NUCLEAR WAR

Consequences of Regional-Scale Nuclear Conflicts

Numerous deaths and dangerous climate effects would result from use of low-yield nuclear weapons being stockpiled in many parts of the world.

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The world may no longer face a serious threat of global nuclear warfare, but regional conflicts continue. Within this milieu, acquiring nuclear weapons has been considered a potent political, military, and social tool (1–3). National ownership of nuclear weapons offers perceived international status and insurance against aggression at a modest financial cost. Against this backdrop, we provide a quantitative assessment of the potential for casualties in a regional-scale nuclear conflict, or a terrorist attack, and the associated environmental impacts (4, 5).

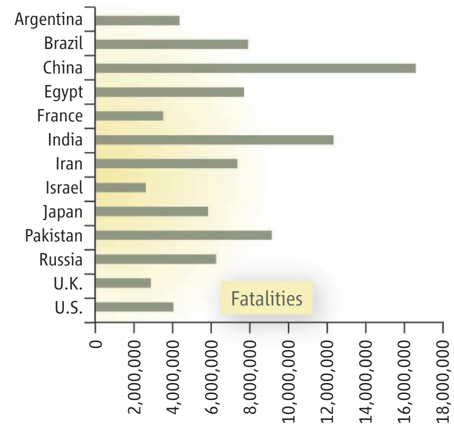
Eight nations are known to have nuclear weapons. In addition, North Korea may have a small, but growing, arsenal. Iran appears to be seeking nuclear weapons capability, but it probably needs several years to obtain enough fissionable material. Of great concern, 32 other nations—including Brazil, Argentina, Japan, South Korea, and Taiwan—have sufficient fissionable materials to produce weapons (*1*, *6*). A de facto nuclear arms race has emerged in Asia between China, India, and Pakistan, which could expand to include North Korea, South Korea, Taiwan, and Japan (*1*). In the Middle East, a nuclear confrontation between Israel and Iran would be fearful. Saudi Arabia and Egypt could also seek nuclear weapons to balance Iran and Israel. Nuclear arms programs in South America, notably in Brazil and Argentina, were ended by several treaties in the 1990s (*6*). We can hope that these agreements will hold and will serve as a model for other regions, despite Brazil's new, large uranium enrichment facilities.

Nuclear arsenals containing 50 or more weapons of low yield [15 kilotons (kt), equivalent to the Hiroshima bomb] are relatively easy to build (*1*, *6*). India and Pakistan, the smallest nuclear powers, probably have such arsenals, although no nuclear state has ever disclosed its inventory of warheads (*7*). Modern weapons are compact and lightweight and are readily transported (by car, truck, missile, plane, or boat) (*8*). The basic concepts of weapons design can be found on of the Internet. The only serious obstacle to constructing a bomb is the limited availability of purified fissionable fuels.

There are many political, economic, and social factors that could trigger a regional-scale nuclear conflict, plus many scenarios for the conduct of the ensuing war. We assumed (*4*) that the densest population centers in each country—usually in megacities—are attacked. We did not evaluate specific military targets and related casualties. We considered a nuclear exchange involving 100 weapons of 15-kt yield each, that is, ~0.3% of the total number of existing weapons (*4*). India and Pakistan, for instance, have previously tested nuclear weapons and are now thought to have between 109 and 172 weapons of unknown yield (*9*).

Fatalities were estimated by means of a standard population database for a number of countries that might be targeted in a regional conflict (see figure, above). For instance, such an exchange between India and Pakistan (*10*) could produce about 21 million fatalities—about half as many as occurred globally during World War II. The direct effects of thermal radiation and nuclear blasts, as well as gamma-ray and neutron radiation within the first few minutes of the blast, would cause most casualties. Extensive damage to infrastructure, contamination by long-lived radionuclides, and psychological trauma would likely result in the indefinite abandonment of large areas leading to severe economic and social repercussions.

Fires ignited by nuclear bursts would release copious amounts of light-absorbing smoke into the upper atmosphere. If 100 small nuclear weapons were detonated within cities, they could generate 1 to 5 million tons of carbonaceous smoke particles (*4*), darkening the sky and affecting the atmosphere more than



Fatalities predicted due to immediate radiation, blast, and fire damage from an attack using 50 nuclear weapons with 15-kt yield on various countries. Airbursts were assumed. Estimates for ground bursts, including early radioactive fallout, are about 25% less (*4*).

major volcanic eruptions like Mt. Pinatubo (1991) or Tambora (1815) (*5*). Carbonaceous smoke particles are transported by winds throughout the atmosphere but also induce circulations in response to solar heating. Simulations (*5*) predict that such radiative-dynamical interactions would loft and stabilize the smoke aerosol, which would allow it to persist in the middle and upper atmosphere for a decade. Smoke emissions of 100 low-yield urban explosions in a regional nuclear conflict would generate substantial global-scale climate anomalies, although not as large as in previous "nuclear winter" scenarios for a full-scale war (*11*, *12*).

However, indirect effects on surface land temperatures, precipitation rates, and growing season lengths (see figure, page 1225) would be likely to degrade agricultural productivity to an extent that historically has led to famines in Africa, India, and Japan after the 1783–1784 Laki eruption (*13*) or in the northeastern United States and Europe after the Tambora eruption of 1815 (*5*). Climatic anomalies could persist for a decade or more because of smoke stabilization, far longer than in previous nuclear winter calculations or after volcanic eruptions.

Studies of the consequences of full-scale

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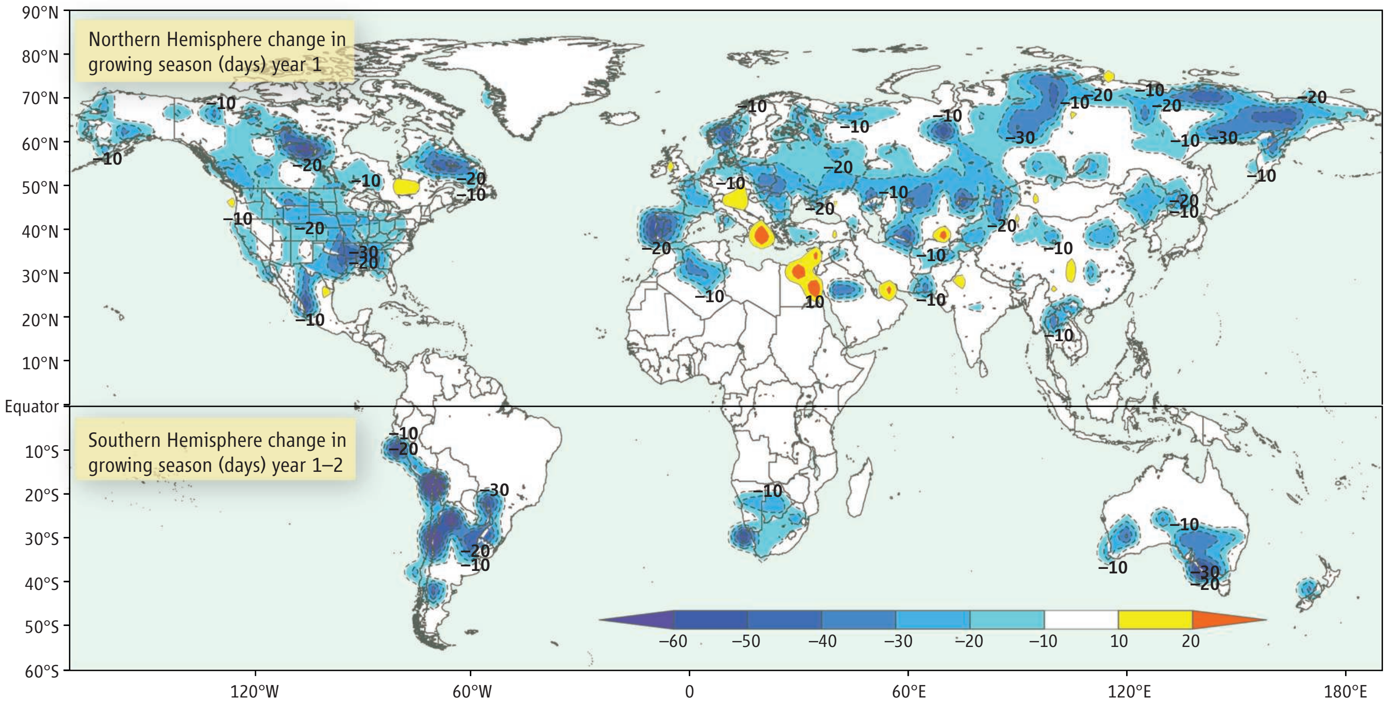

Change in growing season (period with freeze-free days) in the first year after smoke release from 100 15-kt nuclear explosions [modified from figure 11 in (*5*)].

nuclear war show that indirect effects of the war could cause more casualties than direct ones, perhaps eliminating the majority of the world's population (*11*, *12*). Indirect effects such as damage to transportation, energy, medical, political, and social infrastructure could be limited to the combatant nations in a regional war. However, climate anomalies would threaten the world outside the combat zone. The predicted smoke emissions and fatalities per kiloton of explosive yield are roughly 100 times those expected from estimates for full-scale nuclear attacks with high-yield weapons (*4*).

Unfortunately, the Treaty on Non-Proliferation of Nuclear Weapons has failed to prevent the expansion of nuclear states. A bipartisan group including two former U.S. secretaries of state, a former secretary of defense, and a former chair of the Senate Armed Services Committee has recently pointed out that nuclear deterrence is no longer effective and may become dangerous (*3*). Terrorists, for instance, are outside the bounds of deterrence strategies. Mutually assured destruction may not function in a world with large numbers of nuclear states with widely varying political goals and philosophies. New nuclear states may not have well-developed safeguards and controls to prevent nuclear accidents or unauthorized launches. This bipartisan group detailed numerous steps to inhibit or prevent the spread of nuclear weapons (*3*). Its list, with which we concur, includes removing nuclear weapons from alert status to reduce the danger of an accidental or unauthorized use of a nuclear weapon; reducing the size of nuclear forces in all states; eliminating tactical nuclear weapons; ratifying the Comprehensive Test Ban Treaty worldwide; securing all stocks of weapons, weapons-usable plutonium, and highly enriched uranium everywhere in the world; controlling uranium enrichment along with guaranteeing that uranium for nuclear power reactors could be obtained from controlled international reserves; safeguarding spent fuel from reactors producing electricity; halting the production of fissile material for weapons globally; phasing out the use of highly enriched uranium in civil commerce and research facilities and rendering the materials safe; and resolving regional confrontations and conflicts that give rise to new nuclear powers.

The analysis summarized here shows that the world has reached a crossroads. Having survived the threat of global nuclear war between the superpowers so far, the world is increasingly threatened by the prospects of regional nuclear war. The consequences of regional-scale nuclear conflicts are unexpectedly large, with the potential to become global catastrophes. The combination of nuclear proliferation, political instability, and urban demographics may constitute one of the greatest dangers to the stability of society since the dawn of humans.

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Supporting Online Material
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