Chapter 3

THE EFFECTS OF NUCLEAR DETONATIONS AND NUCLEAR WAR

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Nuclear war conjures up images of mass destruction and mutilation that few are willing to contemplate in detail. This chapter reviews the effects of nuclear explosions and describes the damage that might result from various types of nuclear strikes.

The Effects of Nuclear Detonations

The magnitudes of nuclear weapon effects are determined primarily by the yield of the weapon, which is measured in kilotons (kt). (One kiloton is equivalent to one thousand tons of TNT.) The average yields of tactical and strategic warheads are roughly 10 and 500 kt, respectively. For comparison, the bomb that destroyed Hiroshima and killed 70,000 people had a yield of 13 kt.

The direct effects of nuclear explosions include blast, heat, radiation, fallout, and electromagnetic pulse.

Blast. Nuclear explosions in air produce blast effects similar in kind to those produced by conventional explosives. The strength of the blast wave is measured in pounds per square inch (psi) of overpressure. Ordinary residences are damaged by overpressures of 1-2 psi and are completely destroyed at 5 psi; reinforced concrete buildings are demolished by 15-20 psi; missile silos can withstand more than 2,000 psi. The blast wave can directly injure humans by rupturing eardrums or lungs or by hurling people at high speed, but most casualties occur because of falling buildings and flying debris. Most of the immediate damage from a nuclear explosion is due to blast.

A 500 kt warhead detonated above the Washington Monument would destroy reinforced concrete buildings in a 1½ mile radius, including the White House, the Pentagon, the Capitol, and virtually all downtown government buildings. Residences would be demolished up to 4 miles away, beyond the National Zoo to the north, RFK Stadium to the east, and National Airport to the south.

Heat. Unlike conventional explosions, nuclear explosions generate large amounts of thermal radiation that can start fires or cause burns. A 500 kt above the Washington Monument would, for example, ignite fires and cause third degree burns to unprotected people at distances of up to six miles, or as far away as Chevy Chase and Alexandria. People glancing at the fireball in Rockville, Fairfax, or Bowie would be blinded. In Baltimore, the brilliance of the explosion would be far greater than that of the sun at noon, even after many seconds. The many fires ignited by the explosion could coalesce into one superfire, preventing the escape of survivors and turning

shelters into crematories. Thermal effects are less important (compared with blast effects) for smaller explosions—a 10 kt explosion produces third-degree burns about 1 mile away.

Radiation. Nuclear detonations release large amounts of neutron and gamma radiation. An unshielded person would receive a lethal dose of radiation 1½ miles from a 500 kt nuclear explosion, but at this distance he would certainly be killed by blast and heat effects. Radiation effects are more important (compared with blast effects) for smaller explosions—a 10 kt explosion would produce a lethal dose 3/4 mile away. Specially designed weapons called "neutron bombs" produce greater radiation effects for a given yield: a 1 kt neutron bomb produces about the same dose as a normal 10 kt weapon, but the blast damage extends less than half as far. Unless the dose is extremely high, victims of a lethal exposure do not die for several days or weeks.

Fallout. When attacking “soft” targets such as cities or airfields, weapons would be detonated well above the ground to maximize blast effects. The highly radioactive weapon debris would then rise into the stratosphere and gradually fall back to earth over a period of months to years (global fallout). The destruction of “hard” targets such as missile silos requires explosions on or near the surface of the earth. In this case, the weapon debris mixes with dirt from the crater and is carried aloft at low altitudes by the wind (local fallout). Local fallout is difficult to predict because it depends on the weather; for average conditions, a 500 kt surface burst would deposit lethal fallout up to one hundred miles downwind from the explosion, with hundreds of square miles contaminated. People receiving less than a lethal dose of radiation would have an increased chance of eventually developing cancer.

EMP. Nuclear explosions of all kinds produce an electromagnetic pulse (EMP), but the intensity and duration of the pulse depends on the location of the burst. EMP is especially strong when weapons are detonated high in the atmosphere. Since this was discovered just before the end of atmospheric testing, relatively little is known about EMP. An explosion above Johnston Island in 1962 damaged electrical equipment in Hawaii, 800 miles away, and damaged satellites in orbit. It is possible that one or two explosions high above the earth could blanket most of the United States with EMP, causing widespread blackouts and permanent damage to modern electronics. Special precautions have been taken to protect military equipment from EMP effects. A nuclear explosion can also disrupt radio and radar (especially at low frequencies) over hundreds to thousands of miles for many hours.

The Effects of Small-Scale Attacks

As the bombing of Hiroshima showed, a single low-yield nuclear explosion can demolish a city and kill one hundred thousand people. A single modern strategic warhead detonated above a large city could kill over one million.

The use of nuclear weapons on a small scale would not necessarily result in such catastrophic losses, however. A "demonstration shot" to signal resolve or the use of a few nuclear weapons at sea to destroy enemy ships or submarines need not cause any civilian casualties. The use of several low-yield battlefield nuclear weapons could conceivably result in fewer than a thousand civilian deaths. In each of these cases, the primary danger would be escalation to larger-scale attacks. In West Germany, for example, even a "limited" attack on airfields, missile sites, and

nuclear weapon storage sites involving fewer than 100 warheads could result in more than ten million deaths.

The Effects of Strategic Counterforce Attacks

The "limited" war scenario receiving the most attention is a counterforce first strike against key military targets. If the Soviet Union launched such an attack against the United States with about 3,000 warheads (used mostly against missile silos, and avoiding cities), it has been estimated that 12-27 million Americans would die outright, another 11-18 million would be injured seriously, and 2-20 million more would develop fatal cancers from exposure to fallout, for a total of 25-65 million casualties. For comparison, 2 million Americans have been killed or injured in *all* previous wars. A counterforce strike using only 100 warheads would kill 3-11 million Americans. If 100 warheads were used to destroy key U.S. industries, 11-29 million would die. A 100-warhead attack designed to maximize deaths could kill 25-66 million Americans. Corresponding U.S. attacks would kill and injure comparable numbers of Soviet citizens.

The Effects of All-out Nuclear War

It should be clear that even "limited" nuclear attacks have unprecedented consequences; indeed, one may wonder how a nation could determine that it had sustained a "limited" attack rather than an all-out attack. But a war using a large fraction of the 50,000 nuclear weapons in existence would be much more devastating: if the attack came with little warning, 100-160 million Americans would die in the first few days. Maximum use of available shelters could reduce this by 15-35 percent; evacuation by 70-80 percent, but the problem of sheltering the evacuees would remain. A U.S. retaliatory strike could kill 50-100 million Soviet citizens. If, as is usually supposed, such attacks included Europe and China, then the total number of dead would number in the hundreds of millions; some studies estimate that the death toll from direct effects could reach one billion in all-out global nuclear war.

Indirect Effects of Nuclear War

Large-scale nuclear war may cause sizable indirect effects, including:

Global fallout. In the months following a large-scale nuclear war, the northern hemisphere would be blanketed with fallout. This global fallout generally would not be lethal (as would local fallout near surface bursts), but it would sometimes lead to sterility and sickness, and may further weaken those already suffering from injuries or malnutrition. In addition, cancer deaths and birth defects will be increased in later years. Rough estimates show that global fallout from an all-out war would cause 5-13 million cancer deaths and 6-16 million birth defects.

Ozone depletion. Nuclear explosions in air produce copious quantities of nitrogen oxides. If these nitrogen oxides reach the upper atmosphere, the concentration of ozone will be reduced. Ozone absorbs harmful ultraviolet radiation from the sun; a reduction of 60 percent would lead to sunburn and snow blindness within minutes, incapacitating sunburn in 30 minutes. Ozone levels would recover in several years. It would take several thousand high-yield (greater than 1,000 kt)

or high-altitude explosions to deplete the ozone by 60 percent. The United States no longer stockpiles large numbers of high-yield weapons, and, though the Soviets may, there is no reason for thousands of high-altitude explosions.

Nuclear winter. The fires started by nuclear explosions would produce a thick layer of smoke and soot that would reduce the amount of sunlight reaching the earth's surface. Although initial calculations showed that an all-out attack could reduce temperatures by as much as 50-70^{o} F, more realistic analyses give average temperature drops of only 10-20^{o} F—"nuclear autumn" instead of "nuclear winter." Even these temperature drops would, however, be devastating to agriculture. Small-scale attacks on oil storage and refineries could produce such drops in temperature. Changes in precipitation patterns could be more important than changes in temperature. A disruption in the monsoons, for example, could threaten the food supply of one billion people.

Trade disruptions. Some countries, such as Japan, depend on foreign trade for a large fraction of their food. Without imports, a large number of Japanese would starve. This is also true within countries: in the United States, for example, the urban population in the industrial northeast is fed by midwestern and western states. Without modern agriculture, the earth could support a human population less than one-tenth the current size. But modern agriculture depends on the availability of machines, fuel, fertilizer, and pesticides, all of which may become unavailable after a large-scale war, even in countries that did not suffer explosions.

Fortunately, we have no firsthand knowledge of nuclear war. Although what we know about nuclear war is horrible enough, one cannot rule out the possibility that unforeseen effects could make the situation even worse.