

A HARMFUL LEGACY

The lingering humanitarian impacts of nuclear weapons testing

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- There have been more than 2,000 nuclear detonations as part of the weapons testing programmes of at least eight nations—the majority of these devices exploded underground since a partial test ban was agreed in the 1960s.
- The impacts on human health and wellbeing from nuclear tests are both longer-lasting and broader in scope than is often realized.
- Health consequences of nuclear weapons testing have fallen most heavily on minority, rural, or disenfranchised populations because governments have tended to situate their test sites in remote areas populated by such groups.

Introduction

2,053 nuclear detonations have occurred since 1945 as part of the weapons testing programmes of at least eight nations.¹ Nuclear weapons have been exploded in the atmosphere, underground, and underwater at dozens of test sites from Lop Nor in China, to the atolls of the Pacific, to Nevada, to Algeria where France conducted its first nuclear device, to western Australia where the United Kingdom exploded nuclear weapons, to the South Atlantic, to Semipalatinsk in Kazakhstan, across Russia, South Asia, and elsewhere.² One estimate put the explosive yield of all nuclear tests carried out between 1945 and 1980 (the most prolific nuclear testing period) at 510 megatons. Atmospheric tests alone accounted for 438 megatons, which is equivalent to more than 29,000 Hi-

roshima-sized nuclear bombs.³ (Many estimates of the explosive yield of the Hiroshima bomb put it at around 14 kilotons: this is the equivalent of 350 40-ton trucks loaded with TNT chemical explosive.)⁴

The ostensible reasons states carry out nuclear test explosions are in order to prove warhead designs and to develop more sophisticated weapons. Historically, nuclear test explosions have also signaled that a country has joined the 'nuclear weapons club'. The health and broader humanitarian effects of such tests initially received little public attention, but this changed during the 1950s and led to widespread pressure to end atmospheric nuclear testing.⁵ This is because aboveground nu-

clear tests, in particular, generate large amounts of radioactive debris, which disperse up to thousands of kilometres away from explosion sites (see Box 1).

In 1963, the Soviet Union, United Kingdom and United States agreed the Partial Test Ban Treaty (PTBT) prohibiting nuclear test explosions in the atmosphere, underwater, or in outer space⁶, although China declined to join the treaty as did France. (France continued aboveground nuclear testing in the Pacific until 1974.⁷) Since the PTBT's signing, the majority of nuclear explosions have been underground. In principle, exploding nuclear devices underground avoids atmospheric fallout. However, such testing can still create health and environmental problems due, for instance, to contamination of ground water from long-lived radionuclides such as plutonium, iodine-129 and

cesium-135,⁸ and venting in which radionuclides from the explosion are not effectively contained belowground and thus release radioactive debris into the air.

In 1996, negotiations on a global Comprehensive Nuclear Test Ban Treaty (CTBT) were concluded and the treaty was opened for signature. The CTBT prohibits 'any nuclear weapon test explosion or any other nuclear explosion'⁹ and established an international test monitoring and verification system. But, dependent on a list of key countries joining the treaty (such as the United States and China), the CTBT has not yet entered into force internationally. Since the CTBT opened for signature, India and Pakistan have tested nuclear weapons underground (in 1998), as did the Democratic People's Republic of Korea—most recently in 2013.

The health consequences of nuclear testing

Nuclear explosions create massive blast, heat, and ionizing radiation effects. The large amount of ionizing radiation emitted from a nuclear fireball can promptly kill or cause acute illness to living things within direct range by externally irradiating them, mainly with penetrating gamma rays (see Box 2).

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The main issue with nuclear weapons testing is that nuclear explosions exposed to the atmosphere (including venting from underground tests¹¹) create radioactive contamination. Local fallout from a nuclear weapon explosion may deliver significant external doses of ionizing radiation: at more distant locations internal dose (e.g. through inhalation, digestion) becomes relatively more important in terms of health effects. For instance, following atmospheric nuclear testing in Nevada in the 1950s many people in central and eastern United States unwittingly consumed dairy products containing iodine-131, a highly radioactive isotope with an eight-day half-life.

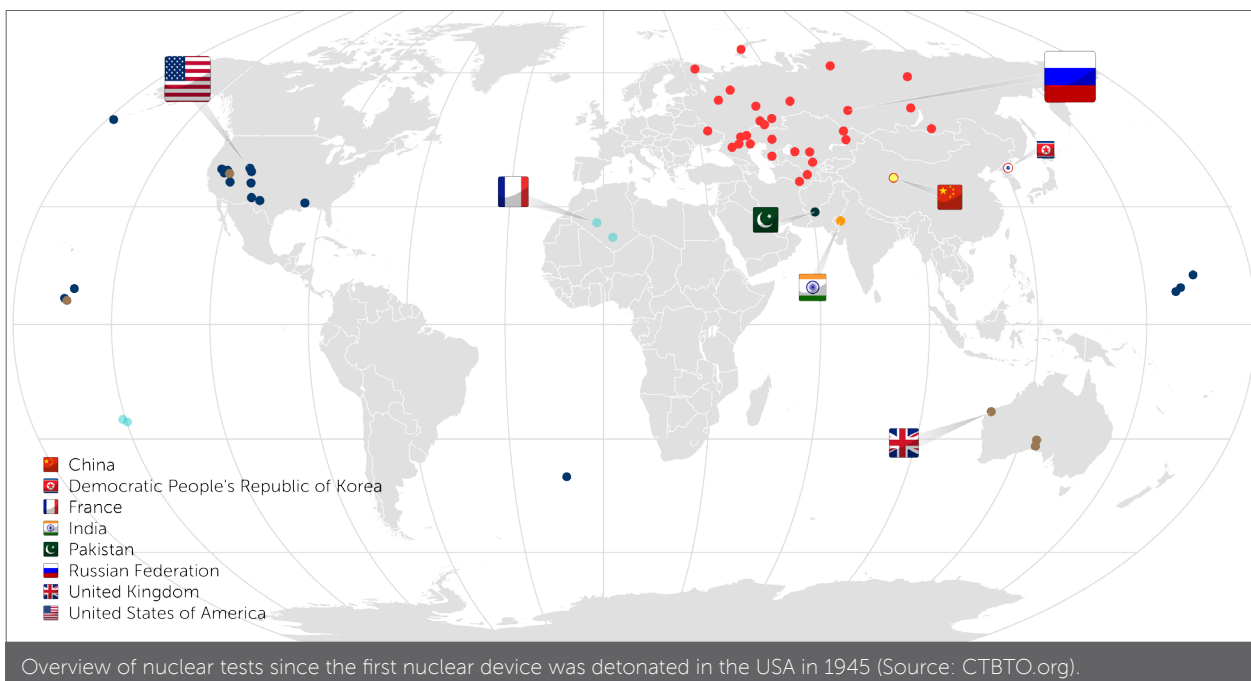
Iodine-131 builds up in the thyroid, 'stimulating the production of benign and cancerous nodules and interfering with the production of hormones, leaving pregnant women and children especially vulnerable.'¹² Rainfall can also cause localized radioactive concentrations of fallout elements far from nuclear test sites.¹³

Throughout the cold war and subsequently, the governments testing nuclear weapons exploded them in what they considered to be sparsely populated areas. This precaution was not effective in all cases: in 1954, for example, a nuclear test explosion carried out by the United States military at Bikini atoll in the Marshall Islands resulted in heavy fallout over populated islands to the east of the test site (see Box 3).

BOX 1

WHAT IS RADIOACTIVE CONTAMINATION?

Radioactive debris generated by nuclear fission contaminates soil particles and water droplets taken into the air during a nuclear explosion. Heavier particles may fall to the earth's surface in the vicinity of the explosion, contaminating the surrounding area. Smaller particles and radioactive gases disperse in the atmosphere and can create 'fallout' much farther from the explosion site, or contribute to global radioactive contamination.



The people of the Marshall Islands were by no means alone in experiencing significant fallout-related health effects due to nuclear testing. Soviet nuclear testing in what is now northeastern Kazakhstan is another notable example.

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Between 1949 and when the Semipalatinsk test site was closed in 1991, the Soviet Union carried out at least 450 nuclear detonations there, including more than 110 tests on the surface and in the air: 'The Institute of Radiation Medicine and Ecology in Semey estimates that in the vicinity of the Semipalatinsk nuclear test site, between 500,000 and one million people were exposed to substantial radiation doses in the years 1949-1962, when the last detonation above ground took place.²¹ Health studies have found that during the 1950s, when atmospheric testing was at its height, there were elevated levels of infant mortality, congenital malformation among children and child leukemia in these populated areas.²²

One of the earliest concerns about long-term health effects to exposure from radioactive products of nuclear explosions concerned the risk of genetic alterations among offspring of the people exposed. Such effects have not been demonstrated in follow-up scientific studies. Rather, the main long-term hazard associated with exposure to ionizing radiation has been shown to be increased cancer risk (a stochastic effect—see Box 2), especially of leukemia and thyroid cancer within a decade after exposure, followed by increased risks of other solid tumors

BOX 2

IONIZING RADIATION

Ionizing radiation is a travelling particle or gamma ray with enough energy to cause atoms or molecules to gain or lose electrons. It can harm the body in two ways—ionizing radiation can directly kill cells, or it can cause mutations to DNA. If the mutations are not repaired, the cell may turn cancerous. Radiation effects on the human body are divided into deterministic and stochastic effects:

- **DETERMINISTIC EFFECTS** are injuries caused when cells are killed by radiation e.g. radiation burns, radiation sickness. This type of effect is observed immediately or soon after the exposure to radiation.
- **STOCHASTIC EFFECTS** are caused by DNA mutations (e.g. cancer, genetic effects). These effects are observed a long time (possibly many years) after the radiation exposure.¹⁰

THE CONSEQUENCES OF THE 'BRAVO' TEST

On 1 March 1954, the United States military detonated a new type of thermonuclear weapon that used a solid fuel, which produced a much larger explosive yield than expected—15 megatons, almost three times what its designers had predicted—and a great deal of radiation.¹⁴ The fallout-related doses from the Bravo test are the highest in the history of worldwide nuclear testing, the people of Rongelap and Ailinginae receiving external exposures of between 1 and 2 gray.¹⁵ (A gray is the International System of Units measure for absorbed radiation dose—the amount of radiation energy that has been deposited in a medium such as a human organ or tissue.¹⁶ To put this in perspective, the average radiation exposure from a transatlantic flight is around 0.02 thousandths of a gray.) A Japanese fishing boat, The Lucky Dragon, was also caught in the fallout path and its crew fell sick from the effects of acute radiation syndrome.¹⁷ United States government investigators subsequently documented harm from the fallout among the Rongelap atoll population including miscarriages and birth defects in both women pregnant at the time of the test and afterward. Study of the Marshall Islands population led to recognition that 'not only can acute exposures to radiation stimulate short-term effects but that late effects can emerge years and decades following the initial exposure.'¹⁸

Eventually, the people of Rongelap were evacuated, although by then fallout had made many of the atoll's inhabitants sick. Some returned in 1957, but self-evacuated in 1985 with help from Greenpeace. More than 60 years after the Bravo test, the Rongelap islanders are still unable to go home because of residual radioactive contamination, which poses a risk to humans and the environment.¹⁹ Marshall Islanders, especially those from Rongelap, have encountered higher than normal rates of cancer including thyroid cancer and leukemia since nuclear tests ended.²⁰



The mushroom cloud of the 15 megaton Bravo test on Bikini Atoll in March 1954. The test, carried out as part of Operation Castle, was the largest nuclear device ever detonated by the United States (Photo: United States Department of Energy).

in later years. 'As studies of biological samples (including bone, thyroid glands and other tissues) have been undertaken, it has become increasingly clear that specific radionuclides in fallout are implicated in fallout-related cancers and other late effects'.²³ From the early 1970s, for example,

health studies of populations exposed to fallout from the Semipalatinsk atmospheric tests indicated a dramatic increase in some forms of cancer, which decreased from the 1980s, although not to pre-nuclear testing period levels.²⁴

Effects on health and the environment

Cancer is not the only health risk, experts have observed. 'For example, fallout and the movement of radionuclides through marine and terrestrial environments ultimately get into the food chain and the human body. The toxicity of contaminants and radioactivity in fallout represent significant health risks. Acute exposures are further complicated when followed by chronic exposure, as such assaults have a cumulative and synergistic effect on health and wellbeing.

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Chronic exposure to fallout does more than increase the risk of developing cancers, it threatens the immune system, can exacerbate pre-existing conditions, affects fertility, increases rates of birth defects, and can retard physical and mental development, among other things.²⁵ Although the question is not definitively settled, other long-term effects from radioactive fallout found in some studies (for instance in Kazakhstan) include increased frequency of chromosomal aber-

rations, elevated levels of cardiovascular disease, and premature ageing.²⁶

The dispersal of radioactive contaminants as a result of nuclear testing also has impacts on the environment. In the Pacific islands for instance, there is evidence that damage and disturbance to coral reefs from atmospheric, underwater and underground tests has resulted in an increase of ciguatera, a form of poisoning when humans eat fish containing ciguatoxins, which are single-celled organisms that live in reefs.²⁷ Fallout contamination from testing has made previously inhabited areas (such as Rongelap) uninhabitable, or cut off access to fishing grounds for populations like the Marshallese, and land that nomadic peoples such as the aborigines of Maralinga in Australia previously used to draw food from.²⁸ As a comprehensive report in the 1990s on the health consequences of nuclear weapons testing observed, these effects 'have fallen most heavily on minority, rural, or disenfranchised populations because governments have tended to situate their test sites in remote areas inhabited by such groups'.²⁹ The report further argued that these populations have suffered increased psychosocial stress, stigma, and loss of wealth and opportunity due to nuclear testing.

Risks to the broader population

As observed above, higher rates of cancer have been found in populations adjacent to test sites affected by significant fallout, including in the Marshall Islands and populations near the Semipalatinsk Nuclear Test Site in northeastern Kazakhstan. However, there is growing scientific evidence to implicate radionuclides in fallout causing increased rates of cancer in populations far from nuclear test sites, especially as mathematical exposure models have become more sophisticated and historical fallout deposition data

accumulates. For example, modeling of the spread of elements such as Iodine-131 and 133 following atmospheric nuclear explosions in the 1950s at the Nevada Test Site indicated slightly elevated lifetime risk of illnesses such as thyroid cancer among people in the continental United States eastward of the tests (the direction of the prevailing wind.) Thyroid cancer is a relatively rare disease: one study assessed that widely-spread fallout from such testing had resulted in an increase to the total number of cases since the 1950s by

about 49,000 persons or ten percent—‘almost all of them among persons who were under 20 at some time during the period 1951-57, with 95 percent uncertainty limits of 11,300 and 212,000’—with not all of these cancer cases expressed yet.³⁰

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There is also global radioactive contamination to consider. The scientific community remains divided over the effects of low-level radiation, with

a significant minority of experts holding that it is essentially harmless, while the majority says that all levels are harmful to some degree.³¹ Nevertheless, scientists have observed that ‘By the early 1960s, there was no place on Earth where the signature of atmospheric nuclear testing could not be found in soil, water and even polar ice.’³² Carbon-14, which is produced in nuclear test explosions, has a half-life of 5,730 years. The Soviet nuclear scientist and dissident, Andrei Sakharov, estimated in 1958 that Carbon-14 would cause 10,000 deaths and other health injuries from the low-dose radiation effects from each megaton of nuclear explosion in the atmosphere over the thousands of years it took for this element to cycle through the biosphere.³³ Other elements in fallout such as Strontium-90 and Cesium-137 have 30-year half-lives and do not decay appreciably before final deposition, for example in human tissue.

Conclusion

This paper has briefly introduced the reader to the broad kinds of humanitarian impacts that radioactive contamination from nuclear weapons tests have caused in the immediate, near, and long term. It should also be mentioned that besides nuclear testing, the military nuclear fuel cycle, involving the production of weapons materials and the fabrication of the weapons, has also resulted in releases of radioactive materials.³⁴ Other health and environmental risks not covered here include harmful run-off from uranium mining, accidents that cause radioactive release, and discharges of toxic or radioactive material during reprocessing and plutonium separation.

While most nuclear weapon testing has ended (at least for the time being) it is clear that these explosions—particularly, but not exclusively, those in the atmosphere—have had lingering consequences for people throughout the world. Then there is, as Andrei Sakharov put it in 1958, ‘the

defenselessness of future generations against our acts’, which includes the health legacy of long-lived radionuclides like Carbon-14.³⁵ Beside the health impacts of radioactive contamination itself, human displacement from test site areas and denial of access to contaminated resources such as land and fisheries has negatively impacted vulnerable populations such as indigenous peoples in particular. Beside adding to the costs of good governance and welfare in a world with finite resources, nuclear testing and its aftermath raises issues of social and economic injustice to those arguably most vulnerable to its health and environmental effects.

Endnotes

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