International Physicians for the Prevention of Nuclear War

Briefing Paper

The catastrophic consequences of nuclear weapons and nuclear war: Summary of the evidence and new research findings

Submitted by International Physicians for the Prevention of Nuclear War to the 1st Meeting of States Parties of the Treaty on the Prohibition of Nuclear Weapons

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Introduction

The Treaty on the Prohibition of Nuclear Weapons (TPNW) is based upon a body of indisputable evidence, documented by scientists, health professionals, and experts in crisis management and response, that the consequences of nuclear weapons use are catastrophic, global, and without remedy. Nuclear weapons—as has been said repeatedly by the advocates for this Treaty in both States and civil society—are an existential threat to humanity which belong in no one's hands.

Much of the evidence underpinning the TPNW has been accumulated over the decades since the US atomic bombings of Hiroshima and Nagasaki; more was learned during the years of nuclear weapons testing and the Cold War; and we have made significant additions to our knowledge in recent years, particularly with regard to the devastating global climate effects of nuclear war.

In this paper, we will summarize the blast, heat, and radiation effects of nuclear weapons; review the impacts on climate from both limited and large-scale nuclear conflicts; and present new data about climate effects that has been published since the adoption of the Treaty.

Just as a thorough understanding of the catastrophic consequences of nuclear weapons compelled States to negotiate and adopt the TPNW in 2017, keeping updated evidence at the forefront of all future deliberations—including at this 1MSP—is essential to understanding the importance of the Treaty, fully implementing its provisions, and achieving its ultimate and most urgent goal—the total elimination of nuclear weapons.

Summary of the Evidence

The detonation of nuclear weapons produces incinerating heat, powerful shock waves and overpressures, ionizing radiation, an intense electromagnetic pulse, and massive amounts of smoke and soot that can alter the Earth's climate. Unlike conventional weapons or other weapons of mass destruction, nuclear weapons instantaneously wipe out entire populations, level cities, and devastate the environment. They produce radioactive contamination that remains active for millennia, causing cancers and other illnesses that can persist across generations. Moreover, the environmental consequences of nuclear war, including severe climate disruption, can lead to global famine and, in the most extreme case, human extinction. No meaningful medical or disaster relief response to the detonation of nuclear weapons is possible.

The physical effects of nuclear weapons include a heat (thermal) wave, a blast wave, an electromagnetic pulse, the release of ionizing radiation, and the production of radioactive isotopes in fallout.

Blast, Thermal and Electromagnetic Pulse Effects

Even a single nuclear explosion over a city can kill hundreds of thousands—even millions—of people immediately. Massive overpressures destroy most buildings; temperatures exceeding thousands of degrees Celsius incinerate all flammable materials; intense winds propel firestorms. A nuclear war with weapons in existing arsenals could kill several times more people in a single day than were killed during the entire Second World War.

The 12.5-kiloton (kt) bomb detonated over Hiroshima decimated the city and created ground temperatures that reached about 7,000 degrees Celsius. Of the 76,000 buildings in the city, 92% were destroyed or damaged. There were more than 100,000 deaths and approximately 75,000 injuries among a population of nearly 350,000. Of the 298 physicians in the city, 270 died or were injured and 1,564 of 1,780 nurses died or were injured. The 21-kiloton bomb detonated over Nagasaki three days later leveled 6.7 square kilometers (2.6 square miles). There were 75,000 immediate deaths and 75,000 injuries, and health consequences for the population of the city that were similar to those of Hiroshima. Total deaths in both cities by the end of 1945 were 210,000.

Hiroshima lay in ruins after the US atomic bombing on 6 August 1945.

The Hiroshima and Nagasaki bombs by today's standards would be considered relatively small tactical-sized nuclear weapons. The average explosive power of weapons in the nuclear arsenal today is 200 kt, though many long-range weapons, including nuclear weapons on high alert, are several hundred kilotons, with the largest at 5 megatons.

Nuclear weapons have extreme blast and burn effects that kill people and destroy infrastructure on a scale and with an intensity that puts them in a class of their own compared with any other weapon. The heat wave from a nuclear detonation incinerates everything combustible in its path, including human flesh. Firestorms consume all remaining oxygen, suffocating everyone who managed to take refuge from the flames themselves. The blast wave and associated overpressures and hurricane-force winds collapse all but the strongest buildings, destroy roads and transportation systems, and turn objects (including human victims) into missiles that amplify the damage, until nothing remains but rubble. An electromagnetic pulse disrupts the electricity supply grid and electronic equipment and systems, including computers, medical equipment and satellite communications, at a scale that could span a continent in the case of a very high-altitude explosion. These levels of destruction, which are more extreme than produced by any other weapon, cannot be limited to military targets or to combatants.

Radiation Effects

Nuclear weapons produce ionizing radiation, which kills or sickens those exposed, contaminates the environment, and has long-term health consequences for those who do not die right away. Acute radiation sickness can cause death within hours, days, or weeks; those who recover may remain ill for months or even years. Lower doses of ionizing radiation can cause leukemia, thyroid cancer, and many other cancers, even many years after exposure. Increased risk of cancer persists for the lifetime of those exposed, as does an increased risk of similar magnitude of a number of chronic diseases, particularly cardiovascular disease, manifesting most commonly as heart attacks and strokes. Radiation exposure also causes birth and developmental defects and genetic damage. Subsequent generations can suffer both because of genetic damage they inherit, as well as exposure to radioactivity from lingering radioactive contamination and fallout. Some radioactive materials like cesium, strontium, and iodine isotopes are recycled by living things and concentrate up the food chain. Young children and women and girls are at greatest risk from radiation.

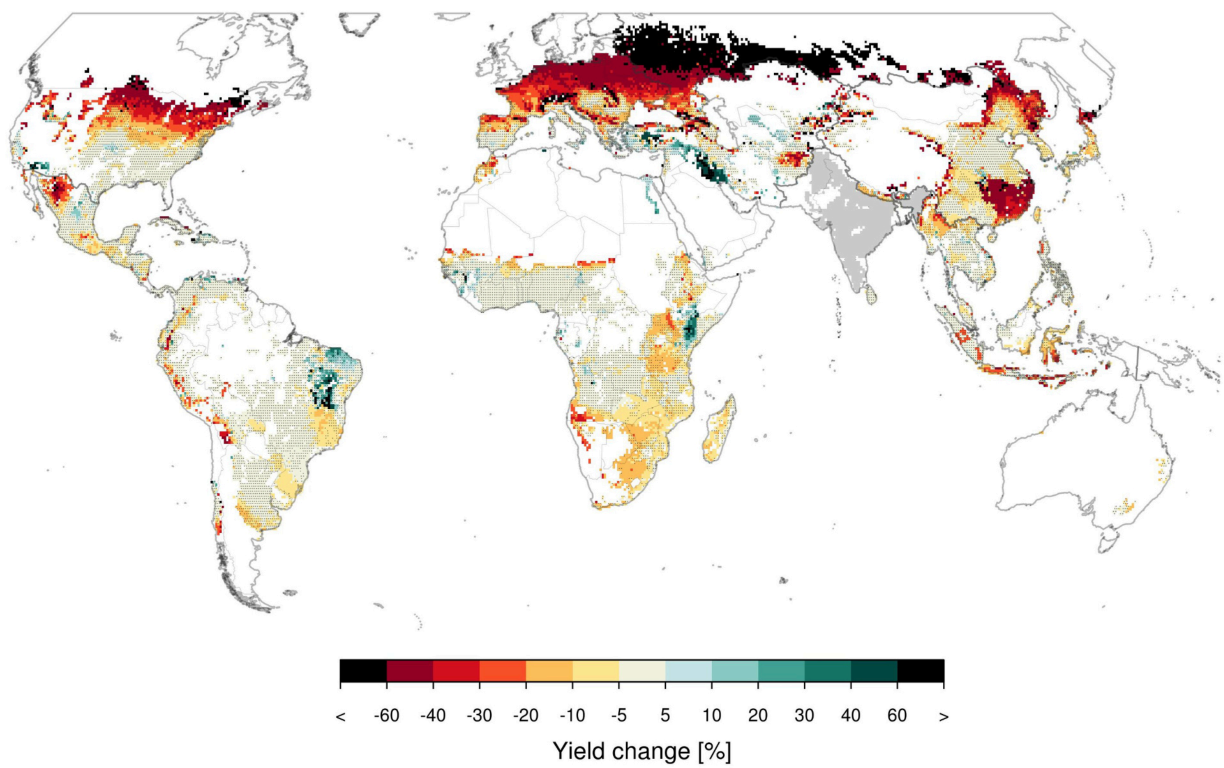
Nagasaki survivor shows wounds from burns and radiation.

There is no antidote to radiation exposure and no way to hasten the pace of physical decay of radioactive material, which is innate to each different radioisotope. Exposure to dangerous ionizing radiation has become a persistent global problem because of fallout from atmospheric tests and contamination of land and water around former test sites, nuclear weapons production facilities, uranium mines and processing sites, and radioactive waste storage sites. Radiation poses a particular problem for health professionals and other first responders, who would jeopardize their own health and safety by entering contaminated areas in the attempt to find and assist survivors.

Climate Effects: Nuclear Famine/Nuclear Winter

A limited, regional nuclear conflict involving only 100 Hiroshima-size nuclear weapons would severely disrupt the global climate and agriculture for more than 25 years. The resulting food shortages would place at least two billion people at risk of starvation. No region, even if distant from the area of conflict; would be spared. The massive arsenals held by the US and Russia can create a frigid nuclear winter, destroying Earth's fundamental ecosystems, on which all life depends.

In landmark studies published in 2007, climate scientists Brian Toon, Alan Robock and others modeled a hypothetical nuclear war between India and Pakistan.[1,2] The models assumed each nation used 50 Hiroshima-size nuclear weapons against the other, in a regional conflict involving less than 0.5% of the world's nuclear arsenals. (It also represents at most one third of today's total Indian-Pakistani nuclear arsenals). But the predicted results were global and apocalyptic. More than 5 million (metric) tons of sooty smoke that had once been Karachi or Mumbai would be lofted high into the stratosphere, to blanket the world in cooler, darker and drier conditions for years to come. The average global temperature would drop about 1.3°C, and food production would fall. A 2013 report predicted that up to two billion people—a staggering number, more than every fourth human—would be at risk of starvation.[3] Mills and colleagues in a 2014 study utilizing more advanced modeling found that surface temperatures would remain reduced for more than 25 years, and "could trigger a global nuclear famine."[4]



A recent multinational study concluded that even a limited nuclear war between India and Pakistan would cause unprecedented global food shortages and probable starvation lasting more than a decade. The map shows the average percentage decrease in maize yield over the first five years post-conflict. Jägermeyr et al (5).

A study in 2020 led by Jonas Jägermeyr, a scientist at NASA's Goddard Institute for Space Studies, examined this scenario's impact on food production in greater detail.[5] It used six leading crop models to assess how agriculture would respond to 100 15-kt nuclear detonations in India and Pakistan. In the NASA team's models, five million tons of soot result in even steeper global cooling of 1.8°C, and at least five years of bad harvests. Hardest hit are more temperate northern regions, including the

United States, Europe, Russia, and China, collectively the world's largest breadbasket. Production of wheat, rice, corn and soybean—four of the world's most important food crops—drops by 11%, 3%, 13% and 17% globally over five years, with "adverse consequences for global food security unmatched in modern history."

Moreover, while this study looks at "available" food, this is not the same as "accessible" food, the food people are able to put on their table. Especially in times of want, available food is never distributed evenly within or among nations. When it falls even slightly, there is widespread hoarding and price inflation. For example, during the Great Bengal Famine in 1943, available food decreased only five percent—but panic-buying ensued, food prices soared and three million people starved to death. One can only imagine what a worldwide drop of available food by 13% would mean. Armed conflict within and between nations would likely escalate as food stocks depleted, hoarding and desperation escalated.

Since initial studies were conducted, the nuclear arsenals of China, India, Pakistan, North Korea, and the United Kingdom at least have grown larger and cities have grown, increasing in population as well as fuel load. In 2019, Toon and colleagues published results of simulations of a range of new scenarios to take account of these changes utilizing state-of-the-art Earth system climate models. Reflecting the rapidly expanding nuclear arsenals in India and Pakistan, these scenarios for an India-Pakistan war involve 250 nuclear detonations—of 15-kt, 50-kt, or 100-kt weapons—and one severe, but still regional, scenario of 500 nuclear detonations of 100-kt weapons.[6] (Even this "severe" scenario involved less than 4% of the world's nuclear arsenal).

The direct consequences of any of these scenarios would be unprecedented. There would be 50 million to 125 million prompt fatalities—more deaths in hours or days than during all of World War II. The impact on climate would also be immense, in all scenarios.

The smallest scenario modeled, a war with 15-kt weapons, would generate 16 million tons (or 16 teragrams, Tg) of soot and an average global cooling of 2.5°C. The larger scenarios are worse. A war involving 50-kt weapons would generate 27 Tg of soot and 4.5°C of cooling. A war with 100 kt weapons would generate 37 Tg of soot and 5.5°C of cooling. In the most severe regional south Asian scenario, a war involving 500 nuclear weapons of 100 kilotons each would generate 47 Tg of soot and 6.5°C of cooling. By comparison, the last Ice Age around 20,000 years ago, when our ancestors contended with wooly mammoths and saber tooth tigers, at its coldest was between 3° and 8°C cooler than pre-industrial temperatures. These changes would develop not over centuries or millennia, but over days and weeks. Global precipitation would decline by 15-40%, and growing seasons would shorten.

These effects would not be evenly distributed, but none would be spared the impacts. Although cooling would be global, the temperature drops across North America, Europe, and Asia would be even worse. The populations of the high latitude nations holding or hosting most of the world's nuclear weapons would bear the brunt of precipitous decline in food production.[5] Studies are currently underway to assess the impact that such events would have on food production in countries around the world.

The findings published to date show that the climatic changes predicted would cause a decline in net primary productivity (NPP) of between 10 and 20% in the oceans and between 15 and 40% on land over multiple years. NPP is the net amount of carbon per square meter per year converted into plant matter after accounting for what plants use for their own respiration. This loss would be comparable to the total current annual human use of food and fiber.

Malnourished and stressed people are at greatly increased risk of a wide variety of diseases. Every major famine worldwide has been accompanied by epidemics of infectious diseases which greatly magnify the toll. Such epidemics have included cholera, other diarrheal diseases, diseases such as typhus, diseases spread by biting insects and animals, and a wide range of respiratory infections including pneumonia and tuberculosis. Not only the incidence, but the severity, complications and deaths from infectious and other diseases are much greater in settings of malnutrition and severe stress.

Studies replicated by multiple groups of atmospheric scientists showed widespread crop failures and mass starvation would result just from the abrupt cooling of 1.3°C-1.8°C, and the attendant shorter growing seasons and decreased rainfall. These models did not consider effects from radioactive fallout, economic, trade, infrastructure, and workforce disruptions, or from damage to the ozone layer. This last point—damage to the ozone layer—is a separate, major consideration. Ozone in the upper atmosphere (stratosphere) shields the Earth's surface from ultraviolet radiation. A 2008 study by Michael Mills modeled the effects on the ozone layer of the same hypothetical scenario—100 nuclear weapon detonations in India and Pakistan—and found that at the peak 25% of global ozone would degrade.[7] A subsequent 2014 study by Mills and his team at the National Center for Atmospheric Research (NCAR) reprised the scenario—100 nuclear detonations in India and Pakistan—and found it would bring ozone losses in the skies above populated areas "unprecedented in human history," alongside "the coldest average surface temperatures in 1,000 years."[4]

The ozone findings have been updated in 2021 by Charles Bardeen and colleagues.[8] Over the high northern latitudes—including the United States and Canada, Europe, Russia, and China—it would be far worse, with up to 55% of the ozone layer destroyed, with recovery taking 12 years and peak increase of 40% in the ultraviolet B wavelengths associated with DNA damage. The exact effects of this increased UV radiation have not been calculated, but would include increased DNA damage, cancers, immune impairment, toxicity to a wide range of animals and plants, and decreased plant growth.

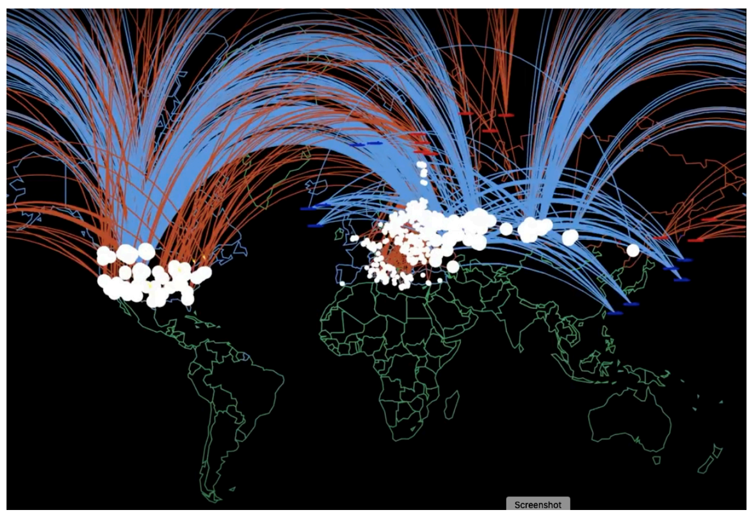
Large forest fires in Canada in 2017, and Australia in 2019 and 2020, threw massive amounts of soot high into the stratosphere. The soot and ash load from the Australian bush fires was tracked in the stratosphere for months, and circled the globe multiple times, in quantities comparable to ash seen after a volcanic eruption.[9] But in a key difference between volcanoes and major fires, volcanic ash is predominantly sulfuric acid—which is transparent, lets sunlight through, does not warm, and falls back to earth rapidly. Not so with black carbon soot. Soot from the Canadian fires rose to 12 kilometers as a vertically-developing, fire-fed pyrocumulonimbus cloud—but then, as the black soot absorbed sunlight and warmed, it was lofted steadily higher over the next two months, to 23 kilometers.[10] The forest fire observations were consistent with the models of Mills, Robock, and other independent scientists.

Scientists continue to model a large-scale US-Russian nuclear war. A paper published in 2019 reviewed simulations by NASA's Goddard Institute for Space Studies that such a war would inject not 5 million or 16 million tons of soot, but 150 million tons. The result, for much of the northern hemisphere, would be years of below-freezing temperatures in summer.[11]

Scientists also continue to discover new effects that would exacerbate the harm. Joshua Coupe and colleagues in 2021 found that that various nuclear war scenarios could induce an El Niño-like pattern of unprecedented magnitude across the Pacific, with associated reductions in equatorial Pacific phytoplankton productivity of about 40%.[12] Nicole Lovenduski and her co-workers in 2020 identified large and abrupt exacerbations in global ocean acidification as consequences of nuclear conflict including potential inability for marine calcifying organisms like shellfish and corals to maintain their shells or skeletons in a corrosive environment.[13] Further ecological impacts of nuclear war are no doubt yet to be discovered and characterized.

War in Ukraine and the dangers of escalation

If the conflict in Ukraine were to escalate to the use of nuclear weapons, the consequences would almost certainly be global and catastrophic. NATO and Russian military doctrines allow for the use of tactical nuclear weapons if facing defeat in a major conventional war. If even a single 100-kiloton nuclear weapon were exploded over Kyiv, it could kill a quarter of a million people and injure a million more, completely overwhelming the disaster response capability of Ukraine. A retaliatory strike against Moscow by the US and NATO, with comparable results, could be expected to trigger further retaliation by Russia against the US. A single 100-kiloton bomb detonated over Washington, DC would kill more than 170,000 people and injure nearly 400,000. An escalating nuclear conflict between the US and Russia would involve many weapons directed against many cities and many of these weapons would be substantially larger than 100 kilotons. According to researchers at Princeton's Science and Global Security project, even a small nuclear war starting in Europe would kill or injure nearly 100 million people within just a few hours in the event of low-yield "tactical" nuclear weapons use by the United States and Russia.[14]



A nuclear war between the US/NATO and Russia, beginning with the detonation of a "small" tactical nuclear weapon in eastern Europe, would likely escalate into a global nuclear war, with at least 90 million people killed and injured within a matter of hours. Princeton University Science & Global Security Department (14).

Russia has 1,588 deployed strategic nuclear weapons, and 1,912 tactical nuclear weapons. Most of the delivery systems for the latter can carry either conventional or nuclear warheads, increasing the risk of worst-case thinking and precipitous over reaction on the other side, and the danger of the threshold to nuclear escalation being crossed. The US has 1,644 deployed strategic nuclear weapons, and 100 B-61 nuclear bombs deployed to bases in Belgium, Germany, Italy, The Netherlands, and Turkey for delivery by aircraft of those nations. France has 280 deployed nuclear weapons, and the UK 120 deployed nuclear weapons.

If the threshold of use of nuclear weapons is crossed, those who have managed nuclear weapons and nuclear war plans tell us the risks of rapid and large-scale escalation are very high.[15] Russia and NATO members France, the UK, and the US possess 3,732 currently deployed nuclear weapons, including all of the 2,000 nuclear weapons on high alert, ready to be launched on short notice. The world has not been this close to nuclear war since the Cuban Missile Crisis of 1962. As former US Secretary of Defense Robert McNamara later reflected, "We lucked out. It was luck that prevented nuclear war."

Diplomacy to remove the danger of nuclear escalation is desperately urgent and needs to progress to negotiations among all nuclear-armed states to eliminate their nuclear arsenals under strict verification and timelines. Otherwise, it will only be a matter of time before our luck finally runs out.

Public Health Assessment

A "small" nuclear war would not lead to human extinction. But it would almost certainly be the end of modern civilization. A series of "years without summers," with crop failures, food hoarding and mass starvation, would disrupt everything from international trade to public order. Every third human might starve to death from the resulting global cooling. No civilization has ever withstood a shock of such magnitude. There is every reason to expect that the economic, political, technical and health systems we take for granted would collapse. A larger nuclear war would jeopardize human survival and that of many other species.

Just as a respiratory coronavirus can emerge in one place to affect people everywhere, a regional nuclear war in South Asia would float its ashes through the stratosphere, to dim the sun worldwide and to kill hundreds of millions in far-off lands. There is nothing specific about the impacts of a nuclear war in South Asia. Smoke from burning cities ignited by a regional nuclear war in northeast Asia, the Middle East, Europe or anywhere else would have similar effects.

The implication of these findings is clear and undeniable: the catastrophic consequences of nuclear weapons, which cannot be contained within the political borders of any state, and would be unacceptable even were that possible, make the weapons themselves unacceptable. The Treaty on the Prohibition of Nuclear Weapons is based upon a proper understanding of this fact, and prescribes the only available remedy: the total elimination of these now-banned weapons of total destruction.

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