Nuclear Arms Control, Nonproliferation, and Counterterrorism: Impacts on Public Health

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Reducing the risks of nuclear war, limiting the spread of nuclear weapons, and reducing global nuclear weapons stockpiles are key national and international security goals. They are pursued through a variety of international arms control, nonproliferation, and counterterrorism treaties and agreements.

These legally binding and political commitments, together with the institutional infrastructure that supports them, work to establish global norms of behavior and have limited the spread of weapons of mass destruction.

Beyond the primary security objectives, reducing the likelihood of the use of nuclear weapons, preventing environmental releases of radioactive material, increasing the availability of safe and secure nuclear technology for peaceful purposes, and providing scientific data relevant to predicting and managing the consequences of natural or human-caused disasters worldwide provide significant benefits to global public health. (*Am J Public Health.* 2014;104:591–595. doi:10.2105/AJPH.2013.301665)

FOR MORE THAN A CENTURY, there have been efforts to outlaw weapons of mass destruction and terror, starting with the first Hague Peace Conference in 1899 and the 1925 Geneva Protocol to prohibit the use of chemical and biological weapons. These efforts were extended to nuclear weapons, the most devastating weapons of all, in the immediate aftermath of World War II. In November 1945, the United States, the United Kingdom, and Canada proposed the establishment of a United Nations (UN) Atomic Energy Commission for "entirely eliminating the use of atomic energy for destructive purposes."[1] This was followed by a call from the General Assembly of the UN for the elimination of atomic weapons and other major weapons adaptable to mass destruction in January 1946. Stopping short of elimination, the Baruch Plan, suggested by the United States in 1946, proposed placing all nuclear weapons and energy under international ownership and control.

None of these initiatives came to fruition, however, and by the 1950s both the United Kingdom and the Soviet Union had tested their own nuclear weapons, with China and France following suit in the 1960s. Because of the existence of nuclear weapons, controlling their spread and use became urgent international goals. A wide-ranging set of activities has evolved over the decades to pursue these goals, including nuclear arms control, nonproliferation, and counterterrorism measures. International institutions, such as the International Atomic Energy Agency (IAEA) and the UN 1540 Committee, have grown to support their implementation.

A broad range of motivations underlies the almost universal support for efforts to control the spread and use of nuclear weapons. These include increasing security for all states, maintaining a balance of power, and a moral imperative to eliminate nuclear weapons altogether. Although states may have different reasons for wanting to control nuclear weapons, there is widespread agreement on the need to do so, and most believe that these treaties and agreements make the world a safer place. However, these activities have other, less recognized benefits as well. Indeed, we argue that the public health benefits are significant both in avoiding events that would have major public health impacts and in supporting the transfer of beneficial technology to the less-developed world.

In cases where countries are deemed out of compliance with their nonproliferation commitments, political and economic actions can have deleterious impacts on elements of the population. Analysis of the relative impact of such sanctions on public health,[2] as compared with other public health benefits discussed in this article, is beyond the scope of this article.

In the following sections we briefly summarize selected international arms control, nonproliferation, and counterterrorism efforts, as well as their institutional infrastructure. (Evaluation of the effectiveness of these treaties and agreements is beyond the scope of this article.) We consider the public health benefits resulting from reducing the likelihood of use of nuclear weapons, preventing environmental releases of radioactive material, providing access to nuclear technology for peaceful purposes, and providing scientific data relevant to predicting and managing the consequences of natural or human-caused disasters worldwide. We hope that this discussion will stimulate thought about how to include public health as an explicit factor in constructing provisions for future treaties and agreements.

NUCLEAR ARMS CONTROL

The most well-known arms control treaties (such as the New START Treaty that entered into force in 2011) are those that limit nuclear weapons and delivery systems. However, many lesser-known treaties and agreements may be more relevant to this discussion. Here we present examples of agreements designed to prevent miscommunication that could lead to war and treaties that limit or ban nuclear weapons testing.

Nuclear Risk Reduction Agreements

In recognition of the chances that a nuclear accident, miscalculation, or other incident could trigger a nuclear war, both the United States and the Soviet Union proposed measures to safeguard against surprise attack and to improve communication during the 1950s and early 1960s. The

Cuban Missile Crisis of 1962 demonstrated how quickly a crisis could escalate, and both countries became more serious about reducing the risks of nuclear war. In June 1963 they signed a Memorandum of Understanding establishing a direct communications link between the 2 capitals to insure reliable and quick communication during a crisis. This became known as the "Hotline Agreement." Although limited in scope, it has proved useful on numerous occasions, including during the 1967 and 1973 Arab–Israeli wars when it was used to provide information about US fleet movements in the Mediterranean.[3] The Hotline Agreement has been updated several times and remains in effect today.

Another example is the 1972 Incidents at Sea Agreement, which came about in response to numerous "incidents" between the United States and Soviet navies in the late 1960s, such as ships coming too close to each other, bumping each other, and making threatening maneuvers.[4] Among other things, this agreement established guidelines for maintaining safe distances, communication protocols, and provided for advance notice of actions that could represent a hazard to navigation or aircraft in flight, including planned ballistic missile launches. Other examples include the 1971 Accidents Measures Agreement,[5] which required advance notification of missile launches that extend beyond national territories, and the more comprehensive 1988 Ballistic Missile Launch Notification Agreement,[6] which required at least 24 hours advance notification of the planned date, launch area, and area of impact for any launch of an intercontinental or submarine-launched ballistic missile. These agreements all remain in force today.

Nuclear Test Limitations

Testing is an important component of a nuclear weapons development program. Therefore measures that limit (or ban) nuclear tests provide barriers to improving existing nuclear arsenals or developing new ones. A comprehensive nuclear test ban has long been a goal of the international nuclear disarmament community. In addition, fears about the health implications of nuclear weapons testing motivated efforts to ban nuclear testing since the earliest days. In March 1954, the United States exploded an experimental thermonuclear device at Bikini Atoll, which, at 15 megatons, exceeded its expected yield by almost a factor of 2.[7] This resulted in a much larger area of dangerous radioactive fallout than had been predicted, contaminating a Japanese fishing vessel whose crew suffered from radiation sickness. Inhabitants of another atoll in the area also suffered radiation sickness. In another incident, radioactive rain containing debris from a Soviet hydrogen bomb test fell on Japan.[7] In the United States, nuclear weapons testing in Nevada resulted in growing concerns about cancer risks among the local residents sometimes referred to as "down-winders."[8]

Treaties signed in the 1960s limited where and how nuclear testing could take place, so in addition to the arms control benefits, they prevented destruction and contamination of the environment, and limited the spread of radioactive contamination across territorial boundaries. The first treaty limiting nuclear testing was the Antarctic Treaty (1961) prohibiting nuclear weapons testing in Antarctic. This was followed by the Limited Test Ban Treaty (1963), banning nuclear testing in the atmosphere, underwater, and in space; and the Outer Space Treaty (1967) prohibiting nuclear tests in outer space or on celestial bodies and prohibiting the orbit of any objects carrying nuclear weapons.

Under the Limited Test Ban Treaty, the parties also agreed not to carry out any underground test that would result in radioactive debris passing across international borders. A Threshold Test Ban Treaty, although negotiated by the United States and Soviet Union from 1974 to 1976, was ratified in 1990, putting in place a technical protocol to verify that neither side will conduct an underground test exceeding 150 kilotons. The verification regime formalized the use of seismic monitoring of underground nuclear tests, which is still carried out today.

Although there were some attempts to negotiate an end to nuclear testing, it was not until the early 1990s that negotiation for a Comprehensive Nuclear Test Ban Treaty (CTBT) began in earnest, culminating when the treaty was opened for signature in 1996.[9] To date, the 183 signatories (the treaty has not yet entered into force) have established a CTBT Provisional Technical Secretariat that has almost completed implementation of an International Monitoring System, involving 4 global networks (seismic, hydroacoustic, infrasonic, and atmospheric radionuclide) to verify that member states do not conduct clandestine nuclear tests. For treaty verification purposes, the International Monitoring System provides close to real-time data transmission of standardized data from across the 4 networks to a centralized data center in Vienna and designated authorities in member states' governments.

NONPROLIFERATION AND THE INTERNATIONAL ATOMIC ENERGY AGENCY

In December 1953, President Dwight D. Eisenhower made his famous Atoms for Peace speech at the UN General Assembly.[10] Up to that point, international discussions had focused mostly on controlling all aspects of nuclear energy for fear of its military uses. Eisenhower's speech emphasized the promise of nuclear energy as a benefit to humankind, and proposed making it widely available for peaceful purposes. Recognizing the potential of harmful uses of nuclear energy, he proposed establishing a framework of international safeguards to ensure that nuclear material was not diverted for military purposes. The IAEA in Vienna, Austria, was established in 1957 on the basis of these ideas.

The Treaty on the Nonproliferation of Nuclear Weapons (NPT), the first international effort to limit the spread of nuclear weapons, entered into force in 1970.[11] The member states of the NPT fall into 2 categories: the nuclear weapon states, which are those states that possessed nuclear weapons at the time the treaty was concluded (the United States, the United Kingdom, the Soviet Union [now Russia], China, and France) and the non–nuclear weapon states. Each nuclear weapon state commits not to transfer nuclear weapons or nuclear explosives to other states or to otherwise assist other states to acquire nuclear weapons. The non–nuclear weapon states commit not to develop or acquire nuclear weapons, and to implement IAEA safeguards for all civilian nuclear material and facilities (IAEA safeguards are designed to detect diversion of material or technology from peaceful civilian use). All states commit not to export

nuclear equipment or material to non–nuclear weapons states except under IAEA safeguards, and agree to facilitate the exchange of peaceful nuclear technology and to work toward future nuclear (and total) disarmament.

The IAEA enters into bilateral safeguards agreements to verify declarations made by states about their nuclear material and activities. It utilizes material control and accounting, environmental sampling, and open-source information analysis allowing the IAEA to conclude whether a state is in compliance with its commitments. The majority of the IAEA's budget is related to international safeguards, nuclear safety, and nuclear security; however, there is also a technical assistance program for non–nuclear weapon states for improving scientific and technological capabilities for peaceful applications of nuclear technology, with a special emphasis on sustainable development.[12] Although IAEA technical assistance has risks if countries circumvent their safeguards agreements, cases of NPT members violating the treaty are rare. North Korea and Iran are the exception rather than the rule, and in both cases their nuclear weapons capabilities were transferred through the nuclear black market, rather than through IAEA technology assistance programs.

COUNTERING NUCLEAR TERRORISM

Preventing the acquisition of nuclear materials is essential in blocking nonstate actors' paths to nuclear weapons. Since September 11, 2001, domestic and international security communities have made concerted efforts to ensure that nuclear and radioactive material are secure. Building on the 1990s' programs aimed at securing nuclear stockpiles in Russia after the disintegration of the Soviet Union, efforts have been broadened globally. The IAEA, although focused primarily on detecting nuclear proliferation, has a substantial program related to nuclear security, including assisting with implementation of the Convention on the Physical Protection of Nuclear Material that establishes guidelines for protecting nuclear material.[13] The IAEA also developed a set of nuclear security activities focused on providing member states with guidance to improve nuclear security. This activity has grown and has been integrated into a nuclear safety and security department including topics such as nuclear forensics, emergency preparedness, and transportation security.

In April 2004, the UN Security Council adopted Resolution 1540, establishing binding obligations on all UN member states to take and enforce effective measures against the proliferation of weapons of mass destruction, means of delivery, and related materials.[14] The UN established a committee to work with countries and facilitate implementation of the resolution. Although facing many challenges, including insufficient resources, the committee has become a clearinghouse for sharing security guidance. Nuclear Security Summits in 2010 and 2012 focused world leaders on this topic and resulted in commitments to securing vulnerable nuclear material worldwide through a series of nuclear security initiatives.[15,16]

Although radiological materials are not useful for nuclear weapons development, illicit use of large quantities could cause mass disruption. Programs aimed at securing civilian radiological sources and at identifying, securing, and safely disposing of so-called "orphan sources" aim to reduce or eliminate the possibility of loss of control of the material in hospital, university, or industrial settings. They are often related to nuclear security programs in the IAEA and the UN 1540 Committee. One significant initiative aims to enhance security for radiological material used in hospitals for therapy or imaging, such as cobalt 60 and cesium 137, in the developing world.

PUBLIC HEALTH BENEFITS

In addition to their security benefits, US and international arms control, nuclear nonproliferation, and counterterrorism activities have significant public health benefits. Although improving security has been the primary driver, the motivation for some of the early treaties, especially those limiting nuclear testing, was directly linked to public health. In the case of counterterrorism and nonproliferation, improvement in nuclear safety (and hence to public health) and access to nuclear technology for peaceful purposes has been a significant factor in obtaining wide international participation. The following discussion illustrates these points.

Reducing the Likelihood of Nuclear Weapons Use

Reducing the risk of accidental nuclear war by establishing global norms and barriers against acquisition and use of nuclear weapons by states or terrorists helps prevent the health and environmental impacts that would result from their use. This can be appreciated by considering the catastrophic devastation seen after the nuclear bombs dropped at Hiroshima and Nagasaki in 1945. Between 25% and 50% of the contaminated population were dead within 4 months (between 120 000 and 240 000 people) with additional deaths from leukemia and solid cancers over the longer term. In addition, patterns such as growth retardation and arteriosclerosis have been seen in exposed-population studies over the past 50 years.[17] The impact of residual environmental contamination was less: contamination levels were reduced by 90% within 1 week and were less than background level within 1 year. However, the types of nuclear weapons used in Japan were relatively small by current standards and detonated above the ground, resulting in instantaneous exposure rather than in environmental contamination that would likely occur if weapons were used today.

On a more global scale, studies of "nuclear winter," published 25 years ago and revisited more recently,[18] have postulated the possibility of dire global climate change impacts that could occur in event of a regional nuclear war. The severity of global impacts would vary greatly depending on one's assumptions, but a nuclear exchange could have impacts far beyond the targeted areas because of disruption of regional climate and agriculture.

Preventing Release of Radiological Material

Nuclear test limitation treaties that ban atmospheric nuclear tests have significantly reduced the release and dispersal of radioactive contamination to the environment and its detrimental impacts to public health. A review of a number of studies conducted to reconstruct the total radioactive dose received from fallout in the 1950s and 1960s released from the Nevada test site, Semipalatinsk Kazakhstan test site, and Marshall Islands nuclear test series, concluded that

in the United States approximately 49 000 fall-out–related thyroid cancers resulted from iodine 131 exposure to people younger than 20 years during the 1951–1957 above-ground nuclear testing at the Nevada test site alone.[19] The estimate would be increased about 10% if global fallout is also taken into account. A total of about 1800 additional deaths could be estimated from external radiation exposure and internal exposure to other radionuclides in the fallout. This public health impact, even though these exposures occurred 60 years ago, will not be completely accounted for until the end of the lifetimes of those exposed.

As demand for energy grows and as the need for low-carbon sources of energy becomes more widely recognized, many see nuclear energy and a key element of a comprehensive energy strategy. If the number of nuclear power plants increases, the industry must work to keep the risk of any major release of radioactive materials as small as possible. The IAEA, which also has a strong mission in nuclear safety, assists the 151 member states by providing access to nuclear safety guidance and expertise needed to minimize the risk of a major accident. Thus, the creation of an international organization primarily for the purpose of nuclear nonproliferation has provided a key resource to support governments in implementing essential nuclear safety measures.

The disasters at Chernobyl and Fukushima Daiichi illustrated the grave local, regional, and global impacts of a major accident. The IAEA's director general categorized the impacts of the Chernobyl accident into physical, health, environmental, psychological, and social.[20] In addition to incorporating lessons learned from such accidents into its safety guidance, the IAEA has a continuing role in assessing their impacts.[21,22] As the results of the Fukushima disaster continue to unfold, the IAEA has organized expert missions to help develop remediation plans for the impacted areas. The agency also provides emergency preparedness services with national reviews, assistance in implementing appropriate legislation, monitoring systems, and training for nuclear accident or radiological emergencies.

Counterterrorism measures taken on international, national, and regional scales are intended to prevent or deter terrorist use of radiological or nuclear devices that would have grave public health impacts, such as acute radiation sickness, longer-term cancers, environmental contamination, and widespread fear. Although the impacts would depend on the specific situation (e.g., amount of material released, the prevailing weather conditions, type of environment, and number of people exposed), the disarray and fear in the aftermath of such an attack would have an impact on both mental and physical well-being. The IAEA Nuclear Security programs work to control access to nuclear material by using physical protection tools. These programs supplement the efforts of the UN 1540 Committee to assist nations to implement state-specific measures to ensure that harmful radioactive materials are not released into the environment.

International efforts to improve nuclear security also help control access to radiological material by the general public. An accident that occurred in Goiânia, Brazil, in 1985 illustrates the grave consequences of unprotected radiological material: the theft of a cobalt 60 source from an abandoned teletherapy machine and its dismantlement for scrap materials resulted in 4 fatalities and widespread contamination and significant societal and economic burdens.[23] Lessons learned from this accident have been incorporated into efforts to increase physical security of radiological sources worldwide.

Nuclear Technology for Peaceful Purposes

As noted previously, the IAEA plays an important role in facilitating the exchange of nuclear technology for peaceful purposes. In addition to its efforts to develop the infrastructure needed for a safe, secure, and safeguarded nuclear fuel cycle, it has major efforts for improving public health and agriculture. In 2014, 20% of the IAEA's budget will be used to support Technical Cooperation for Development.[24]

The World Health Organization estimates that more than half of the total number of cancer cases are found in developing countries and about 75% are incurable because of lack of a timely diagnosis.[25] Nuclear diagnostics and techniques are important in detecting and curing both infectious and noncommunicable diseases such as cancer, but availability lags in the developing world. The IAEA supports advances in nuclear medicine and radiation therapy for the diagnosis and treatment of cancer.

Agricultural production will need to increase by an estimated 70% by 2050 to meet the projected demand.[26] Nuclear techniques can be used in developing countries to increase production sustainably by breeding improved crops, enhancing livestock reproduction and nutrition, and controlling animal and plant pests and diseases. Working with the Food and Agriculture Organization, the IAEA works to improve agricultural productivity by developing new plant species and food irradiation measures, as well as sterilization techniques to eradicate pests.[27] An example is the development and deployment of sterile nuclear insect technology to assist in eradicating the tsetse fly in Africa and curb fruit fly populations in Central America. Another example is the use of nuclear diagnostics to detect and identify animal diseases and prevent cross-boundary contamination.

Data collected from the International Monitoring System network for detecting nuclear tests are also useful for other purposes.[28] The CTBT Provisional Technical Secretariat has been considering the best way to share seismic data with tsunami warning centers to help identify potential tsunami-causing earthquakes and facilitate more timely evacuations. Aviation safety could be improved by sharing data from the global infrasound network, which can be used to predict the direction of large ash plumes caused by volcanic eruptions. There are likely other benefits that can be realized, such as using the infrasound and radionuclide network data to aid climate change research. Quantifying the benefits related to the advancement of science is more difficult.

CONCLUSIONS

Although we have not attempted a quantitative analysis of the public health benefits of international arms control, nonproliferation, and counterterrorism activities, we have illustrated how the treaties and agreements outlined in this article provide public health benefits in addition to their primary security objectives. By reducing the chances of nuclear war, tracking and securing dangerous nuclear and radiological materials, and

reducing the possibility of environmental contamination, these regimes help to avoid potentially catastrophic impacts to human health and the environment. They have also laid the framework for assisting less-developed countries to improve their public health through peaceful uses of nuclear technology. We hope that this article raises awareness of the public health benefits of these activities and stimulates discussion about how to explicitly include public health implications in the negotiation of future agreements. ■

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