FAS
Public Interest Report
Journal of the Federation of American Scientists

Volume 55, Number 1 January/February 2002

The BW Protocol as a Health Care Intervention

By Lynn Klotz

The Biological Weapons Convention (BWC) of 1972 prohibits the development and stockpiling of biological weapons. Because the BWC has no means to verify compliance with the Convention, it has not prevented the proliferation of biological weapons even in some countries that are parties to the Convention. The international community recently had an unusual opportunity to strengthen the BWC by enacting a protocol, which an Ad Hoc Group of States Parties began negotiating in Geneva in 1996. The negotiations resulted in a compromise proposed protocol in 2001, which requires investigations and on-site visits within the geographic boundaries of the States that are party to the protocol.[1]

While there is wide support among nations for a protocol, the United States has rejected the proposed protocol on grounds that it would be ineffective in preventing BW development and use and would compromise national security by revealing US defensive strategies for BW. Unfortunately, the US has blocked enactment of any protocol for the time being. The following summary of a longer analysis on the FAS website deals with effectiveness of the proposed protocol.

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In This Issue

Arms Control: Where Now?

By Henry Kelly

There's no shying from the fact that arms control has taken a beating over the past year, and in spite of heightened concerns about weapons of mass destruction following the September 11 attacks and the anthrax letters, the public doesn't seem particularly concerned. Bipartisan interest in controlling access to Russian nuclear materials and other areas of nonproliferation indicates that we can make progress. But we've got to take an unflinching look at where arms control stands and where we can find practical opportunities.

The public is clearly not paying much attention to classic arms control issues. Even the astounding decision to withdraw from the ABM treaty raised only the faintest response. The treaty permits withdrawal if we certify that our "supreme national interests" are threatened. The cursory justification of this "supreme interest" the US provided sets a low bar for any other nation wishing to withdraw from a treaty for political convenience.

A few weeks after announcing withdrawal from the ABM treaty, the US undermined all hope for agreement on proposed measures to verify the Biological Weapons Treaty. The US remains adamantly opposed to the Comprehensive Test Ban Treaty and while it has done nothing inconsistent with compliances, it has taken a series of steps that may be used to justify US testing in the foreseeable future — including the provocative decision to increase the readiness of the Nevada Test Site. And while the administration has announced its intention to sharply reduce the number of strategic offensive weapons, it appears determined to do so in a way that would make it easy to reverse this process on short notice. It also failed to make the essential deci-

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The FAS Public Interest Report

The FAS Public Interest Report (USPS 188-100) is published bi-monthly at 1717 K St. NW Suite 209, Washington, DC 20036. Annual subscription is $50/year.

Archived FAS Public Interest Reports are available online at www.fas.org or phone (202) 546-3300, fax (202) 675-1010, or email fas@fas.org.

About FAS

The Federation of American Scientists (FAS), founded October 31, 1945 as the Federation of Atomic Scientists by Manhattan Project scientists, works to ensure that advances in science are used to build a secure, rewarding, environmentally sustainable future for all people by conducting research and advocacy on science public policy issues. Current weapons nonproliferation issues range from nuclear disarmament to biological and chemical weapons control to monitoring conventional arms sales; related issues include drug policy, space policy, and disease surveillance. FAS also promotes learning technologies and limits on government secrecy. FAS is a tax-exempt, tax-deductible 501(c)3 organization.

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sion needed to remove the justification for maintaining even 2,000 alert weapons: a clear break from the practice of targeting Russian nuclear facilities. The US government has also undermined its nonproliferation message by lifting the embargo on Pakistan and India imposed after their 1998 nuclear tests without receiving any pledges to refrain from further testing in return.

The expectations of US behavior are now so low, and fear of undermining a popular US President so great, that the US press, public, congress, our allies—and even the Russians and Chinese—have not raised serious complaints about any of these policy changes.

Those of us convinced that a framework of international agreements is essential for protecting ourselves, and the rest of the world, from weapons of mass destruction must make some hard-eyed decisions about how to proceed. Here are my suggestions:

Support innovations in defense systems needed to cope with 21st century threats.

It should be easy to agree on the high priority problems.

* A strong, balanced program of basic and applied defense research.
* Improved detection and early warning systems.
* Strengthened security systems consistent with civil liberties.
* Development and deployment of techniques for quickly identifying and treating anyone exposed to dangerous nuclear, biological, chemical materials or agents.
* Improved command, control, communication, and intelligence systems, including new methods for early detection of any WMD materials.
* Enhanced training for all medical personnel, first-responders, and others in a position to help detect dangerous activities and act to protect individuals.
* Continued improvement in precision conventional offensive weapons capable of minimizing civilian casualties and risks to US forces.

Defuse the tensions created by unilateral abrogation of the ABM treaty.

US attempts to test and deploy an ABM system promises to be a colossal waste of money. Unlike other boondoggles, however, this effort threatens real harm to US security. It provides incentives for a future nuclear arms race, cements current launch-on warning postures, and provides a rationale for a foolish venture into space-based weaponry. And our zeal to invest strengthens the political hand of Russian and Chinese nuclear and space weapons advocates. Given the demise of the ABM treaty we should:

* Design and build support for replacing the ABM treaty with another agreement limiting the scope of NMD deployments.
* Begin active discussions on an international treaty to block offensive weapons in space. While there's clearly value in improving ways to protect and defend satellites, offensive systems would threaten critical US military and civilian satellites.
* Start active high-level US-Russian discussions on measures for limiting the dangers of accidental launch through discussions on missile de-alerting. A nationwide US missile defense system is sometimes justified as a means to reduce this risk—surely the most reliable and least expensive method would be to eliminate the risk in the first place.
* Move aggressively to strengthen the missile technology control regime with incentives for air-tight commitments from Russia, China, and other nations to stop any support for long-range missile work.
* Work hard to reduce or eliminate tactical nuclear weapons - with special emphasis on the large number of Russian tactical

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Civic Scientific Literacy: *A Necessity in the 21st Century*

By Jon D. Miller

Americans and other citizens of modern industrial societies have lived in an age of science and technology during most of the 20th century. Continuing advances in information technologies, the mapping and application of genomic information, and the wired and wireless infrastructures needed to fully utilize these developments will accelerate the pace of scientific and technological advancement in the 21st century.

The economic need for and value of a scientifically literate populace are well known. Science and technology have had a pervasive impact on both the methods of production and the products that are manufactured. The manufacture of traditional industrial products like steel and the shaping of this and other metals into products have been largely automated. Workers in the modern office are characterized by the technologies used—word processors, data entry operators, data base managers, fax clerks, and photocopy technicians. The industrial challenges of the 21st century will be the manufacture of microcomputer chips, genetically-engineered products, and new products yet to be invented. In this kind of economy, a basic understanding of science and technology will be the starting point for the development of the additional professional and technical skills needed to be competitive in an era of intense international economic competition.

Parallel to the need for a more scientifically literate workforce, the economy of the 21st century will need a higher proportion of scientifically literate consumers. From the experience of the last two decades, it is clear that increased exposure to computers at work and school has stimulated a strong and growing home microprocessor market. As more products incorporate new technologies, the information about the desirability, safety, and efficacy of those products will require a basic level of scientific literacy for comprehension. Some 20th century technologies like the irradiation of foods for preservation have never achieved a high level of commercial success due to public misunderstanding and resistance. A strong technologically-based economy in the 21st century will require that a substantial portion of the consuming populace be scientifically literate.

Of equal importance to these economic arguments, the preservation of democratic governments in the 21st century may depend on expansion of public understanding of science and technology. Over recent decades, the number of public policy controversies that require some scientific or technical knowledge for effective participation has been increasing. At the community level, the fluoridation controversies and referenda of the 1950's and 1960's in the United States illustrated the importance of a scientifically literate electorate. The more recent controversies over the siting of nuclear power plants, nuclear waste disposal facilities, and the use of embryonic stem cells in biomedical research point again to the need for an informed citizenry in the formulation of public policy.

It is clear that national, state, and local political agendas will include an increasing number of important scientific and technological policy issues in the 21st century. While a detailed discussion of public participation in the formulation of science and technology policy is beyond the scope of this paper, it is important to note that the public plays the role of final arbiter of disputes, especially when the scientific community and the political leadership are divided on a particular issue. As new energy and biological technologies move toward the marketplace, there will be important public policy issues to be decided and some of these issues may erupt into full-scale public controversies. The preservation of the democratic process demands that there be a sufficient number of citizens able to understand the issues, deliberate the alternatives, and adopt public policy.

If citizens are to discharge this responsibility in the context of an increasingly scientific society, it is essential that a significant proportion of the electorate be able to understand important public policy disputes involving science or technology. I refer to this level of understanding as "civic scientific literacy." This paper will summarize a measure of civic scientific literacy that has been widely used over the last two decades and examine the present level and structure of civic scientific literacy in the United States.

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The Conceptualization and Measurement of Civic Scientific Literacy

To understand the concept of civic scientific literacy, it is necessary to begin with an understanding of the concept of "literacy" itself. Historically, an individual was thought of as literate if he or she could read and write their own name. In recent decades, there has been a redefinition of basic literacy skills to include the ability to read a bus schedule, a loan agreement, or the instructions on a bottle of medicine. Adult educators often use the term "functional literacy" to refer to this new definition of the minimal skills needed

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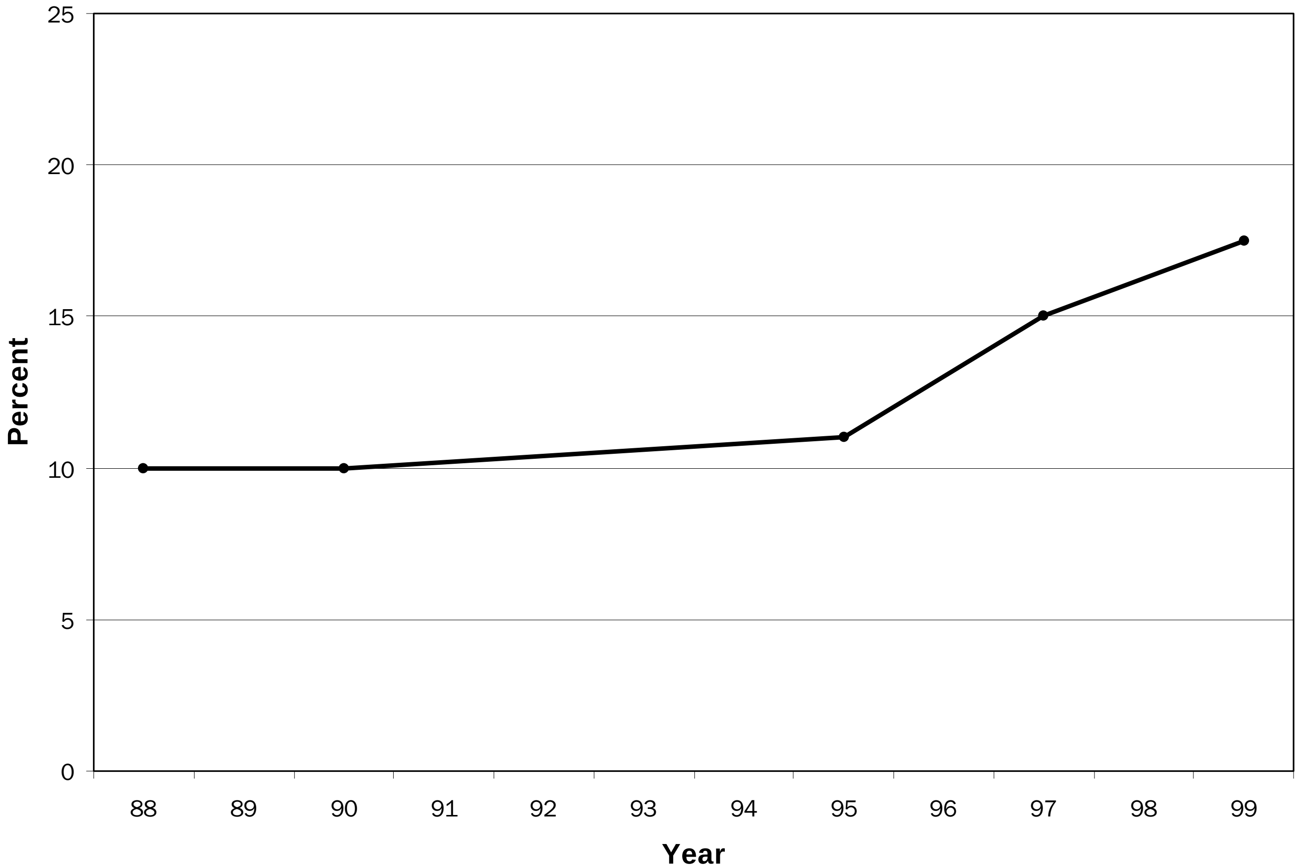

Figure 1. Civic Scientific Literacy in the United Stated, 1988-1999.

"Scientific Literacy" *Continued from page 3*

to function in a contemporary industrial society (Resnick and Resnick, 1977; Harman, 1970). The social science and educational literature indicates that about a quarter of American adults are not "functionally literate," and there is good reason to expect that roughly this proportion applies in most mature industrial nations and a slightly higher rate in emerging industrial nations. In this context, civic scientific literacy is conceptualized as the level of understanding of science and technology needed to function as citizens in a modern industrial society.

Although a detailed discussion of the conceptualization and measurement of civic scientific literacy is provided in the refereed literature (Miller, 1998), it may be helpful to summarize this measure briefly. In broad terms, to be classified as civic scientifically literate, a citizen needs to display:

1) an understanding of basic scientific concepts and constructs, such as the molecule, DNA, and the structure of the solar system,
2) an understanding of the nature and process of scientific inquiry, and
3) a pattern of regular information consumption (Miller, 1998).

In practical terms, the level of concept vocabulary and process understanding required reflects the level of skill required to read most of the articles in the Tuesday science section of the New York Times, watch and understand most episodes of Nova, or read and understand many of the popular science books sold in bookstores today.

Using this measure, approximately 10 percent of American adults qualified as civic scientifically literate in the late 1980's and early 1990's, but this proportion increased to 17 percent in 1999 (see Figure 1, page 4). Since each percentage point in a national survey of adults aged 18 and over in the United States represents approximately 2 million individuals, this result means that about 34 million Americans were civic scientifically literate by the end of the 20th century. This rate of civic scientific literacy is higher than that found in Canada, the European Union, or Japan, using similar measures (Miller, Pardo, & Niwa, 1997; Miller and Pardo, 2000). At the same time, it is a level that may be too low for the requirements of a strong democratic society in a new century of accelerating scientific and technological development.

What Factors Contribute to Civic Scientific Literacy?

While it is useful to know the level of civic scientific literacy in the United States, it is important to understand the factors associated with a functional level of understanding of basic scientific terms and processes. To identify the factors associated with civic scientific literacy, a structural equation analysis[1] of the 1999 U.S. data set was conducted (Jöreskog and Sörbom, 1993). The analytic model included each individual's age, gender, highest level of education, number of college science courses completed, presence or absence of minor children in the household, and level of use of informal science education resources. The total effect of each of these variables on civic scientific literacy is shown in Figure 2 (page 6).

Despite a general expansion of educational access in the United States in the last half of the 20th century, both age and gender had moderately strong influence on civic scientific literacy in 1999. Holding constant all of the other factors in the model, women were slightly less like likely to be scientifically literate than men (-.24) and older adults were slightly less likely to be scientifically literate than younger adults (-.24). Independent of age and gender, the level of educational attainment was positively related to civic scientific literacy (.19).

The number of college-level science courses taken is the strongest predictor of civic scientific literacy (.53). It is important to understand this variable and its impact. The variable is a measure of the number of college-level science courses, including courses at both community colleges and four-year colleges and universities, but excluding graduate courses. The number of courses was divided into three levels: 1) no college-level science courses, 2) one, two, or three courses, and 3) four or more courses. Those individuals with one to three courses reflect the students who took college-level science courses as a part of a general education requirement rather than as a part of a major or a supplement to a major. The use of an integer measure would have given undue weight to majors and minimized the impact of general education science courses in the analysis.

It is not well known in the scientific community that the United States is the only major nation in the world that require general education courses for its university graduates. University graduates in Europe or Japan can earn a degree in the humanities or social sciences without taking any science course at the university level. In cross-national studies, a slightly higher proportion of American adults qualify as scientifically literate than do adults in the European Union or Japan, and comparative structural equation analyses of those data show that this exposure to college-level science courses accounts for US performance (Miller, Pardo, and Niwa, 1997; Miller and Pardo, 2000). Although university science faculties have often viewed general education requirements with disdain, these analyses indicate that the courses promote civic scientific literacy among US adults despite the disappointing performance of American high school students in international testing (Schmidt, McKnight, and Raizen, 1997).

The model also included a variable indicating whether there were any minor children living in the respondent's household. In this model, the net impact of having minor children in the home, also known as the "science fair" effect, was .02, indicating a miniscule effect on parents and children's scientific literacy.

The analysis found that the use of informal science education resources was positively related to civic scientific literacy (.30). The measure included each individual's use of science magazines, news magazines, science books, science museums, home computer, science Web sites, and the public library. The magnitude of the influence of informal education resource use—second to college-level science courses—indicates that the efforts of members of the scientific community to enhance the scientific literacy of non-scientists is having a positive effect.

Implications for the Scientific Community

What are the implications of this work for the scientific community? Let me suggest three points to consider.

First, it is clear that the generally defamed general education requirements to take at least a year of science courses continues to make a major contribution to the civic scientific literacy of citizens who are outside the scientific community. Other studies have shown that civic scientific literacy is positively associated with support for basic scientific research and for the intellectual freedom needed for good science. We need to recognize the value of these courses and seek to make them more effective in the years ahead. As one example, the National Science Foundation provides funding for the enhancement of undergraduate science courses, but only a few scientists and fewer institutions have attempted to understand how important these courses are to improving civic scientific literacy.

> ... studies have shown that civic scientific literacy is positively associated with support for basic scientific research and for the intellectual freedom needed for good science.

Second, the accelerating pace of scientific development will place increasing demands on informal science educators—science writers, journalists, television and movie producers, and web masters—and their institutions to keep Americans up-to-date about new scientific and technological developments after the end of formal schooling. The relatively strong influence of informal science education resource use in the 1999 analysis indicates that the system is working, but it will need the help and leadership of more members of the scientific community to meet the accelerating demands of the 21st century.

Finally, it is clear that the best long-term source of civic scientific literacy is to improve pre-collegiate education so that all students who graduate from college are scientifically literate. The fact that college-level science courses are currently able to

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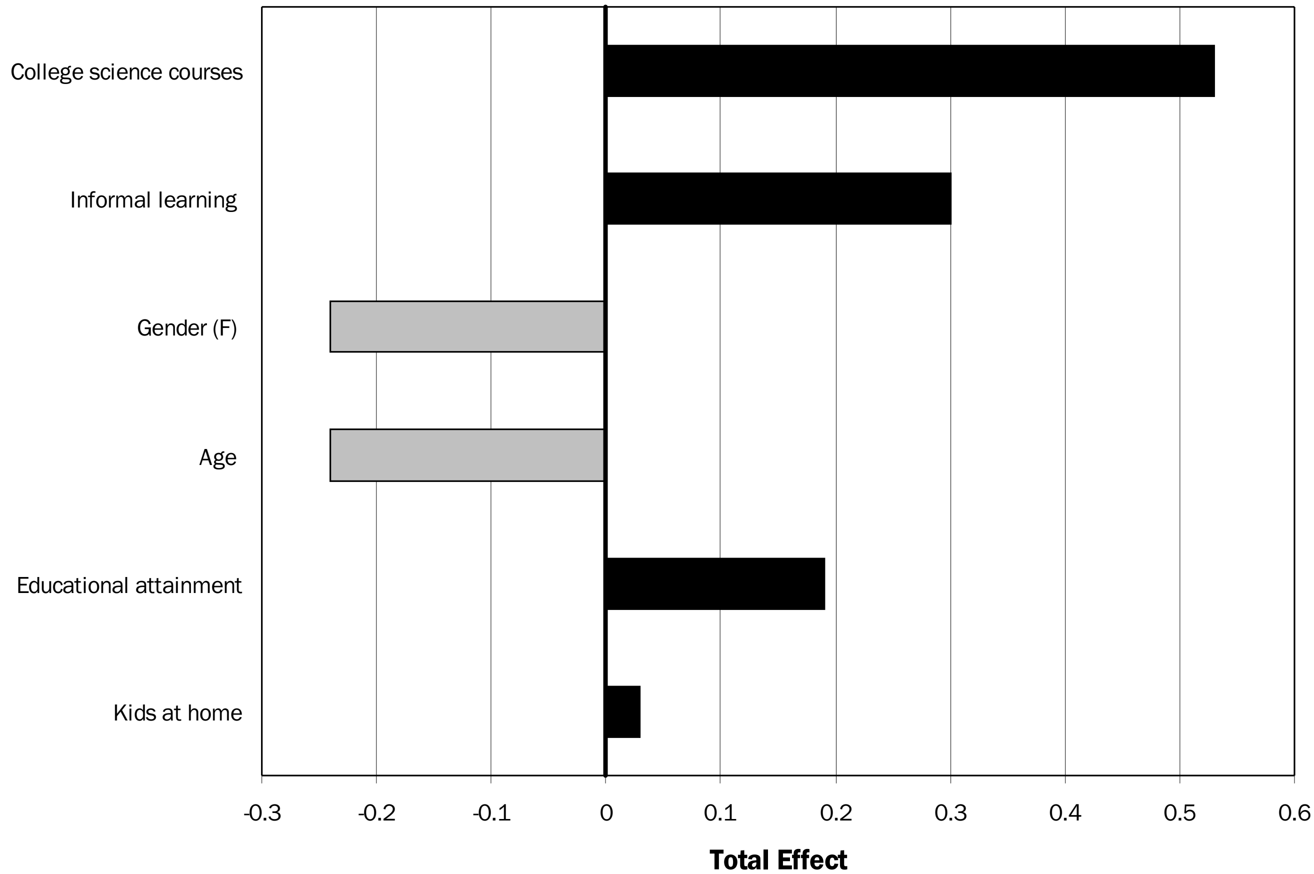

Figure 2. Factors Contributing to Civic Scientific Literacy in the United Stated, 1999.

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compensate in part for inadequate middle school and high school science should be of little consolation to the scientific community. A slightly high proportion of American adults may qualify as more scientifically literate than European or Japanese, but the truth is that no major industrial nation in the world today has a sufficient number of scientifically literate adults. We should take no pride in a finding that four out of five Americans cannot read and understand the science section of the New York Times. ***PIR***

Jon Miller is Director and Professor of the Center for Biomedical Communication in the Northwestern University Medical School and Professor in the Medill School of Journalism at Northwestern University. Dr. Miller has measured the public understanding of science and technology in the US for the last two decades, and has examined the factors associated with the development of attitudes toward science. He is one of the few scholars in the US that has studied both the development of knowledge and attitudes in adolescents and young adults and the attitudes of national samples of adults. His basic approach to the study of public understanding and attitudes has been replicated in approximately 30 countries. He is the Director of the International Center for the Advancement of Scientific Literacy, now located at Northwestern University. His published works include four books, the latest of which is Biomedical Communications *(Academic Press, 2001)—and more than 40 journal articles and book chapters. Miller is also the editor of a new collection of original research* Public Perceptions of Biotechnology *(Hampton Press, available in late 2002).*

Notes:

[1] In general terms, a structural equation model is a set of regression equations that provide the best estimate for a set of relationships among several independent variables and one or more dependent variables. For all of the structural analyses presented in this report, the program LISREL was used, which allows the simultaneous examination of structural relationships and the modeling of measurement errors.

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"BW Protocol" *Continued from page 1*

The analysis considers the protocol to be a health care intervention that helps to prevent sickness and death from a biological weapons attack. This perspective allows us to use standard pharmacoeconomic procedures and benchmarks to analyze the cost-effectiveness and cost-benefits of the proposed protocol.

Pharmacoeconomic analyses are widely used to look at the costs, benefits and effectiveness of health-care interventions to assess health care choices, weighing costs and outcomes of new drug therapies and prevention practices. Each choice has its cost—and relative beneficial outcome. Health care analysts use pharmacoeconomics to determine the best "health-care buy."

Seen in the light of quantitative pharmacoeconomics, our analysis shows that a protocol that would provide only a small decrease in the probability of a BW attack on the US would still be highly cost-effective, because its cost is so low compared to the extremely high cost of a successful BW attack of moderate size.

Given the present terrorist threat, many believe that the risk of attack is not insubstantial. For a successful terrorist attack, it is more likely that weaponized BW agents will purposefully or inadvertently come from a State than be developed by terrorists on their own.

Data for the Analysis and Data Strategy[2]

To make a case for US support of the BWC protocol, assumptions regarding the data are conservative, that is, they tend to support the US government's contention that the protocol is ineffective. Thus, throughout the analysis, "conservative" means: where good data are not available or are uncertain, data values are chosen that tend to make supporting the protocol less favorable, financially and otherwise. The analysis is carried out for a period of 25 years.

Cost to the US to support the protocol. The total yearly cost to support the protocol was calculated to be $8.7 million. It is the sum of three costs: the 22% US contribution to the estimated $30 million yearly operating costs of the international organization to administer the protocol,[3] $2 million yearly operating costs of the US implementing organization, and a $60,000 per year cost to facilities to host visits from the international organization.

Statistics for the scale of the attack. A BW attack on the US of moderate size is defined here as one in which 30,000 people are infected with 9,000 fatalities. This attack size is used throughout the analysis. A well-executed anthrax attack on a US city could cause over 100,000 fatalities,[4] and a recent simulation of a small pox attack on the US called "Dark Winter" estimated that several million people could be killed.[5] Thus, the BW attack size of this analysis is conservative compared to what we could experience.

For a small pox attack, 30 percent of the victims could die.[6] For an anthrax attack, a higher percentage of victims could die.[7] Since each death costs the US about $1.2 million (see the economic value of human lives, calculated below) for an attack with an agent that causes greater than 30% fatalities, the cost will rapidly rise with the number of fatalities.

It is assumed that the average age of victims of a BW attack is 42 years, slightly over the average age in the US of about 37 years.[8] Average age and life span are needed to determine life-years saved for cost-effectiveness analysis.

The economic value of human lives. The value of human lives and lives saved by a health-care intervention can be expressed in dollars. In the US, a human life may be valued at $34,000 per year, which is the gross national product per year (GNP) per capita. For an average victim's age of 42 years and with a life expectancy of 77 years,[9] each life saved through prevention of a BW attack results in 77 – 42 = 35 life-years saved. Thus, the average dollar value of each life saved from preventing a BW attack is 35 x $34,000 = $1.19 million. This number is used in the cost-benefit analysis.

Data for the likelihood of an attack and protocol effectiveness. The conservative probability of 0.01 per year for an attack on the US is chosen for the analysis. This low probability translates to a 50 percent chance of no BW attack of moderate size on the US in the next 69 years (years=log[0.5]/log[1-0.01]).

> Seen in the light of quantitative pharmacoeconomics, our analysis shows that a protocol that would provide only a small decrease in the probability of a BW attack on the US would still be highly cost-effective.

Effectiveness of the protocol is represented simply by the reduction of the probability for a BW attack.[10] For a weakly effective protocol, we assume this reduction to be 10%; that is, the probability of a BW attack becomes 0.009 per year (0.01 x [1-0.1]). Said another way, a weakly effective protocol would prevent only one attack in ten. This is the value for reduction in attack probability used in the analysis.

All attack-associated data are weighted by the probability of attack without the protocol or with the protocol in place, as appropriate.

Direct and indirect costs of the attack. The direct cost of an attack is taken to be the cost of medical treatment of victims and is estimated to be $535 million, based on treatment costs for a number of serious diseases.[11]

For this analysis, indirect costs of an attack are equal to direct costs for

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Table 1. Data used in pharmacoeconomic analysis (Attack-related costs are realized only in the years when an attack on the US occurs).

	No Protocol	Protocol in Place
Yearly Probabilities:		
Attack	0.010	0.009
No Attack	0.090	0.991
Yearly Cost:		
Protocol Implementation	$0	$8.7 million
Attack Related Costs:		
Direct Cost of Attack	$535 million	$535 million
Indirect Cost of Attack	$535 million	$535 million
Cost of Fatalitie	$10.7 million	$10.7 million

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medical care of victims. This is a serious underestimate as the indirect costs will likely be several times the direct costs. Indirect costs would include prophylactic antibiotics or vaccines for those that are exposed, but not infected; lost work days of non-infected people who are ordered to stay at home; the cost of quarantining those who are infected or possibly infected; costs of environmental clean-up; costs related to mental or physical care of panicked unaffected individuals; criminal investigation costs; and costs of emergency and military responses to the attack. Thus, the total cost estimate ($535 million x 2) of about $1 billion, for the BW attack of moderate size is very conservative.

A third type of cost is the cost of fatalities. At an economic value of $1.19 million per person (see page 7), a BW attack with 9,000 fatalities would cost the US $10.7 billion, an amount that also would greatly exceed the direct costs.

Observations from the data. Compared to the small financial cost to the US to support the protocol, $8.7 million per year ($122 million net present value for 25 years), a moderately-sized attack on the US would be extremely expensive, minimally $1 billion, not including the $10.7 billion economic value of lost human lives.

The logic of this extreme situation is almost akin to Pascal's logic in his well-known wager for belief in God: "Let us weigh the gain and the loss in wagering that God is… If you gain, you gain all; if you lose, you lose nothing. Wager, then, without hesitation that He is."[12] Like Pascal's argument, there is much to gain and little to lose in supporting the protocol. The simple pharmacoeconomic model for the analysis presented below "transforms" political arguments into a discussion of probabilities, which may help clarify discussion about effectiveness of the protocol.

A Primer on Pharmacoeconomics[13]

Two common pharmacoeconomic measures, cost-effectiveness and cost-benefit, were employed for the analysis. Cost-effectiveness (CE) is the dollar cost of the intervention divided by the life-years saved (lys) from the intervention:

Equation (1)

$$CE = COSTS/lys$$

For the BWC protocol, COSTS is net present value (NPV)[14] cost of the protocol to the US over the years that the protocol is in place. lys is the life-years saved from the prevention of a biological weapons attack due to the protocol.

What constitutes a cost-effective or good health-care buy? Health-care interventions with CE less than the GNP per capita, $34,000 per lys, are cost-effective and a good health-care buy. (In certain cases, society will tolerate higher cost per life-years saved for some health-care interventions.)

In cost-benefit (CB) analysis, both BENEFITS and COSTS are defined and measured in dollar amounts.

Equation (2)

$$CB = BENEFITS-COSTS$$

BENEFITS are the cost-savings from prevention of a BW attack due to the protocol, which when in place, reduces the probability of an attack and thus reduces the probability-weighted direct and indirect costs of an attack and number of fatalities. All benefits are also expressed as NPV.

The model and results

In our simple model for pharmacoeconomic analysis, the probability of an attack in each year is independent of whether or not an attack occurred in the preceding year. Also, the costs of the protocol and of an attack are assumed to be constant over the 25 years for which the analysis is carried out. The cost and probability data for the analysis are summarized in Table 1.

The particular scenario represented by the probabilities in Table 1 is for a relatively ineffective protocol. To reiterate, effectiveness of the protocol is represented solely by reduction of the probability of an attack—in this case a 10% reduction from 0.01 to 0.009 per year for a BW attack with no protocol in place.

Summary of results of cost-effectiveness and cost-benefit analysis. The expected number of lives saved by the protocol is simply the difference in fatalities for no protocol vs. protocol in place. This difference is calculated as follows. The expected number of fatalities in any single year with no protocol is given by:

[Probability of an attack (no protocol)] x [number of fatalities] = 0.01 x 9000 = 90

The expected number of fatalities in any single year with the protocol in place is given by:

[Probability of an attack (Protocol in place)] x [number of fatalities] = 0.009 x 9000 = 81

Thus, in any one year, the expected number of saved lives from the protocol is 90 - 81 = 9 and the expected total number of life-years saved is therefore 9 x 35 = 315. The NPV for life-years saved over the 25 years of the analysis is 4,440 lys.[15]

The NPV cost of the protocol over the 25 years of the analysis is $122 million, so the cost-effectiveness of the protocol using Equation (1) is

CE = $122 million/4,440 lys = $27,500 per lys

which is under the $34,000 value demarcating a good health-care buy. More importantly, the value for CE was arrived at by using only assumptions about the data that were unfavorable to effectiveness of the protocol.

Using appropriately discounted and probability-weighted values in equation (2), CB = $43 million. Therefore, by supporting the protocol the US will actually save money; that is, the expected cost-savings are *well above* the cost of supporting the protocol for 25 years.

A less conservative case. For a BW attack of greater scope or with higher indirect costs, the protocol could be considerably less effective, and still be a good heath-care preventative measure. The indirect costs of an attack could easily be ten times the direct costs, which may still be conservative. Furthermore, the protocol could be more effective and thwart 20% of all potential attacks. For this less conservative case, how low can the probability of attack be to ensure that the protocol is still cost effective and has positive benefits over costs; that is, CE is less than $34,000 cost per lys and CB is greater than $0?

For this case, the yearly probability of attack on the US can be as low as 0.004, which translates to a 50% chance of no BW attack on the US in the next 173 years. Thus, the protocol would be cost effective even if the risk of attack on the US is very small. Benefits over costs remain positive as well, CB = $65 million NPV.

By supporting the protocol the US will actually save money; that is, the expected cost-savings are *well above* the cost of supporting the protocol for 25 years.

Conclusion

Pharmacoenonomics is one analytical tool to gauge the effectiveness of the protocol. Based on this approach, it is in the US' interest to support a BWC protocol. The US' arguments for rejection of the proposed protocol—on the grounds of effectiveness—are without merit. ***PIR***

Dr. Lynn Klotz is a member of the FAS Working Group on Biological Weapons. He is a an expert in many areas of biotechnology and biological weapons control and has published several reports dealing with the Biological Weapons Convention Protocol, including papers on the pharmaceutical and biotechnology industries' response to the protocol and technical issues related to compliance with the BWC. He received the Dreyfus Teacher-Scholar Award for excellence in teaching, while an associate professor of biochemistry and molecular biology. The Gene Age: Genetic Engineering and the Next Industrial Revolution*, which he co-authored with Edward J. Sylvester, was nominated for the Pulitzer Prize for Nonfiction in 1983.*

NOTES:

1 See for example: Rosenberg, B., "Allergic Reaction: Washington's response to the BWC Protocol," Arms Control Today, July/August 2001. Link: http://www.armscontrol.org/act/2001_07-08/rosenbergjul_aug01.asp

2 The detailed description of the data and analysis may be found on the FAS web site (www.fas.org) in the paper entitled "The Biological Weapons Protocol as a Health Care Intervention: Cost-effectiveness and Cost-benefit." The spreadsheet developed for this analysis allows testing of many scenarios and is available from Lynn Klotz lynnklotz@compuserve.com

3 Details of the operating budget and a spreadsheet for the budget may be found on the FAS web site. (http://www.fas.org/bwc/papers/structure/start.htm). The US 22% contribution is from the UN scale of assessment.

4 Christopher, G., et al., "Biological Warfare: a Historical Perspective," Journal of the American Medical Association (JAMA), August 1997. U.S. Congress, Office of Technology Assessment, *Proliferation of Weapons of Mass Destruction: Assessing the Risk, OTA-ISC-559* (Washington, DC: U.S. Government Printing Office, August 1993). Link: http://www.wws.princeton.edu/~ota/disk1/1993/9341_n.html pg 54.

5 Disease by Design: De-mystifying the Biological Weapons Debate. Crowley, Mi. BASIC Research Report 2001.2, November 2001. Link: http://www.basicint.org/BWreport.htm Part II, Section 7.3.

6 Fatalities of 30% is commonly accepted for smallpox. See, for example, the links http://www.hopkins-biodefense.org/pages/agents/agentsmallpox.html and http://www.who.int/emc/diseases/smallpox/faqsmallpox.html

7 See, for example, http://www.fda.gov/cber/vaccine/anthrax.htm or Meselson, M., Guillemin, J., Hugh-Jones, M., et al. "The Sverdlovsk Anthrax Outbreak of 1979." Science 1994;266:1202-1208.

8 Reference: Mean Age of Americans: 36.6 (Nov. 1, 2000). Population Estimates. Program, Population Division, U.S. Census Bureau, Washington, D.C. 20233. Internet Release Date: January 2, 2001. Link: http://eire.census.gov/popest/archives/national/nation2/intfile2-1.txt

9 Reference: Life Expectancy of Americans: 76.7 yrs (1998). Anderson, R.N., National Vital Statistics Reports; Vol. 48, No. 18. Hyattsville, Maryland: National Center for Health Statistics. 2001. Link: http://www.cdc.gov/nchs/fastats/lifexpec.htm

10 Some opponents to the protocol would argue that the protocol could increase the probability of attack, not reduce it, because it would give a false sense of security or reveal our defensive strategies. Almost all protocol supporters

Continued on page 10

Learning Technology | **Survey in International Investment in Ed Tech R&D Released**

By Marianne Bakia

The Learning Technology Project released its first report, A *Survey of International Investment in Educational Technology Research and Development,* in late January. The report is a first of its kind analysis of government investment in educational technology research and development. It covered the US, Australia, Canada, European Union, Ireland, Japan, Korea, and South Africa. This information is an essential first step toward strengthening and coordinating learning research programs around the world.

The survey fount that countries invest heavily in demonstration and implementation projects related to educational technology, but little is spent on reasearch. The US spends over $900 billion a year on education and training, and the worldwide investment is roughly $2 trillion. Worldwide investment in computers and communication services for education and training is $16 billion.

Despite the considerable public resources spent to acquire technology for educational institutions, and despite the extraordinary talents and dedication of the many teachers and software developers who have produced ingenious products that are already contributing to educational practices worldwide, a significant gap separates the educational technology now in use from the incredible potential offered by these technologies.

The study found that the US designated approximately $200 million to educational technology research and development in FY2000, although less than $40 million was invested for non-military applications. The survey also found that US research programs are scattered across many different agencies with little coordination. While the European Commission invested comparable levels of funding ($65 million), the programs are much better coordinated.

Despite the considerable public resources spent to acquire technology for educational institutions ... a significant gap separates the educational technology now in use from the incredible potential offered by these technologies.

Australia has just begun an innovative, multi-million dollar program that essentially commissions the creation of interoperable, standardized content for Australian elementary and secondary schools. Beginning in 2001 and running until 2006, the goal is to generate high-quality, researched and evaluated, online curriculum content for Australia's schools. This government coordinated program features public-private partnerships and expects to reduce potential duplication, increase cost efficiencies, and stimulate market and private investment in educational technology development.

Electronic copies of the report as well as additional resources related to educational technology research and development can be found at http://fas.org/learn/intl_rev/index.htm. The study was funded by the Spencer Foundation. ***PIR***

Marianne Bakia is the Project Director of the FAS Learning Technologies Project, which encourages research and development to ensure that advances in computers, communication, and other information technologies make learning more productive, more accessible, and more fun for people of all ages.

"BW Protocol" *Continued from page 9*

understand that the protocol is only one of a number of measures needed to reduce the risk of biological weapons, so they would not have a false sense of security nor reduce efforts in other areas to prevent BW proliferation. Regarding revealing defensive strategies, the managed access procedures built into the proposed protocol are more than adequate to protect confidential national security information, as the US has stated to be the case in the Chemical Weapons Convention.

[11] Hospital cost and stay estimates were derived from several different severe illnesses: 1) Respiratory syncytial virus (RSV) among the elderly costs $11,000 per RSV pneumonia hospitalization (Han, L.L., Alexander, J.P., Anderson, L.J., J Infect Dis 1999 Jan;179(1):25-30); 2) Costs for treating viral meningitis are over $2,000 per day, but hospital stays are short, 4 to 5 days. (Parasuraman, T.V., Deverka, P.A., Toscani, M.R., Managed Care 2000 Jan;9(1):41-6); 3) For severe sepsis, the average costs per case were $22,100 (Angus, D.C., Linde-Zwirble, W.T., Lidicker, J., Clermont, G., Carcillo, J., Pinsky, M.R., Crit Care Med 2001 Jul;29(7):1303-10); 4) Estimate three weeks in hospital for small pox survivors (Forman, J., Boston Globe, Tuesday November 20, 2001, page C1).

[12] From the internet version of the Stanford Encyclopedia of Philosophy (http://plato.stanford.edu/entries/pascal-wager).

[13] See for example: Luce, B.R., and Elixhauser, A., "Socioeconomic Evaluation and the Health Care Industry," Journal of Research in Pharmaceutical Economics, Vol. 2(4) 1990.

[14] Throughout the analysis, the interest or discount rate used to calculate NPV is 5%.

[15] Whether we discount life-years saved is a philosophical and psychological question. One could argue that our children's and grandchildren's lives in the future are as valuable as our lives now, in which case we would not wish to discount life-years saved. In this analysis, life-years saved are discounted at 5%, the same as money. Since most of us believe that future lives are more valuable than future money, discounting future lives at the same rate as money is a conservative assumption, because it leads to higher cost/lys values making less of a case for the protocol.

"Arms Control" *Continued from page 2*

weapons, many of which are vulnerable to terrorist theft.

Ensure that the US does nothing inconsistent with the CTBT.

Strong efforts are needed to ensure that the US maintains its moratorium on nuclear testing. There is no sensible justification for "mini-nukes" to defeat buried hardened targets. DOE stockpile programs to ensure the stewardship of US weapons must be focused on providing the greatest possible assurance of safety and reliability, and not on projects that may be intellectually exciting but of marginal relevance to this core mission.

Strengthen control of fissile materials.

Controlling access to nuclear materials remains the most important single investment blocking proliferation of nuclear weapons. Full funding for programs that bring Russian nuclear materials under control is essential.

Develop strong international measures for verification of the BWC.

The US has an overwhelming interest in strengthening international efforts to control biological weapons. A fresh look at options for doing this through a formal protocol would be acceptable, if the US shows a clear commitment to move rapidly to an agreement. The administration's proposals for stronger national laws could certainly be a part of the agreement, but are clearly not sufficient. The US needs to accept some inspection and reporting under an international framework while recognizing that formal inspections are unlikely to provide necessary confidence in compliance. The formal measures must be supplemented by the broadest possible "neighborhood watch" system in which researchers, equipment suppliers, and many others are trained to be alert to questionable activities and know how to act on suspicions.

We can still salvage a safer world from the recent reversals in arms control.

Develop restrictions on arms transfers based on states' respect for human rights and regional stability.

Many of the countries now receiving arms and military training as a reward for their support of US anti-terrorism efforts have terrible records in human rights. If we need to reward countries like Pakistan, Tajikistan, Azerbaijan, and other nations for aiding the US anti-terrorism efforts, we should do so not by expanding arms sales but through increases in economic aid and other non-military support.

These steps could avoid the greatest problems created by an administration driven more by ideology than by careful thought. They do, of course, require admission that international agreements can be helpful—this is a challenge in itself. But a majority of Americans should, and I believe would, be able to support all of these actions. We can still salvage a safer world from the recent reversals in arms control. ***PIR***

Henry Kelly is the President of FAS.

Are FAS Member Dues Contributions? Or Vice Versa?

Since the merger of FAS and the FAS Fund this past fall, members want to know whether the status of their FAS membership has changed. There are no significant changes in our membership program. As in the past, memberships are renewed annually, usually in the spring at the same time that members elect representatives to the FAS board. The new FAS retained the 501(c) 3 IRS designation of the FAS Fund, a tax-exempt, charitable nonprofit organization. That means membership payments are now tax-deductible, minus $7 for the Public Interest Report. The minimum annual dues for regular members are $50; rates for student and senior members are $20. First-time members pay $35.

Payments above the annual dues amount are considered charitable contributions and provide you with the same tax advantages as membership dues. You may deduct the full amount of your gift for tax purposes.

You may renew your membership at any time of the year. The FAS website allows you to renew a membership and make a contribution on-line. In addition to www.fas.org/join.html, Helping.org and Working Assets are venues for joining and making a gift to FAS. In fact, the Internet is the most active source of FAS' new members. When you use a credit card to make an on-line dues payment or gift to FAS, please remember that we accept MasterCard and Visa.

We also enclose a reply envelope in each issue of the Public Interest Report. Our address for contributions or dues by mail is Development Office, 1717 K Street, NW, Suite 209, Washington, DC 20036. Whether over the Internet or by mail, we are grateful for your support! ***PIR***

Strategic Security | **Counterforce and the New Nuclear Posture**

By Michael Levi

With much fanfare, President Bush last fall unveiled a new nuclear strategy he claims is unburdened by the dead hand of cold-war thinking. But when Pentagon planners revealed the nuclear force structure required by this new approach, they claimed that the United States still needs 2,000 active nuclear warheads. While the disconnect may appear confusing, what happened is quite simple: In spite of much rhetoric about moving beyond deterrence, key cold war requirements remain unchanged.

America will keep around 2,000 nuclear weapons deployed largely because it has a long list of Russian targets to aim at. In 1962 America adopted counterforce, the practice of targeting Soviet military assets, including Inter-Continental Ballistic Missile (ICBM) silos, as an alternative to aiming at cities. While it certainly takes only a handful of nuclear weapons threatening cities to deter a nuclear attack, it takes far more to account for every enemy missile; from that reality, the cold war arms race was born.

As many analysts have pointed out, President Bush's announced cuts will take US strategic forces to the lowest possible level consistent with counterforce. In this sense, the cuts, though dramatic, epitomize cold war arms reductions. Unless counterforce is abandoned, we can not honestly say that we have broken with the Cold War.

Ending the targeting of Russian ICBMs would not only be a powerful symbolic act but would also deliver concrete security benefits. Because the US targets Russian missiles directly, Russia maintains its missiles on hair-trigger alert, ready to launch on warning of a US strike. Given Russia's old and unreliable early-warning system, this creates the real and terrifying possibility of an accidental nuclear attack on America. If the targeting of Russian missiles were stopped, the hair-trigger might be relaxed, and an immediate nuclear threat would be defused.

Why, then, are we not moving beyond cold war counterforce? An old argument claims that counterforce, by threatening weapons rather than people, is morally superior. But given the proximity of Russia's nuclear installations to its cities, a counterforce attack would still kill tens of millions. The morality argument fails.

Many have been concerned with the unilateral nature of the announced cuts, pointing out that since the target stockpile levels are not binding, they might easily be raised. Arms-controllers should seize on the flip-side: these levels can easily be revised downwards without entering a new series of negotiations. President Bush should take advantage of this flexibility to announce the end of counterforce targeting, and demostrate that shift through a cut to 1,000 nuclear weapons.

Unless counterforce is abandoned, we can not honestly say that we have broken with the Cold War.

President Bush has rightly declared that it is time to move beyond cold war arms control. Yet we are being asked to believe that by simply abandoning arms control and declaring the end of mutually assured destruction, we have left the Cold War in the past. Things are not so simple. Fundamental nuclear doctrine, not the precise size of nuclear stockpiles, ties us to the Cold War, and only a break from that doctrine will move us beyond the perilous consequences it entails. ***PIR***

Michael Levi is the Director of the FAS Strategic Security Project.

FAS Public Interest Report
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January/February 2002, Volume 55, Number 1

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