encourage readers to consider the Biodefense Report as a venue to publish their research on biology, bioterrorism, infectious disease, decontamination, and other related topics. I would also like to invite senior researchers to submit abstracts of ongoing research that might provide opportunities for collaboration with officers entering graduate school or with cadets and midshipman at one of the service academies. This not only provides a service to the graduate or undergraduate students, but also opens up the opportunity for cross-disciplinary collaboration. A mathematician reading about the ongoing work of sociologists, may be able to recommend some type of analytical work to model the behavior of a social system. Similarly, the mathematician might find new applications by reading the work of biologists.

I hope you enjoy this first issue of the Biodefense Report. Again, I invite you to submit articles for publication and to provide suggestions for improving this bulletin. Future copies will be available in hard copy or may be accessed via the U.S. Military Academy's Combating Terrorism Center website at

http://www.ctc.usma.edu/

You can contact the editor through the Combating Terrorism Center or directly at:

Dept of Math Science
US Military Academy
646 Swift Road
West Point, NY 10996
ian.mcculloh@usma.edu
(845) 938-5218

Bio Terrorism Defense: The Fundamentals

Dr David Franz COL(Ret), Senior Fellow, Combating Terrorism Center

Why do we spend $6B a year to protect the population from biological terrorism? The US denounced biological weapons in 1969. These weapons have never been seriously used on the modern battlefield. When five Americans died of inhalation anthrax in 2001, our spending jumped from a few hundred million to billions. Thirty to eighty thousand of us die of influenza every year, 120 thousand in automobile accidents and more than 400 thousand of smoking related illnesses. Our spending on these real killers isn't even close.

Bioterrorism is a very complex threat with enormous *potential* impact; the actual risk is probably very low, but the impact of a successful attack could be enormous…too great to ignore. That's the dilemma in a sentence. We accept the consequences of well-known risks if there are beneficial tradeoffs, but we live in fear of this unknown because we perceive it to be completely beyond our control.

Looking back at biological warfare during the Cold War, the threat was difficult to understand because the facilities, equipment and people involved were 'dual-use' and intelligence really difficult to collect; there were no good signatures. Dealing with the threat was also difficult because, unlike for chemical attack, we just couldn't overcome the technical barriers to designing real-time detectors. Therefore, we were disappointed when 'detect-to-warn' didn't work in the 90s and the value of physical protection diminished. After our experience with the 'anthrax letters' of 2001, we began to appreciate our vulnerability. The footprint of the laboratory for production—or of the weapon itself—can be too small to easily discover. And, attribution of an attack may be impossible. Finally, there are no magic solutions. Protecting Americans—or the force—will require an integrated suite of partial solutions, and it will never be perfect. Although, the massive blanket-bombing and ICBM-led biological attacks that the Soviet Union was prepared to undertake are just hard-to-believe memories, even small terrorist attacks could be enormously disruptive to our society or our military operations.

Core Preparation: So how should we think about protecting our citizens? We might develop a core capability (medical and physical countermeasures) with a front-piece (deterrence) and a back-piece (public resilience). At the top of the core are specific medical and physical countermeasures and response capabilities built on a non-specific—or dual-use—base. There are a small set of 'outlier agents' the use of which is either 'too easy' or has a potential impact too high to ignore. This list will change slowly over time, but today it includes smallpox virus, dried anthrax spores and the largely economic, animal-only threat, foot and mouth disease virus. For those, we need specific vaccines, drugs and rapid diagnostic tools. Like an insurance policy, some of these specific countermeasures may never be used.

For a next-tier agent list numbering in the low 10s—generally more difficult to use as weapons or of lower impact—we also need clinical diagnostic and laboratory identification tools; these capabilities are affordable because they can, generally, be built on instrument platforms that are in common use. For this group, we also need broad spectrum antibiotics and antivirals. Most of the countermeasures for this group have more than one application or are relatively less expensive.

Supporting these capabilities, we need educational programs to assure that medical and veterinary personnel, emergency responders, and even citizens are 'aware' of the presentation of unusual diseases of potential concern. Although it's not easy maintaining awareness regarding rare events, we have developed some reasonably effective means of providing that training. Disease surveillance systems can be of value whether or not we ever have a terrorist attack. Regarding surveillance, it is important that we look for disease wherever it is found, not independently for human disease in humans and animal disease in

animals. Approximately 75% of the agents we worry about as intentionally introduced or emerging are 'zoonotics,' meaning they cause disease in humans AND animals. Syndromic disease surveillance can be very dual-use—it will pick up even a disease which we have never seen and are not instrumented to detect—and this capability is essential because the most important variable that we can control in reducing the impact of an outbreak is discovering it early. Finding a specific bug in the air before it causes disease would be even better. Environmental detection systems have been developed which would give us warning of an attack hours or days before illness in the population, but their value is still unproven. We currently sample air in key buildings and locations in more than thirty American cities. If the right bug is used and our sensor is at the right place, this program could buy us valuable time.

These broad, but still quite specific, preparations to detect or medically protect against, diagnose or treat disease, must be supported by a robust hospital and public health infrastructure. Although we take its adequacy for granted, our public health system could always be improved, and we will probably never be able to afford the hospital redundancy to assure adequate surge capacity to deal with a local outbreak. There is a need for more study on how to both supplement hospital space in time of crisis and distribute drugs, vaccines, or simply information to the masses. Much of this could be very dual-use, as valuable after a hurricane or earthquake as in response to a bioterrorism event.

Finally, all of the applied countermeasures and response capabilities we will need to protect our way of life are only possible if we maintain our excellent base of fundamental research. Because of the diversity of biology and the ever increasing 'power' of biotechnology, for good or ill, a very broad tech base will become ever more important in the future. As technical barriers to the abuse of biology drop the overlap between the population with the intent to harm us and the population with the technical ability to do so will become ever larger. Constantly improving our fundamental technical understanding of both the microbe and the host will help us stay ahead of the threat and give us a rich source of information upon which to draw when a crisis does occur.

Proactive Deterrence: There must be a front-piece to our defenses, which I have called 'proactive deterrence,' and a back-piece, which others call 'public resilience.' Proactive deterrence involves a broad spectrum of activities from overwhelming military force against rogue states or terrorist groups to winning hearts and minds; from intelligence, forensics and attribution to the nation's natural and transportation resources; to our foreign policy, our culture and even our values as a people. The balance between 'hard power' and 'soft power' as described by Joseph Nye is critical to this form of deterrence. This front-piece is less about Bioterrorism than about terrorism generally, but as the technical barriers to bioterrorism fall, deterring bioterrorism will be little different than deterring terrorism.

Public Resilience: Public resilience, the back-piece, also requires balance. When we think of the resilience, we picture the citizens of New York City on 9-11… or the citizens of Israel every day. In this smaller, more dangerous world, we may need to reevaluate the way we look at risk. Building just the right amount of resilience—not so much that we lose too much of the good that comes from freedom—won't be easy, but it may be necessary. Resilience is about education, awareness, social networks, the will to set goals and take decisive action…to take care of oneself. Boaz Ganor said, "Learn to live with Terrorism…without accepting its existence."

In the recent past, we at the Combating Terrorism Center, have held workshops on the technical barriers and enablers to bioterrorism and on the value of public resilience for bioterrorism. Through similar workshops and this bulletin, we intend to explore the complex and ever changing world of bioterrorism in the future. I am pleased to be associated with the outstanding leadership and staff of the Combating Terrorism Center at West Point. Through my role as Senior Fellow for Bioterrorism, I hope to help broaden the perspective of the faculty and the Corps of Cadets regarding the threat of the illicit use of biology to harm our citizens or reduce the fighting effectiveness of our force. In future editions of this bulletin, we will further tease apart the complexities of the biological threat and, together, broaden our understanding and prepare the force of the future to more effectively protect the nation from this ancient form of terrorism once again popularized at the beginning of this twenty first century.

Spring 2006 Bioterrorism Workshop: Public Resilience

Mr. Brian Fishman, Combating Terrorism Center Associate

Will the public panic after a bioterrorism attack? How do terrorists think about that panic? And, what can be done to educate the public to reduce the psychological impact of such an attack on the public? These were the questions addressed at a May 5th workshop organized by the Combating Terrorism Center's Alfred P. Sloan Foundation bioterrorism program.

Bringing together some of the world's foremost experts on biological threats and terrorism, the workshop was a forum for discussing creative techniques to develop a public that is resilient to the threat of biological attack. The CTC's Senior Fellow for Bioterrorism, Dr. David Franz, moderated a discussion between Dr. Bruce Hoffman, both the CTC's Senior Fellow for Terrorism and RAND's Corporate Chair in Counterterrorism and Counterinsurgency; Ms. Judith Miller, former New York Times reporter and author of *Germs,* one of the most widely read texts on the threat of bioterrorism; and Dr. Monica Schoch-Spana, an expert in public education and Senior Associate with the Center for Biosecurity at the University of Pittsburgh Medical Center.

Most important among the workshop's numerous findings were how expectations of the public's response to biological threats have changed over time. Experts used to assume that a panicked public would overwhelm public health systems and might even resort to violence as a means of procuring health care during a crisis. But, the anthrax attacks of 2001 changed the conception of the public from a *problem to be managed* to a *constituency to be served*. This highlighted the importance of effective, credible communication systems to inform the public of risks and treatment opportunities.

Nevertheless, communicating via the media is increasingly complex. Identifying trusted opinion-leaders is difficult as consumers diversify their sources of information. Very few media outlets are trusted by all of the public, which complicates public education.

Public education is critical because the threat is real. Unaffiliated, amateur terrorists may attempt to use biological weapons because they do not have the technical or organizational capacity to carry out a large-scale attack using conventional means. The increased psychological impact of a biological attack may make such a weapon appealing to an ambitious amateur with limited operational capacity.

The panelists and a very impressive audience suggested means to build social institutions that promote a resilient public. Many argued that education is critical, both in formal and informal settings. One creative way to increase social "bio-literacy" is by encouraging science classes in journalism schools. While many journalism schools have dedicated courses covering business or armed conflict, few dedicate class time to the peculiar demands of understanding, synthesizing, and explaining scientific processes.

Another means of preparing journalists to provide credible, accurate information to a concerned public is to 'embed' reporters in academic, government, and private laboratories around the country. This would increase the bio-literacy of the media and create opportunities for public education.

The CTC at West Point is working to do its part by developing, in conjunction with numerous departments at USMA, a bioterrorism curriculum for cadets, which is also applicable in universities nationwide.

More information on the CTC's bioterrorism program and the May 5th workshop can be found online at www.ctc.usma.edu/bioterrorism.

Interview with the Honorable Richard Danzig, J.D.

Interviewed by LTC Margaret Stock, Professor of Law, USMA

On October 10, 2005, the Combating Terrorism Center, the Department of Social Sciences, and the Department of Law hosted bioterrorism expert and former Secretary of the Navy Richard J. Danzig and his wife Andrea during their three-day trip to the West Point area. Secretary Danzig is currently the Sam Nunn Prize Fellow at the Center for Strategic and International Studies (CSIS) in Washington, D.C., as well as a consultant to the Department of Defense on bioterrorism issues.

Secretary Danzig and his wife enjoyed a tour of the USMA campus and lunch at the Cadet Mess Hall before Secretary Danzig gave a well-received talk to cadets and faculty on the topic "Terrorism: Four Ideas Muddled As One." Comparing bioterrorism to other terrorist threats, Secretary Danzig argued that the bioterror threat warrants exceptional preparation, but is often discounted by those who do not fully understand its nature. He said that bioterrorism preparation and consequence management are hampered by the lack of a common, systemic, operational understanding of bioterrorist threats. Using past examples of bioterror attacks—especially the 2001 anthrax attacks in the United States—Secretary Danzig explained ways in which the United States could improve its ability to prevent and respond to this unique threat.

Following his talk, Secretary Danzig met with the Dean, BG Patrick Finnegan; COL Michael Meese, the Social Sciences Department Head; and members of the Center for Combating Terrorism. He also gave an informal talk to the CTC and SOSH faculty, including an extensive question-and-answer session. Later, Secretary Danzig provided answers to our interview questions.

Q. When and why did you become interested in bioterrorism issues?

A. As Under Secretary of the Navy from 1993-97, I pressed the Pentagon to give more attention to the risks of bioterrorism and biowarfare. My view was that these risks were greater than was generally recognized because they were unfamiliar, they involved medical issues about which most Generals and Admirals were little educated and which they thought were relevant to doctors, not war-fighters; and because the United States—quite rightly—had forsworn an offensive capability and so Americans had little sense of how these weapons might be used. It was also widely thought that the imprecision of many of these weapons (for example, because of the vagaries of the wind) and their delay of a day or two in taking effect made them ineffective instruments of war. My view was that, in fact, an enemy could effectively use bio-weapons to sow panic, attack infrastructure, divert resources, etc.

Q. As a consultant for DoD on bioterrorism, what do you do? What projects are you working on?

A. After I left the Navy Secretary's job and the anthrax letters were sent in the fall of 2001, I was asked by several DoD agencies to advise—particularly from a policy-maker's perspective—how we might strengthen our defenses. I now consult on this topic for a range of DoD and intelligence agencies and the Department of Homeland Security, often working with other government agencies and non-governmental bodies. I am particularly active in emphasizing gaps that exist between agencies when a bioterrorism problem overlaps them or falls between them.

Q. Can you give an example of a problem of this type?

A. For example, I have been emphasizing that our detection and alarm systems are designed to alert us to an attack, but not define its perimeter (and thus who should receive drugs) or its source (and thus enable us to more readily catch the perpetrator). In my current work, I suggest ways of addressing these critical tasks.

Dr. Danzig has authored a paper entitled, "Catastrophic Bioterrorism: What Is To Be Done?" which has been published by the Center for Technology and National Security Policy at the National Defense University in Washington, D.C. Copies of the paper are available at the Combating Terrorism Center.

Q. Are there unique characteristics of the bioterror threat that distinguish it, say, from nuclear weapons?

A. Yes. Commonly noted in discussions of bioterrorism are the relative ease of obtaining material for weapons (pathogens exist in nature, and many are used for legitimate purposes, such as vaccine research), the small amount of material required for attacks (ounces or pounds will do), the low visibility of production facilities (bioweapons can be made in a room without the telltale markers that characterize large nuclear facilities), and the relative ease of dissemination. I would emphasize an even more important, but not commonly noted, factor: when we talk about bioterrorism, we are talking about terrorists acquiring not **a weapon** (as with a nuclear device) but rather **the means of production of weapons** and, therefore, the ability to attack repeatedly.

Q. Do most people appreciate the bioterror threat? If not, why not?

A. By and large, people don't appreciate the bioterror threat because bioterrorism hasn't happened yet on a broad scale. The task of a skilled and far-sighted government is to get ahead of events and to plan for them before they happen.

Q. What should the government be doing to prevent/protect against a bioterror threat? What should the military be doing?

A. The government should be doing a great many things. For example, we must improve our intelligence, particularly by engaging biologists and the pharmaceutical community. We must do more and better research on a range of neglected topics—for example, decontamination. We must better prepare for the social and psychological consequences of bioterrorism and bio-warfare. And, we must identify the priority of this problem and the person principally in charge of responding to it.

Q. What books or articles would you recommend to a cadet who is interested in learning more about bioterrorism? What courses would be useful?

A. I think it is an error that West Point and other institutions for military education offer biology only for pre-medical students. The science is exploding and necessary for an understanding both of this threat and for other aspects of our future. On the particular topic of bioterrorism, the Internet offers a rich collection of articles and government reports. The book Germs by Judith Miller, Stephen Engelberg, and William Broad offers an engaging and readable overview of the history of the problem and our government's response to it before 9/11 and shortly thereafter.

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Cost Effective HIV Testing Implementation

Steven T. Morse and Brent C. Nolan, Sophomores at the United States Military Academy

ABSTRACT
In the fight to slow the devastating spread of AIDS worldwide, increasing awareness through free public HIV testing may be the most effective strategy. One method for reducing the cost of this endeavor is batch testing, in which blood samples are pooled into groups. Using current infection rates in two focus countries, Rwanda and Vietnam, we have found the cost effectiveness of this method allows the same number of people to be effectively batch tested at about 10% the cost of individual testing.

INTRODUCTION
The AIDS pandemic affects over 40 million world-wide, and millions more are infected each year. With the launch of President Bush's Emergency Plan for AIDS Relief (PEPFAR), the United States has provided $15 billion to combat the disease in over 120 countries since 2001.

Detection of the disease remains the biggest challenge in controlling the spread of AIDS within a country. Although an HIV test currently costs only about $0.70, this price multiplied over several populations, combined with peripheral treatment and prevention programs, can quickly exceed available domestic or international resources.

One method for reducing the cost of this endeavor is batch testing, where blood samples are pooled into groups. If the batch tests positive for HIV, each individual in the batch must be retested, but otherwise whole groups of people can be tested with a single $0.70 batch. Using current infection rates in two PEPFAR focus countries, Rwanda and Vietnam, we attempt to first determine the cost effectiveness of this method and then the optimal batch size.

LITERATURE REVIEW
We used the United States C.I.A. World Factbook as a primary source of HIV/AIDS infection projections in both countries, due to the Factbook's constantly updated material and the credibility of the C.I.A. for this type of information.

Rwandan Socio-cultural Considerations
Rwanda's continued recovery from the 1994 genocide and the continued tension between Tutsi and Hutu peoples are obviously the greatest obstacles to effective deployment of HIV testing by domestic and international health organizations. However, working with President Paul Kagame and the Rwandan government, PEPFAR should convince the warring ethnicities that the testing is mutually beneficial. Also, with the cheaper method offered by batch testing, the proposition of HIV awareness testing may appear more palatable to at least domestic organizations. Rwanda's international airport near Kigali and functional system of paved roadways should make efficient air delivery and ground distribution within the country feasible.

Vietnamese Socio-cultural Considerations
Vietnam is a growing Communist country currently in the midst of dealing with climbing inflation and population growth rates. Vietnam has made continued efforts for the past few decades to slowly modernize its economy and its communication and transportation systems. Perhaps most importantly, it is seeking to join the World Trade Organization (WTO) in 2006. In coordination with UNAIDS and PEPFAR, this desire for world recognition, and its own domestic ambitions of *doi moi* ("renovation"), might be leveraged to help bring a system of HIV awareness testing to the country. Also, Vietnam's increasingly amicable trade relationship with the United States might further motivate us to consider helping to thwart the spread of HIV.

METHODOLOGY
To test the practicality of AIDS batch testing, we simulated a small population of 5000 random variables and found the average positive batch test rate. Then, generalizing this average to a more realistic population of 1 million, we compared costs.

Specifically, we let B be a random variable representing the number of HIV tests for a particular batch size. B is binary (success or fail) and equals either 1 or $n+1$, where n is the batch size. So, if there are no HIV-positive individuals in a given batch, then $B = 1$ and only one test is needed. If the batch is

positive then $B = n + 1$, and every member must be now individually tested in addition to the already tested batch. So for example, with $n = 2$, where 1 signifies a HIV-

Table 1: Two simulations of the random variable *B*, with *n* = 2.

Person 1	Person 2	*B*
0	0	1
0	1	3

positive individual, and the numbers in the *B* column represent the number of tests performed. After simulating 5000 iterations, we consolidated our data into a probability mass function (PMF) for *B*, which associates a probability with the success or failure of a batch test. For Vietnam, (0.4% HIV-positive). In other words,

Table 2: PMF of *B*, for Vietnam

x (=B)	1	3
p(x)	0.9918	0.008

the probability of a positive batch test (and so the need for further testing) is about 0.8%. Multiplying these probabilities by batch-size *B* and summing, we find the expected value for *B* at just over 1. At first glance this seems to imply we are doing now more tests than we would without batch testing. However, since we are only paying to test essentially half the population, we are actually ahead. In the case of Table 2, we could expect to spend about $355,500 on a population of 1 million, compared with $700,000 using individual testing.

RESULTS

We now turn to our initial problem, finding the optimal batch size. We found that a slightly larger batch, though increasing the expected value for *B*, often decreases the overall cost of the operation. Especially for relatively small rates of infection, a large batch size ($n = 20$) can mean nearly 90% savings. In Rwanda, where about 5.1% of the population is infected with the virus, a batch size $n = 3$ is the most cost effective. In Vietnam, on the other hand, where only about 0.4% are expected to test positive, we were able to use a batch size $n = 20$ successfully, with significant savings as compared with testing every individual.

In short, as the likelihood of an HIV-positive batch decreases, the risk of having to retest each individual in the batch decreases, which allows for larger batches and more money saved.

However, batch testing is not limited to countries with low HIV-positive populations: even with much higher probability of infection, batch testing still proves worthwhile. For example, with an infection rate of 10%, a batch size of $n = 3$ is still more cost-effective than $n = 2$ or $n = 1$ (no batch). Even with infection rates of as high as 20%, using a batch of $n = 2$ is more efficient than none.

CONCLUSION

Rwanda:

Rwanda's existing physical and social infrastructure will allow testing materials to be distributed to Rwandans in a rather expedient manner, but it will require careful social considerations. Supplies can be flown into the country using the capitol's international airport, and radially distributed – possibly taking advantage of the share taxis that daily swarm the airport. For greatest cost-effectiveness the people should be tested in groups of three, and to reduce racial tension the groups should be indiscriminate between Hutu and Tutsi ethnicities.

Vietnam:

Vietnam is a growing country. Unlike Rwanda and many of the other African countries where AIDS is most pervasive, Vietnam has a relatively low probability of infection. In coordination with the centralized government, international aid organizations should administer the test in groups of approximately 20, taking advantage of the relatively industrialized communication and transportation systems and the government's probable desire to cooperate in the interest of expanding its foreign trade.

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ABOUT THE AUTHORS

Steven Morse and Brent Nolan are both sophomores at the U.S. Military Academy at West Point. This project was completed as part of their core course in probability and statistics, required of all students at the Academy. Steven is an Applied Mathematics major, while Brent is majoring in Computer Science. Both authors will graduate in May 2008 and enter the active Army.

Communicating the Risk of Weapons of Mass Casualty

LTC James Ness, Ph.D., USMA

On April 4, 1997, a Navy intelligence officer was investigating the suspicious activities of a Russian flagged commercial vessel, the Kapitan Man, which was alleged to be spying on U.S. nuclear submarines in the Strait of Juan de Fuca.[1] The Navy officer observed the Kapitan Man from a helicopter and took photos of its activity. Upon return from the mission, the officer turned in his film for processing and mentioned that he thought something might have gotten into his eyes. Similar complaints were made by the helicopter crew. The next day, the Navy officer received a call from the analyst who processed the film. The analyst reported that he had noticed in the photographic images a red light that was not identifiable as a running light. He thought it could quite possibly be a laser. The Navy officer went to a physician to have his eyes checked. The physician documented corneal abnormalities and suggested the cause could have been from laser exposure. The diffusion of this information was rapid. The Kapitan Man was detained, and a congressional hearing ensued. The Navy officer and the helicopter crew were referred to the DoD tri-service directed energy center in San Antonio, Texas, for evaluation along with the photographs taken by the Navy officer.

The analysis of the photographs revealed that the red light in question was not a laser source. Nor was there any evidence of a laser source in any of the photographs. In addition, there was no laser found on board the Kapitan Man. The prevailing counter argument to the possibility that there was no laser was that it had been thrown overboard. Lack of definitive evidence

The Blind Leading The Blind: WWI Mustard Gas Casualties
Used by the International Committee of the Red Cross to depict effects of laser weapons[a]

of a laser source notwithstanding, the Navy officer was diagnosed with corneal erosion.

Corneal erosion is painful and can cause a blur in vision. However, red light is principally absorbed in the inner layers of the retina and not at the cornea. Thus the Naval officer's corneal erosion could not have been induced by a red laser source. A blue or ultraviolet source can affect the cornea, but neither the Navy officer nor members of the helicopter crew reported having seen any such light source. Moreover, the photographs revealed no evidence of any light source other than red. The erosion in the Navy officer's cornea was later determined to be associated with a disease mechanism possibly exacerbated by rubbing his eyes.[b] By the time of the examination in San Antonio, the helicopter crew had no complaints and their ophthalmologic assessments were within normal limits.

However, the problem remained how to communicate the outcome of the assessment, while staying true to the facts and allowing those involved in this now international incident to retain some integrity. The decision was made to report that the Navy officer had a dystrophy of the cornea that needed further treatment and that there were a few slightly depigmented spots identified in the fundus photographs not inconsistent with laser exposure. It was additionally noted that

[a] Resolution VIIB of the 25th International Conference of the Red Cross invited the ICRC to keep the Movement informed of the development of new weapons technologies, in addition to mines, the use of which could be prohibited under existing international law. Pursuant to this request the ICRC convened four meetings of experts between 1989 and 1991 on battlefield laser weapons and an additional expert meeting in 1994 on other weapon systems of possible concern. Based on the information assembled on laser weapons, the ICRC concluded that the large-scale production of laser weapons suitable for permanently blinding large numbers of soldiers or civilians could occur by the mid-1990s and that, because of the severity of blinding as an injury, the anti-personnel use of such weapons would violate the principle of unnecessary suffering. The experts consulted in these meetings also stressed that portable laser weapons would inevitably proliferate and therefore be frequently used indiscriminately.

[b] Corneal map-dot-fingerprint dystrophy is the most common corneal dystrophy and is named from the appearance of its characteristic slit lamp findings. Corneal dystrophies usually are hereditary, bilateral, progressive, and not associated with systemic or local disease.

these depigmented spots could also be a result of typical mottling due to disease, aging, or the Officer's natural pigmentation pattern.

The above scenario is an example of a general phenomenon that occurs in situations that require public communication of risk. Certain terms have a psychological saliency that focuses collective attention on a concept (e.g., radiation, laser, PTSD, anthrax) in a manner that can overshadow alternatives and exceptions to the collective idea of that concept. This forces a competition between the deliberate practice of determining etiology and culturally held concepts. In the case of the laser incident, indiscriminate use of lasers for the purpose of blinding was a pervasive theme. Most people, who heard laser and eye injury, concluded that a laser was used by the crew of the Kapitan Man with the intention to blind. Alternative explanations and exceptions were not easily accepted to the extent that the official diagnosis was well-tempered. The diagnosis was well-tempered to prevent any harm that might result from misdiagnosis, to mitigate reaction and further tension between opposing positions, to avoid any suggestion that the Navy officer's symptoms were a psychological manifestation, and to be sure that a very serious disease process (corneal dystrophy) would get appropriate medical attention. This strategy was effective and negotiated an etiology closer to the facts—but one that was certainly conditioned by the prevailing health fears associated with the potential for laser induced eye injury.

In general, all modern wars have been associated with symptom clusters that appear as "syndromes", but whose etiologies are confounding.[2,3] For example, Jones et al. (2002) researched pension files of the British military from 1872 through 1991 and found three varieties of post-combat disorder: a debility syndrome without psychological or cognitive symptoms associated with wars fought before 1918, a somatic syndrome involving cardio-respiratory symptoms (e.g., rapid heart beat, shortness of breath, fatigue, etc.) associated with World War 1, and a neuropsychiatric syndrome (e.g., depression, anxiety, headaches, etc.) associated with World War II through the first Gulf War. There was no single presentation of symptoms common across the various wars studied. Moreover, none of the syndromes identified could be linked to a definitive etiologic agent such as exposure to microbial agents, depleted uranium, chemical agents or uniquely identifiable psychological trauma. This led researchers to implicate cultural factors (e.g., common health fears, compensation, trends in diagnostic labeling) as contributing to these unexplainable illnesses.[4]

Culture is defined as a system of shared beliefs, values, customs, behaviors, and artifacts that the members of a society use to cope with their world and with one another, and that are transmitted from generation to generation through learning.[5] In this context, symptoms and culture are linked in a dynamic relation.[6] Symptoms may be quite real, as they were for the Navy officer who experienced corneal pain and blurred vision. The problem was—and often is—how symptoms are interpreted intellectually and to what cause(s) they are attributed. From this perspective, the primary impact of culture may be its influence upon (1) categorization and interpretation of functional somatic presentations, and (2) the ways in which these categories are understood and applied to express symptoms (e.g., aches, pains and distress) to other members of the culture. Thus, culture can serve to condition a novel medical explanation that satisfies most of society at any particular time, but at the cost of ignoring exceptions and alternate explanations.[4] In this way, popular health fears alert us to particular areas of the body and offer explanations that resonate with widely shared beliefs.[3,7]

Two processes seem to be involved in the evolution of symptom clusters associated with modern wars. One process is the rapid spread of notions concerning health-related problems. These health-related notions are best described as "memes" (a unit of cultural transmission or imitation).[6,7] Memes are memorable, have strong psychological appeal and speak to the concerns of a specific generation. They can replicate with relative high copying-fidelity (note consistency of symptom clusters within a war period) at sometimes alarming rates. The meme process spreads horizontally, within a generation or time-bounded category,[6] and resonates with the presently held notions. As a recent example, "Gulf War Syndrome" has been persistently attributed to toxin exposure,[8] which in turn has sustained arguments such as those concerning its possible relationship to a mycoplasma species infection. This attribution has been proven incorrect[c], but not before Gulf War I veterans were inappropri-

[c] February 2001 the U.S. Army Medical Research and Materiel Command conducted an external peer review of the DoD funded work on mycoplasma and found no putative role of *Mycoplasma fermentans* in the etiology of illness in veterans presenting with symptoms akin to chronic fatigue syndrome. Further, ethical concerns were raised in the use of a non-FDA approved technique used to enroll personnel in the course of antibiotic treatment.

ately treated with doxycycline as part of a clinical trial.[9]

The second, slower and more deliberate process redefines public conceptions toward a perspective that integrates relatively more complex sets of facts. This more deliberate process is purveyed across generations to salient individuals by way of educational institutions and through professional scientific literature. The result is a gradual accumulation of skill, technology, and information.[6] For example, the definition of HIV/AIDS has evolved since the Centers for Disease Control first defined the syndrome in 1982 as at least moderately predictive of a defect in cell mediated immunity, occurring in a person with no known cause for diminished resistance to that disease. In 1984 the discovery of HIV as the "cause of AIDS" resulted in a revised definition of AIDS to include a growing list of opportunistic infections and diseases only if HIV was present. Recently the link between HIV and AIDS has been questioned. The existence of the full range of AIDS symptoms and opportunistic infections in both HIV free and HIV infected transplant and cancer patients suggests that HIV infection may be an epiphenomenon of immune suppression rather than a necessary cause. Immune suppression may predispose people to HIV infection (just as it predisposes them to other opportunistic infections) rather than resulting from such an infection.[10] Each of these discoveries has led to a deliberate incremental increased understanding of AIDS yielding important advances in treatment and a sense in the general public that the disease is treatable and manageable.

These two processes (meme & deliberate) are dynamic and continually shape health concerns in general and war associated syndromes in particular. Just as in post-war syndromes and threats of pandemic disease, an outbreak of an unknown infectious agent would, under a current public emphasis over the threat of terrorism, facilitate conclusions of the use of a biological weapon of mass destruction. Although the concern over the threat of weapons of mass destruction is very much real, the idea of such a threat meets the criteria of meme. The "meme" process cannot be prevented, but it can be attenuated by carefully considered risk communication that is measured, precise, leverages culturally accessible terms and avoids culturally "loaded" ones. It is important that we understand and recognize that the more deliberate process will bring about a reasoned approach, but that process is incremental with new technical information often hard to convey to the general public. It is therefore essential that we facilitate the deliberative process through interdisciplinary curriculum and through the dissemination of information drawn from research and technology in a manner accessible to the public. To keep pace with events that will be present in the future, a broad education across disciplines at the undergraduate level is required with specialization achieved through apprenticeship and post baccalaureate education. This will provide a broad base of knowledge to make information across disciplines accessible and facilitate multidisciplinary solutions to current and future threats to our national security.

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[1]The San Diego Union-Tribune February 12, 1999.

[2]Jones, E., Hodgins-Vermaas, R., McCartney, H., Everitt, B., Beech, C., Poynter, D., Palmer, I., Hyams, K., Wessely, S. (2002). Post-combat syndromes from the Boer war to the Gulf war: A cluster analysis of their nature and attribution. British Medical Journal, 324, 1-7.

[3]Sartin, J. (2000). Gulf War Illness: Causes and controversies. Mayo Clinic Proceedings, 75, 811-819.

[4]Jones, E. & Wessely, S. (2005). War syndromes: The impact of culture on medically unexplained symptoms. Medical History, 49, 55-78.

[5]Bates D.G. & Plog F. (1990) Cultural Anthropology. 3rd ed., New York: McGraw-Hill.

[6]Sterelny, K. (2006). Memes Revisited. British Journal of Philosophical Science, 57, 145-165.

[7]Dawkins, R. (1976). The Selfish Gene. New York: Oxford University Press.

[8]Nicolson, G., Berns, P., Nasralla, M., Haier, J., Nicolson, N., & Nass, M. (2003). Gulf War Ill nesses: Chemical, Biological, and Radiological Exposures Resulting in Chronic Fatiguing Illnesses can be Identified and Treated. Journal of Chronic Fatigue Syndrome, 11, 135-154.

[9]Nicolson, G. & Nicolson, N. (1995). Doxycycline treatment and Desert Storm. Journal of the American Medical Association, 273, 618-619.

[10]Root-Bernstein, R. (1993). Rethinking AIDS; The tragic cost of premature consensus. Free Press/ Macmillan USA.

ABOUT THE AUTHOR

LTC James Ness is an Associate Professor of Psychology in the Department of Behavioral Sciences and Leadership at the U.S. Military Academy and is the Director of the Academy's Leader Development Research Center. LTC Ness earned his Ph.D. in experimental psychology in 1988 from Virginia Polytechnic Institute and State University. He has published on a wide range of topics in scientific and military journals.

CONFERENCE REVIEW

Conference on Quantitative Methods in National Defense, 15-16 Feb 2006

Presentation: *Statistical Methods for Chemical and Biological Attacks within Buildings*

Presenters: Sushil Sharma (USGAO) Don MacQueen (Lawrence Livermore National Lab), Brent Pulsipher (Pacific NW National Lab), and Sean McKenna (Sandia National Lab)

Reviewed By: MAJ Krista Watts, Instructor, Deptartment of Math Sciences, U.S. Military Academy

Summary: When there has been a suspected chemical or biological attack within a building, local, state and federal agencies are responsible for examining the building and determining whether an agent is present. Until now, there has been no real strategy for how to collect and test samples in a manner that maximizes the probability of detecting an agent if one is present while also minimizing the time necessary to collect and test samples. Mr. Sharma gave the example of a 108,000 square foot facility that had a 390 square foot contamination. Using random sampling, you would need 333 samples to have a 95% chance of finding the hot spot. This problem is further compounded because not all surfaces are equally likely to attract a toxin. Items such as computer screens might be more likely to draw an airborne toxin. Additionally, when modeling how a toxin might spread, it is not a simple matter of calculating Euclidean distances. Objects such as walls and doors affect the path of the toxin. The basic questions that a responding agency must answer are:

How many samples should I collect?

From where should I collect samples?

What sample collection methods should I use?

Visual Sampling Plan (VSP, a free software developed by Pacific NW National Lab) attempts to answer the first two questions. It claims to provide statistically defensible solutions to sampling design using world-class mathematical and statistical algorithms. VSP uses nonparametric upper tolerance levels and calculates Non-Euclidean distances using Dykstra's algorithm.

DO YOU KNOW...

Dr. David Franz, COL(Ret), Senior Fellow, Combating Terrorism Center

An ***infectious*** disease causing organism is one that can be transmitted from one person—or animal—to another, not necessarily easily. *Infectiousness* is sometimes measured by the number of organisms required to initiate an infection. Bacteria and viruses are infectious; toxins and chemical agents are not. Contact with a person suffering from an infectious disease does not necessarily imply that the disease will spread to another, nor does infectiousness relate specifically to spread.

A ***contagious*** disease causing organism is one that can be transmitted by contact with the sick. *Contagiousness* or *communicability* is often considered in the context of the kind of contact or nearness to the patient required for transmission to another. The term *reproductive rate* (R-value) is used to describe an organism's contagiousness in a typical societal setting; it is simply the number of additional people that one infected person infects with the disease. The R-value is a function of many things: route of infection, stability of the organism in the environment, population and individual behavior. A highly contagious agent like the viruses that cause influenza or measles might have an R-value of 30-40. The R-value for variola virus, which causes smallpox, has been estimated at less than ten. The R-value for SARS appears to have been around one. These rates of transmission are, of course, extremely dependant on population density, behavior and immune status of the exposed population at risk.

BOOK REVIEW

Biohazard

by Dr Ken Alibek

Reviewed By: Dr Frederick I. Moxley, Combating Terrorism Center Associate

Several books related to biological threats have come and gone over the course of the past decade or so. Some have proven to be very informative, while others have only tweaked our collective interest, causing us to continue our search for more definitive literary works regarding the subject matter. Although not a recent release, the book ***Biohazard*** (circa 2000) by Ken Alibek is considered by many an expert to be a must read for those interested in the field of biodefense. ***Biohazard*** provides a very informative look at the most grandiose, yet covert effort by the Soviet Union to develop biological weapons that has ever been known to man. Having defected to the west during the 1990's, Dr. Alibek describes in a no-holds-barred manner, how he led the *Biopreparet* program on behalf of the USSR to continually design and develop biological weapons for use against the U.S. and its allies during the cold war. It provides both a chilling and insightful look at the complexities involved with the use, detection, deterrence and counter-proliferation issues concerning biological weapons that must be addressed to this day.

LINKS AND WEBSITES

NIAID Biodefense Research

http://www3.niaid.nih.gov/biodefense/

The Biodefense website of the National Institute of Allergy and Infectious Diseases (NIAID), is a part of the National Institutes of Health (NIH). This very informative site includes biodefense-related information for biomedical researchers, the public, and the media.

Strategic National Stockpile

http://www.bt.cdc.gov/stockpile/

This government website is for the Center for Disease Control's (CDC) Strategic National Stockpile (SNS). The SNS was designed to harbor large quantities of medicine and medical supplies to protect the American public if there is a public health emergency (terrorist attack, flu outbreak, earthquake) severe enough to cause local supplies to run out. Once a federal, state or local authority agrees that the SNS is needed, the medicine(s) desired are then delivered anywhere in the U.S. within 12 hours. Each state has plans to receive and distribute SNS medicine and medical supplies to local communities as quickly as possible.

Bioterrorism: frequently asked questions

http://www.ama-assn.org/ama/pub/category/6667.html

In anticipation and preparation of a bioterrorist event, this webpage addresses the numerous questions and concerns involved with general aspects of such an occurrence. Managed by the American Medical Association (AMA).

Biological Threats

http://www.fema.gov/areyouready/biological_threats.shtm

One of the most informative general overviews provided by a government agency, this website provides information in order to prepare for, thwart, deal with, and what to do after a biological attack/occurrence has taken place. It also addresses the pathogenic means (vector) in which a biological agent may be used, and what equipment would serve the public best. Managed by the Federal Emergency Management Agency (FEMA).

UPCOMING EVENTS

Combating Bioterrorism / Pandemics: Implementing Policies for Biosecurity. 24-26 July 2006.
http://web.mit.edu/mitpep/pi/courses/combating_bioterrorism.html

GIS Conference: Social Networking Technology and Crisis Response. Arlington, VA. 3 October 2006.

3rd USMA Combating Terrorism Center Bioterrorism Workshop. West Point, NY. October 2006. http://www.ctc.usma.edu/events.asp

Preparing for Pandemic Influenza Conference. Arlington, VA., 11-12 October 2006.
http://www.homelanddefensejournal.com/hdl/conf_influenza.htm

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Address correspondence to:

The Biodefense Report
Combating Terrorism Center
607 Cullum Road
United States Military Academy
West Point, NY 10996

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