Projected US Casualties and Destruction of US Medical Services From Attacks by Russian Nuclear Forces

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The number of direct, short term casualties and collateral damage to US medical services were calculated for two thermonuclear attack scenarios: 1) 2,000 Russian warheads believed to be on high alert status today; and 2) a future Russian force of 500 warheads targeted in response to the deployment of a US National Missile Defense (NMD) system. The first scenario would cause 52 million prompt fatalities, 9 million injuries, and massive destruction of US health facilities. The second scenario produces more than 100 million casualties. Even with an effective US NMD system—defined as capable of successfully intercepting more than 100 warheads—nearly 70 million fatalities would occur. M&GS 2002;7:68-76.

Since the early 1960s, the medical community has assumed responsibility for educating the population about the medical consequences of nuclear war.[1-9] With the end of the Cold War, public concern about the threat of nuclear war and the dangers of nuclear weapons has waned. In fact, threats and dangers remain. Although there have been significant reductions in the number of nuclear weapons, there are still some 32,000 nuclear weapons in the world's arsenals.[10] Most disturbingly, approximately 2,000 Russian and 2,500 United States warheads are mounted on missiles on high alert status.[11] After receiving their instructions to fire, US missiles can be launched within 15 minutes, and missile flight times between the Russian and the US land masses are estimated to be 25 minutes.[12] Continued maintenance of these missiles on such hair-trigger alert increases not only the dangers of accidental or unauthorized launch, but also the risks of rapid, intentional initiation of full-scale nuclear war.

In a well-publicized event on January 25, 1995, Russian military radar systems mistook the launch of a weather rocket from Norway for a possible missile attack. President Yeltsin was given five to ten minutes to decide if he should launch a retaliatory attack against the US.[13] Two years later, Russian Defense

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Minister Igor Rodionov asserted, "Russia may soon approach a threshold beyond which its missiles and nuclear systems become uncontrollable."[14] Public debate in the US regarding nuclear policy is occurring in the absence of any published post-Cold War estimate of the expected casualties in the event of the large scale use of these weapons—whether by design or by accident.

The Call for De-Alerting

A 1998 study estimated that a limited accidental attack on the US, involving 64 warheads on a single Russian Delta IV submarine, could cause 6,838,000 prompt fatalities. The study called for the de-alerting of US and Russian nuclear weapons.[15] A number of different steps can be taken to de-alert these missiles, lengthening the time it takes to launch them. For example, the warheads or guidance systems can be physically removed from the missiles.[12] In various forms, de-alerting has been urged by the National Academy of Sciences;[16] the Canberra Commission;[17] General George Lee Butler, commander of the US Strategic Command from 1991 to 1994, and 62 senior military colleagues from 17 nations;[18] and other experts such as Sam Nunn, former chairman of the US Senate Armed Services Committee and Admiral Stansfield Turner, former Director of Central Intelligence.[13,19,20] Numerous state medical associations have called for de-alerting, and in a September 7, 1999 letter to the President of the United States, the American Medical Association, citing the recommendations of General Butler, called on the President to "take the lead in developing such policies to minimize the danger of a nuclear catastrophe." Despite these calls, neither the US nor Russian government has acted to de-alert these weapons.

George W. Bush has called for major reductions in the US and Russian arsenals. Reportedly, after his first briefing as President on US nuclear forces Bush was stunned. "I had no idea we had so many weapons," he said. "What do we need them for?" But even the most ambitious reductions proposed by his administration still leave some 2,000 warheads in each arsenal, and these reductions would not actually occur for up to 10 years even if agreement were reached immediately.

Nuclear Attacks With and Without NMD

In this paper, therefore, the authors first calculate the medical consequences of an attack on the United States by the force of 2,000 Russian nuclear warheads currently believed to be on high alert status, and likely to remain so even with a new arms control agreement. Second, a near-term future scenario is examined involving the anticipated deterioration of Russian strategic nuclear forces over the next decade to a level below 1,000 warheads.[21] In this second scenario, the Russians have targeted a postulated 500 weapons to attack major US population centers in response to the mitigating effects of a US National Missile Defense (NMD) system. The extent to which an NMD system of varying degrees of effectiveness could protect against the consequences of the attack is considered for two reasons.

First, the US government is currently considering whether to deploy a [limited] multi-layered National Missile Defense system (NMD) because of the possibility that a "rogue" state might acquire the ability to launch a limited nuclear attack on the US at some point in the next 5-15 years. Such an attack, it is suggested, would involve fewer than 20 relatively small nuclear warheads.[22] Proponents of NMD concede that even if the currently proposed system were to work it would not be able to protect against a large scale nuclear attack, but they hold out the possibility that future advances in technology might enable it to do so.[23] Public support for NMD appears to be based in part on inflated expectations of what a missile defense system could do. A 1998 poll showed that 54% of Americans thought the US already had the ability to shoot down incoming ballistic missiles.[24] There is no evidence that the US public understands the level of civilian protection that an NMD system would or would not provide.

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Second, a US decision to proceed with a missile defense system appears to jeopardize the de-alerting of US and Russian nuclear forces and further deep reductions in the arsenals of the two countries. Speaking to the Duma on the day it approved ratification of the START II treaty, Russian President Vladimir Putin stated that the entire arms control regime could unravel were the US to build a missile defense system that violated the Anti-Ballistic Missile Treaty: "I want to stress that, in this case, we will have the chance and we will withdraw not only from the START II Treaty, but from the whole system of treaties on the limitation and control of strategic and conventional weapons."[25] While the Bush Administration has tried to convince the Russian government to proceed with deep reductions even if the US proceeds with an NMD, it is not clear that they will be successful. After meeting with Defense Secretary Rumsfeld in August, Defense Minister Ivanov reaffirmed Russian opposition, stating that "The existing, multi-layered system of strategic security that exists in the world today fully meets Russian needs."

In the aftermath of the attack on the World Trade Center, Russian policy remains unclear. At the Asia-Pacific Economic Cooperation (APEC) meeting in Shanghai, President Putin indicated some willingness to accept further development of an NMD in return for cuts in both US and Russian nuclear arsenals. It is not clear if such a deal can be completed, and if it is, the remaining warheads would probably remain on high alert status. Ironically, US officials have encouraged continued high alert status by trying to persuade the Russians that they would not be threatened by an NMD system as long as they retained "large diversified arsenals of strategic offensive weapons," maintained on high alert that permits "launch on warning." Thus the current US position effectively encourages Russia to maintain thousands of warheads on hair-trigger alert.[26]

Methods

The authors employed a multi-component computer program and set of databases developed by the Natural Resources Defense Council (NRDC), the output from which includes the immediate mortality from blast, burn, and ionizing radiation for a given targeting scenario.

US Targets for Russian Nuclear Weapons

The first scenario considers an attack on the continental United States involving 2,000 550-kiloton Russian warheads delivered to their targets by SS-18 and SS-19 interconti-

Description	# Targets	# Warheads (each)	Burst Height (m)	Total Warheads	%Total
ICBM Launch Control Centers: MM-III	50	2	0	100	5.0
ICBM Silos: MM-III	500	2	0	1,000	50.0
ICBM Launch Control Centers: MX	5	4	0	20	1.0
ICBM Silos: MX	50	4	0	200	10.0
Strategic Bomber Bases	5	4	1,840	20	1.0
Other Military Airfields	101	1	1,840	101	5.1
International Airports (Civilian)	60	1	1,840	60	3.0
SLBM Facilities	11	2	1,840	22	1.1
Other Naval Bases and Naval Yards	18	1	1,840	18	0.9
Nuclear Warhead Storage Facilities	10	2	0	20	1.0
Nuclear Weapons Design and Production Facilities	14	1	1,840	14	0.7
Political-Military Leadership and Infrastructure	33	1	1,840	33	1.7
Urban Centers of Commerce and Selected State Capitols	50	1	1,840	50	2.5
Electric Power Plants	342	1	1,840	342	17.1
Totals	**1,249**			**2,000**	**100**

Table 1. Summary information for the 1,249 discrete targets selected for 2,000 Russian nuclear weapons in the first scenario.
Geographic coordinates for these targets have been verified to the nearest minute or better. The 342 electric power plants targeted in this scenario comprise approximately 68% of the current US electric generating capacity. Political-military leadership and infrastructure targeted in the first scenario are: Camp David (Thurmont, MD); Central Intelligence Agency Headquarters (Fairfax, VA); Department of Energy Germantown Office (Germantown, MD); Department of Energy Headquarters (Forrestal Building, Washington, DC); Department of State Main Office Building (Washington, DC); F.E. Warren Air Force Base Headquarters (Cheyenne, WY); National Aeronautical and Space Administration Headquarters (Washington, DC); New Boston Satellite Tracking Ground Station (New Boston, NH); Nuclear Regulatory Commission Headquarters (Rockville, MD); Onizuka Air Force Base Satellite Tracking Ground Station (Sunnyvale, CA); PARCS Radar (Cavalier Air Force Station, Pembina County, ND); PAVE PAWS Radar (Beale Air Force Base, Yuba County, CA); the Pentagon (Arlington, VA); Schriever Air Force Base Satellite Tracking Ground Station (Colorado Springs, CO); the US Capitol Building (Washington, DC); US Courts of Appeal (DC and First-Eleventh Circuits); US Army Missile Command Headquarters (Huntsville, AL); Vandenberg Air Force Base Satellite Tracking Ground Station (Vandenberg, CA); and the White House (Washington, DC). Urban centers of commerce and selected state capitols targeted in the first scenario are: Atlanta, GA; Austin, TX; Birmingham, AL; Boston, MA; Charleston, WV; Cheyenne, WY; Chicago, IL; Columbia, SC; Columbus, OH; Denver, CA; Harrisburg, PA; Hartford, CT; Huntsville, AL; Indianapolis, IN; Jefferson City, MO; Kansas City, MO; Kansas City, MO; Knoxville, TN; Las Vegas, NV; Lincoln, NE; Los Angeles, CA; Madison, WI; Memphis, TN; Miami, FL; Minneapolis, MN; Montgomery, AL; Nashville, TN; New Orleans, LA; Oakland, CA; Oklahoma City, OK; Olympia, WA; Omaha, NE; Philadelphia, PA; Phoenix, AZ; Pittsburgh, PA; Providence, RI; Raleigh, NC; Richmond, VA; Sacramento, CA; Salt Lake City, UT; San Diego, CA; San Francisco, CA; San Jose, CA; Santa Fe, NM; Savannah, GA; Seattle, WA; Springfield, IL; St. Lewis, MO; Trenton, NJ; Wilmington, DE.

nental ballistic missiles (ICBMs).[27] Each warhead is assumed to have a 25% chance of failing to explode on target because of technical problems, but the complex issues of warhead "fratricide" (the failure of a nuclear warhead to detonate due to the effects of nearby explosions) is not addressed, nor are the targeting logistics relating to "footprint size" (the maximum area within which targets could be reached by warheads independently targeted and released during the ballistic phase of the flight of a single ICBM).

Actual Russian nuclear war plans are, of course, highly secret. More is known about the US war plan, the Single Integrated Operational Plan (SIOP). The US SIOP is constructed annually, and current guidance identifies four categories of major attack options (MAOs) which the US must be continuously prepared to execute against Russia. The MAOs range from attacks restricted to Russian military targets with cities excluded, to broader attacks on leadership, economic, and urban-industrial targets.[28] While the targets Russian nuclear war planners might choose cannot be known with certainty, this first scenario assumes a Russian attack similar in target categories to a comprehensive US MAO, with 1,249 discrete targets, some receiving multiple warheads. Summary information on the targeting is given in Table 1.

The Counterforce Scenario

In this first scenario, most of the Russian warheads (66%) are targeted at ICBM missile silos (550 targets) and launch control centers (55 targets) deployed at three bases:

- F.E.Warren (150 Minuteman III and 50 MX missiles distributed over approximately 22,000 square kilometers (km^2) at the intersection of Colorado, Wyoming, and Nebraska);
- Minot (150 Minuteman III missiles distributed over approximately 16,000 km^2 in North Dakota);
- Malmstrom (200 Minuteman III missiles distributed over approximately 30,000 km^2 in Montana).[29]

Because both ICBM launch control centers and silos are designed to resist blast and other effects of a nuclear explosion, this calculation assumed two Russian warheads were detonated on each Minuteman III target and four warheads on each MX. More warheads were assigned to each MX target because these missiles carry up to ten highly accurate warheads each, whereas Minuteman III missiles carry fewer, less accurate warheads each.

The height of burst at which a nuclear explosion occurs determines the nature and degree of its effects. In the first scenario, ground bursts were assigned to targets hardened to resist blast effects, and for less vulnerable targets a height of burst—1,840 meters—was chosen that maximizes the radius of high crushing pressure [10 pounds per square inch (psi)]. At this height no local fallout is predicted to occur, in contrast to the ground bursts where significant fallout is calculated. Sixty of the electrical plants chosen as targets in this scenario contain nuclear reactors, but for this calculation the secondary impact of radioactive contamination from these destroyed plants, which would be substantial, was not assessed.

The NMD Scenario

The second scenario considers an attack on the continental United States by a Russian force of 500 550-kiloton warheads. The US is assumed to have deployed a missile defense system that can intercept incoming warheads. In response, the Russians have targeted their missiles on US population centers in order to maintain the ability to inflict unacceptable casualties. As with the first scenario, 25% of the 500 warheads are assumed to malfunction and a height of burst of 1,840 meters for all warheads is selected, resulting in no significant local fallout.

The 500 specific population targets for Russian nuclear weapons were selected as follows: a one square-kilometer population grid for the continental United States was computed using 1999 census data;[30] for each one-square kilometer cell in that grid, the population within a 9.6 kilometer circle centered on the cell (i.e., the expected zone of mass fires, as discussed below) was summed; the cells were then rank-ordered according to the summed populations; and, finally, the 500 cells with the largest population sums were selected as targets under the constraint that the 9.6 kilometer circles around the

Figure 1: Targets are shown for the 2,000-warhead scenario (filled circles) and for the 500-warhead scenario (open triangles). Map courtesy Natural Resources Defense Council.

selected cells did not overlap. The authors then examined the effects of an NMD capable of intercepting 10%, 20%, or 30% of these warheads—an operational capability that greatly exceeds current expectations for this technology. Figure 1 displays the locations of the targets for both the 2,000 warhead and the 500 warhead scenarios.

Casualty Calculations

Immediate fatalities are determined primarily by the area of anticipated fire storms generated by the nuclear explosions. Mass fires are assumed to ignite across the area exposed to 10 or more calories per square centimeter (cal/cm^2), coalescing into giant firestorms with hurricane-force winds and average air temperatures above the boiling point of water. Within this area, the combined effects of superheated wind and toxic smoke would result in a death rate approaching 100%.[31] Assuming 20 kilometers visibility, a 550-kt surface burst would create a thermal flux of 10 cal/cm^2 to a distance of 6.3 kilometers (3.9 miles). An air burst at 1,840 meters would create a thermal flux of 10 cal/cm^2 to a distance of 9.6 kilometers (5.9 miles).[32]

To calculate casualties resulting from this attack at distances beyond the firestorm, a model was employed based on the experiences at Hiroshima and Nagasaki, where injuries and deaths occurred even at relatively far distances from the ground zeroes (primarily as the result of indirect blast injury to persons inside wooden houses at the time of the attack). At Hiroshima, a 24.9% injury rate and a 2.1% fatality rate occurred for people living in the band of terrain exposed to overpressures of between 0.8 to 2.3 psi, and at Nagasaki a 9.5% injury rate and 1.1% fatality rate occurred in areas exposed to 1.0 to 2.7 psi.[33] For a 550-kt explosion at 1,840 meters, overpressures of this magnitude occur in a band extending from 7.9 out to 15.4 kilometers from ground zero.[32] Subtracting out the population living in the zone of 100% lethality due to firestorms, the same census data were used to calculate injuries and deaths based on the averaged probabilities for Hiroshima and Nagasaki. Probabilities for overlapping zones were summed using the formula: (Combined probability of P1…PN) = 1-((1-P1)x(1-P2)x … x(1-PN)).

Fallout patterns were calculated with the K-Division Defense Nuclear Fallout Code, 3rd Edition, (KDFOC3) developed at Lawrence Livermore National Laboratory.[34] The most probable wind velocities and directions for the continental United States in 2.5-degree latitude by 2.5-degree longitude cells for 15 elevations (from the surface to approximately 30 kilometers in altitude) for each month of the year were used for the fallout calculations.[35] Fallout depends on the fraction of the explosive yield from fission reactions, and calculations were performed for fission fractions of 50% (the most commonly cited value) and 80%.[36] Under the assumption that radioactive products from the explosions decay exponentially with a time constant of 1.2 hours,[32] the dose rates two days after the explosion will be less than 1% of the initial dose rates, therefore health effects were computed for fallout dose rates integrated over the first 48 hours after the explosion. The sheltering factor, a factor by which the instantaneous dose rate is divided to account for the protection against fallout offered by various structure types, was varied between 1 (no sheltering), 4 (an average single-story, residential structure), 7 (an average multistory structure) and 40 (basement environments).[37] Fallout casualties were calculated using probability functions for severe radiation sickness and mortality, choosing a conservative value of 4.5 Sieverts (Si) for the 50%-lethal dose.[38]

In this paper the authors have not attempted to calculate the additional long term and indirect casualties that would be expected. These include deaths from exposure; from epidemic disease with the breakdown of public sanitation and the widespread incidence of radiation induced immunosuppression; from starvation with the disruption of transportation and food distribution networks; from cancers induced by radiation exposure; and from the effects of widespread damage to the ecosystem. Previous studies have suggested that such deaths might exceed the direct casualties discussed in this study, but because they are less subject to precise calculation, they have not been considered further.[1,8,39]

Hospital Data

Damage to the US hospital system was estimated using 1998-1999 data obtained from the American Hospital Association.[40] From this database a total of 5,939 facilities in the continental United States (for which geographic coordinates were provided) were used in the calculation. Information fields included hospital name, city, state, latitude and longitude, beds, intensive care unit beds, burn unit beds, operating rooms, full-time-equivalent personnel, and full-time equivalent physicians and dentists.

Results

From the combined effects of blast, burns, and radiation, the attack by 2,000 warheads would cause 52 ± 2 million deaths and 9 ± 1 million injuries, even though it was primarily directed at military targets in sparsely populated areas. The goal of the first attack, to recall, was to destroy US military, political, and economic targets. In the 2,000-warhead scenario, there were 660 air bursts, many of which had overlapping zones of mass fires and blast damage because the distances separating some of the targets were less than the diameter of the zones. Because of this overlap, randomly removing 25% of the attacking warheads (due to malfunctions) does not correspondingly reduce the number of casualties by 25%. The standard deviations given above for the total numbers of killed and injured were largely determined by the effect of randomly removing 25% of attacking warheads averaged over multiple computer runs, and were less significantly determined by the input parameter variation for the fallout calculations, discussed below.

Sheltering	Warhead Fission Fraction	Casualties (thousands)	Killed (thousands)	Severe Radiation Sickness (thousands)	Area (10^3 km^2) in which 48-hour Integrated Dose ≥ 4.5 Si
None	50%	2,571 ± 585	1,285 ± 223	1,286 ± 626	319 ± 22
None	80%	3,950 ± 1,479	1,848 ± 348	2,102 ± 1,519	402 ± 33
Residential	50%	666 ± 71	402 ± 27	264 ± 76	143 ± 4
Residential	80%	1,032 ± 185	509 ± 52	523 ± 192	180 ± 7
Multistory	50%	437 ± 44	312 ± 14	125 ± 46	102 ± 2
Multistory	80%	571 ± 57	371 ± 8	200 ± 57	130 ± 4
Basement	50%	129 ± 21	65 ± 2	64 ± 21	15 ± 1
Basement	80%	228 ± 18	87 ± 8	141 ± 20	29 ± 1

Table 2: Statistical results for the fallout resulting from the 2,000-warhead scenario attacks against the 605 US missile silo and launch control center targets.

Percent of Incoming Warheads Intercepted	Number of Incoming Warheads Intercepted	Total Number of Exploding Warheads	Mean Number of Deaths in Mass Fire Zones (thousands)	Maximum Number of Deaths in Mass Fire Zones (thousands)
0%	0	375	97,104 ± 2,714	111,290
10%	37	338	87,394 ± 2,568	111,398
20%	75	300	77,683 ± 3,061	105,853
30%	113	262	67,973 ± 3,180	99,734

Table 3. Statistical results from the 500-warhead scenario assuming that 25% of the warheads malfunction and a US National Missile Defense system is in place. For these calculations, successively greater percentages of the attacking warheads were randomly removed and the resulting mean, standard deviation, and maximum numbers of deaths in mass fire zones determined.

Figure 2 displays the fallout patterns resulting from the nuclear explosions at the 605 US missile silo and launch control center targets (representing two thirds of the targets for the 2,000 warheads) for the most probable wind patterns for the month of August. Fallout calculations were computed for warhead fission fractions of 50% and 80%, for four values of the sheltering factor, and for each month of the year in order to understand the different variables. The standard deviations given in Table 2 are derived from monthly variations in wind speed and direction. Under the maximal assumption of high fission fraction (80%) and no sheltering, the resulting four million fallout casualties represent less than 10% of the total casualties from the 2,000-warhead scenario. The area of fallout zones in which a 50%-lethal dose occurs does not vary substantially by month, and decreases the greater the effective sheltering of the population.

In the second scenario, the US targets for 500 Russian nuclear weapons are chosen to maximize loss of life. If all 500 warheads detonated over their targets, a total of 132 million deaths and 8 million injuries are calculated to occur. Under the assumption that 25% of the warheads malfunction, the attack would produce a total of 97 ± 3 million deaths in mass fire zones, where the standard deviation was determined from the random removal of 125 of the attacking warheads. Figure 3 displays a map of the northeastern United States, showing population targets from the 500 warhead sce-

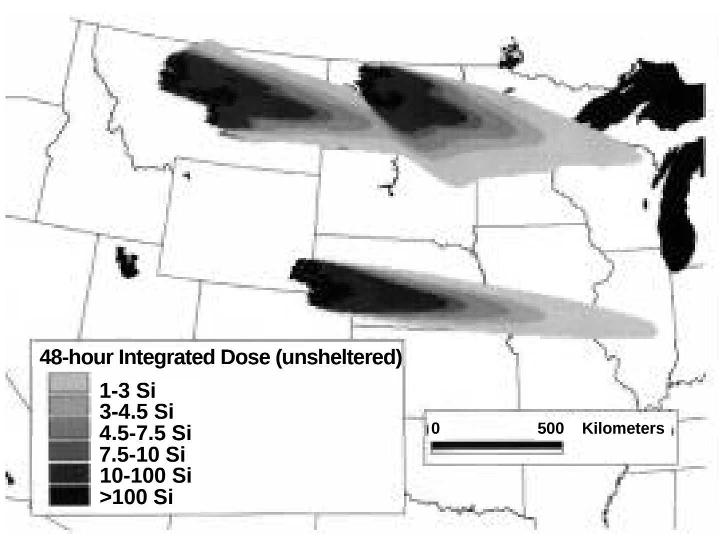

Figure 2: Fallout patterns resulting from the 2,000 warhead scenario attacks against the 605 US missile silo and launch control center targets. The most probable wind patterns for the month of August were used for this calculation. The 48-hour integrated dose to unsheltered individuals is plotted. Figure courtesy Natural Resources Defense Council.

		2,000-warhead scenario		500-warhead scenario with 20% of incoming warheads intercepted by US National Missile Defense	
	Total Before Attack	Average Number in Mass Fire Zones	Average Percent in Mass Fire Zones	Average Number in Mass Fire Zones	Average Percent in Mass Fire Zones
Hospitals	5.939	973 ± 38	16.4%	1,396 ± 57	23.5%
Beds	1,000,617	243,949 ± 10,248	24.4%	354,750 ± 17,884	35.5%
ICU Beds	85,521	24,075 ± 1,160	28.2%	35,525 ± 1,788	41.5%
Burn Beds	1,151	516 ± 31	44.8%	585 ± 55	50.8%
Operating Rooms	23,233	5,909 ± 281	25.4%	8,496 ± 425	36.6%
Total Hospital Full Time Equivalent Employees (FTEs)	4,339,452	1,200,175 ± 51,520	27.7%	1,667,860 ± 87,131	38.4%
Hospital Physician and Dentist FTEs	97,421	27,981 ± 1,526	38.9%	42,222 ± 3,924	43.3%

Table 4: Summary data on impacts of the two nuclear attack scenarios on US medical services. Standard deviations were determined by the random removal of warheads due to malfunction and, for the 500-warhead scenario, the effect of a US National Missile Defense.

nario with mass fire and blast zones. Somewhat unexpectedly, the mitigating effect of an NMD system does not reduce the number of fatalities by very much, as shown in Table 3. Even if almost one third of the warheads are intercepted, there are still potentially 100 million deaths and, on average, 68 million deaths in mass fire zones.

Table 4 provides summary data on the impact of the two attacks on the US medical infrastructure. High percentages of beds, operating rooms, and personnel are destroyed in both scenarios by being inside the zones of the firestorms. Figure 4 shows the hospitals in the Phoenix, Arizona metropolitan area along with zones of firestorms and outer destruction calculated in the 500-warhead scenario. Six explosions would destroy 37 hospitals, leaving 6 hospitals in a 50-km buffer zone around the area of firestorms with 531 beds to treat the 177,000 injured. A high incidence of severe burns is associated with nuclear explosions, but there would not be any burn beds available to assist the immediate survivors.

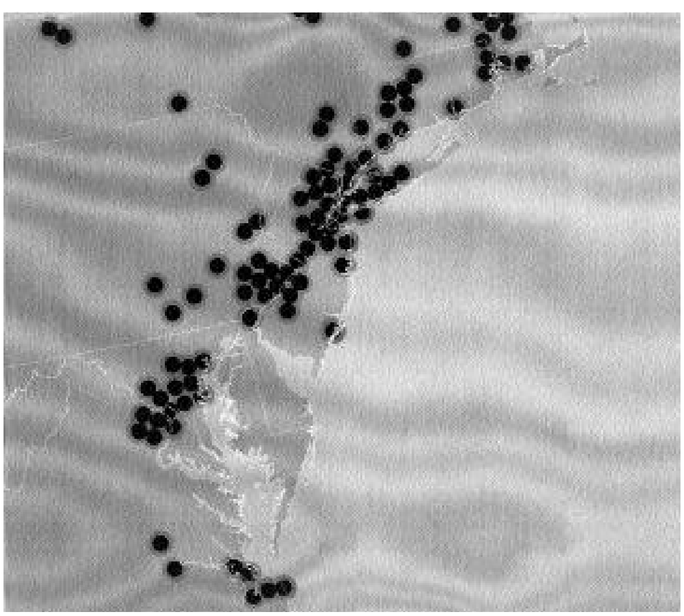

Figure 3: A map of the northeastern United States displaying the population targets for the 500 warhead scenario and the zones of mass fires and blast damage. Mass fire zones are shown in black. Outer zones of blast destruction are shown in dark gray. Figure courtesy Natural Resources Defense Council.

Discussion

Although some progress has been made in reducing the numbers of strategic nuclear weapons since the end of the Cold War, these calculations show that an attack with the remaining nuclear arsenals would still cause death and injury on an unimaginable scale, destroying as well 25-40% of the nation's medical infrastructure. Survivors would have little chance of receiving medical care.

The 2,000 Russian warheads on high alert status pose an immediate and overwhelming threat to the population of the United States. A missile defense capable of successfully intercepting more than 100 attacking warheads—if such a system could be developed—does not protect the American people from these weapons. Only by abolishing nuclear weapons altogether can the danger be eliminated. In the interim, the danger can be reduced substantially and almost immediately by taking Russian and US missiles off high alert status. Construction of an NMD will make it more difficult for this important step to be taken and to significantly reduce the number of nuclear weapons. As has been shown, a force even one fourth the size of the Russian arsenal now on alert can produce upwards of 100 million fatalities, satisfying any conceivable need for a nuclear deterrent.

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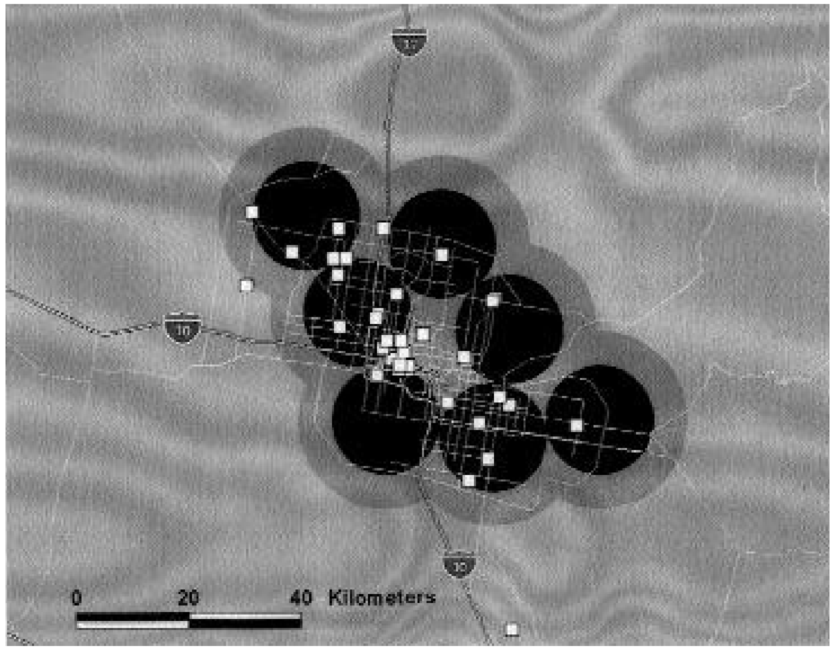

Figure 4: Map of the Phoenix, Arizona metropolitan area with nuclear explosive effects displayed from the 500 warhead scenario. Squares denote hospitals, black areas are mass fire zones and dark gray areas are zones of blast damage. Figure courtesy Natural Resources Defense Council.

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