Nuclear Civil Defence in South Asia: Is It Feasible?

While nuclear arsenals in India and Pakistan keep growing, there has been some suggestion of them seeking to develop civil defence measures to protect their populations from a nuclear war. This paper discusses the practicality of nuclear civil defence in south Asia. It first outlines the nuclear weapons effects from which India and Pakistan must seek to protect their citizens. It then describes briefly how other nuclear weapons states have approached tasks such as protection of their citizens against blast, fire and fall-out, and possible evacuation of populations from cities, as well as alerting and educating the public to nuclear danger. The authors then assess the challenges that India and Pakistan would confront if they seek to implement such measures. Finally, with these constraints in mind, the paper offers simple proposals for civil defence measures that might mitigate in some small way the great damage that would follow from nuclear weapons use in the subcontinent.

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I
Introduction

Nations with nuclear weapons not only threaten others but unavoidably also have to cope with the danger of being targeted by other nuclear weapon states. The threat of nuclear blackmail goes hand in hand with the prospect of nuclear war. In response, apart from preparing for war, governments also attempt to protect their own population against an enemy nuclear strike by seeking to establish civil defence measures. The motives behind these attempts at civil defence have been mixed. There is a genuine desire to save lives – although it is ironic that after first having endangered millions of lives by choosing to go nuclear, governments should then attempt to protect some small fraction of those lives. However, civil defence plans have also been used as a political device to assuage public fears of nuclear dangers by offering the possibility of surviving a nuclear strike.

As the first countries to acquire nuclear arms, the US and the USSR were also the first to pursue nuclear civil defence and invested enormous resources in this effort. The UK and some other European countries also worried about nuclear civil defence throughout the cold war. Each country that has tried to institute civil defence has grappled with questions of the practicality of such steps. While succeeding in finding what they consider to be adequate ways of sheltering a handful of top military, bureaucratic and political leaders against nuclear attack, each country eventually has ended up abandoning the goal of large-scale civilian protection from direct nuclear attack. Summing up some 30 years of nuclear civil defence planning experience, a 1979 US government report noted that "On paper, civil defence looks effective... However, no one thinks that the US has an effective civil defence".[1]

Despite this experience, India and Pakistan have been making sporadic announcements of plans for civil defence since their 1998 nuclear tests. For example, it was reported that "the Delhi government has prepared a blueprint on how to go about things in the event of a nuclear attack on the capital… keeping in mind the measures adopted by certain western countries".[2] Other cities are concerned too. For example, in June 2002, the state government of Karnataka was concerned about possible attacks on Bangalore, home to several military facilities.[3] For its part, Pakistan has announced that its Civil Defence Academy will begin to educate government and private sector officials and the media about coping with nuclear war, and to train school teachers to impart civil defence lessons.[4]

Given the decades of study and experience by other states that led them to accept that there is no feasible means to protect their society from nuclear attack, it may seem obvious that India and Pakistan's efforts are bound to fail, and amount to no more than flogging a dead horse. However, the consequences of nuclear war are so grave that no possibility of saving some lives should be dismissed out of hand. Rather, the feasibility of civil defence in south Asia, as distinct from the west, needs to be determined bearing in mind the very different characteristics of south Asian nuclear arsenals, as well as its geography, society and economy. While many of the people living in densely crowded south Asian cities would be killed by a nuclear explosion, it is possible that casualties may be somewhat reduced with appropriate and effective civil defence measures. In this paper, we seek to carry out this analysis to determine if it is at all possible to mitigate in any way the great damage that would follow from nuclear weapons use in the subcontinent.

We first outline, in Section II, the effects of a typical nuclear attack by India and Pakistan on one another's cities. It is these effects that they must seek to protect their citizens from as part of any civil defence measures they may consider. In Section III, we summarise briefly the civil defence experience of some other countries to determine how they approached the problem of protection against nuclear blast, fires, and radioactive fall-out. In Section IV, we assess the challenges that India and Pakistan would confront if they seek to implement such measures. Finally, with these constraints in mind, we propose a few steps that, if

Figure 1: Blast Pressure as a Function of Distance

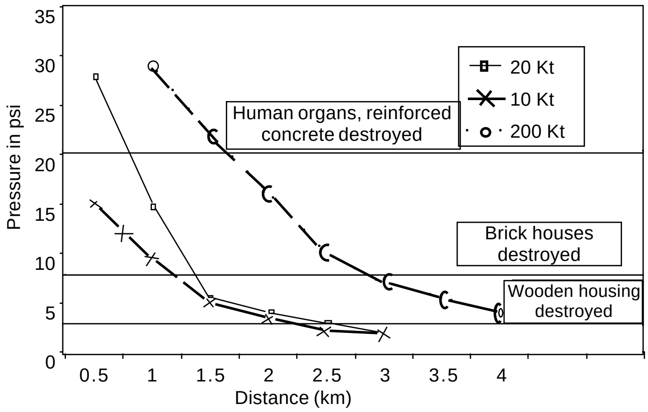
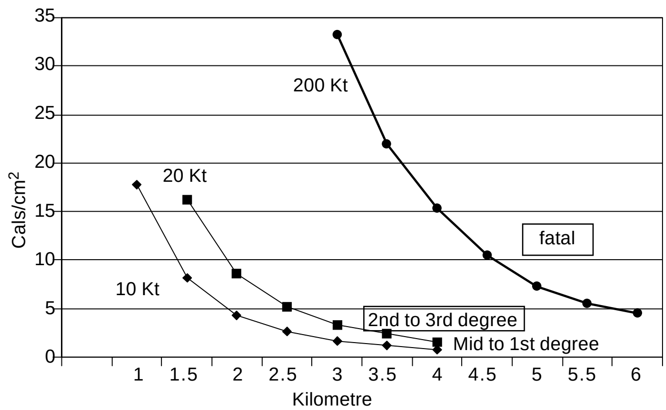


Figure 2: Thermal Energy as a Function of Distance



properly implemented and if circumstances permit, may serve to help save some lives.

II
Nuclear Weapons Damage

Any nuclear civil defence plan must begin by assessing the likely damage against which protection for the public is to be sought. This section is devoted to such an assessment. Although our assessment is based on technical analyses of the physical and biological consequences of a nuclear explosion, we will omit scientific details here in the interests of readability. The only quantitative data that we present will be in simple graphical terms. Some readers may still find the contents of this section too technical. But it is our view that an understanding of the problem at least at this level of technicality is unavoidable and essential for any informed debate and decision-making about civil defence plans.

The loss of human life, injury and suffering as well as damage to property and nature expected from a nuclear attack on a target city, or military targets close to cities, is determined by the number and yield (explosive power, generally measured by the tonnage of its conventional TNT equivalent) of the nuclear weapons that are anticipated to be used.[5] During the cold war, the US and the USSR each had to seriously consider the possibility of being attacked by the other with several thousand nuclear warheads of yield going from hundreds of kilotons to megatons. The major nuclear war damage assessments in both countries assumed such an onslaught, which their civil defence plans had to address.[6] There were similar expectations for states who expected to be on the frontline in the superpower conflict. The *Greater London Area War Risk Study* (*GLAWARS*) commissioned by the city of London in the 1980s looked at the effects of nuclear attacks of up to 90 megatons on the UK, with 10 megatons being used on London.[7]

In south Asia, by contrast, for the foreseeable future the most likely possibility is the use of one or two weapons of much smaller yield being used on a major city. The yield of the weapons developed by India and Pakistan is usually taken to be similar to those used on Hiroshima and Nagasaki, i e, in the 10-20 kiloton range. The current arsenals of the two countries are believed to be many tens of such warheads each. It is possible that in the future India and Pakistan may develop and deploy hydrogen bombs, which can have much larger yields. Official Indian government sources claimed that among the weapons tested in 1998 was a hydrogen bomb with a design yield that was said to be as high as 200 Kt.[8] In our analysis, we will therefore consider cases of a single nuclear weapon of yields 10 Kt, 20 Kt and 200 Kt respectively, dropped on a major metropolis like Delhi, Mumbai, Lahore or Karachi.

The Effects of Nuclear Weapons

The enormous energy released by a nuclear weapon comes out in the following major forms: (1) Blast and shock waves (50 per cent of the total energy released) (2) Thermal radiation (35 per cent) (3) Prompt nuclear radiation (5 per cent) and (4) Residual long-term nuclear radiation or 'fallout' (10 per cent).

Detailed studies of each of these component effects has been available for a long time, from both theoretical derivations and the experience of nuclear tests and the tragic attacks on Hiroshima and Nagasaki.[9] A more recent and extremely valuable resource for applications to south Asia is M V Ramana's work which describes the consequences of a hypothetical nuclear attack on Mumbai, India.[10] For our purposes we only need to adapt results from this literature to cases of our interest. However, we also note here that for thermonuclear weapons of several hundred kiloton yield the damage from mass fires ignited and sustained by the explosion has been often underestimated and is in fact an important effect that can be greater than damage from blast and extend to much larger distances.[11]

As a general rule the physical parameters of the output of a nuclear explosion, such as the amount of heat, pressure and nuclear radiation produced by it, are available relatively accurately. But the consequences of these different hazards on human casualty rates are far less precisely predictable. The nature of the terrain matters as does the cloudiness of the atmosphere, the weather, the time of day, and of course the geography and demography of the city that is attacked, the design and construction of buildings etc. Estimating biological and physical damage from a nuclear attack is made even more of a complex matter by a variety of chance factors that can end up protecting and shielding people even when they are clearly in the danger zone, and in other cases killing them even when they are in safer zones. Instances of both kinds happened in Hiroshima. There is discrepancy between different sources in the literature, and sometimes between different sections in the same source. Empirical evidence of nuclear casualties comes from (fortunately) only the two bombings in Hiroshima and Nagasaki. Nuclear tests do not yield much information on their impact on humans, except those due to radioactive hazards on the inhabitants of the Pacific Islands where large H-bombs were tested.

For purposes of planning civil defence one must use conservative estimates of human survivability. Obviously one cannot

Figure 3: Total Gamma Plus Neutron Radiation

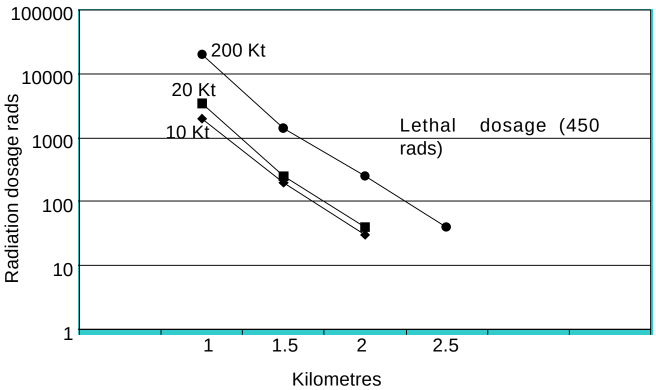
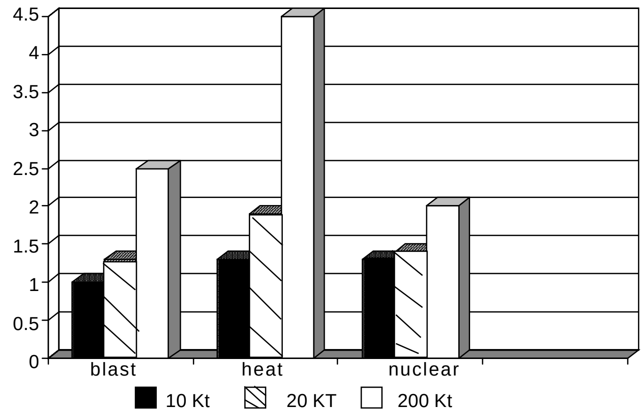


Figure 4: Radii of High Fatality Domains



invoke fortuitous factors that could save lives. Therefore, in the graphs presented here that depict the release of blast, heat and radiation from nuclear explosions of various yields, we mark domains of human and structural damage on the assumption that they are completely unshielded. We assume in our discussion that the ground is level and the air is clear.

Blast and Shock Wave

The blast wave produces enormous pressure on all objects in its path. This lasts for about 10 seconds up to distances of a few kilometres, but can do great damage. It also produces winds of very high speed and strength. The pressure produced (in psi, denoting pounds per square inch; normal atmospheric pressure is 14.7 psi) increases with the tonnage of the weapon and falls off as we go away from the explosion centre (sometimes referred to as "ground zero" or just the "centre"). As a rough rule (assuming that the ground is flat), the distance at which any given blast pressure is produced varies as cube-root of the yield ($W^{1/3}$).[12] We show below a graphical representation of this data for the cases of our interest (weapons of yield 10 Kt, 20 Kt and 200 Kt).

A pressure of 20 psi, sufficient to destroy reinforced concrete buildings, will be accompanied by winds of about 800 km per hour (500 miles per hour). At 5 psi pressures, able to knock down wooden or poorly constructed houses, winds will be of the order of 250 km per hour (150 miles per hour).

In cities like Mumbai or New Delhi, a large fraction of the population lives in slums, housed in huts put together from assorted combinations of tin sheets and mud walls. These will all be completely demolished at a pressure of 2-3 psi or more, which will prevail even at a radius of 2 km from the 10-20 Kt bombs. The 200 Kt weapon will destroy such settlements as far away as 4 km. People in these areas will be unsheltered and exposed to the raw furies of the nuclear explosion and flying debris in the ultra-hurricane winds that will prevail.

Most middle class homes and shops in Indian and Pakistani cities have walls made of brick and cement. Most of these will be destroyed by a pressure of 10 psi. People trapped in those buildings have a serious chance of being killed by falling roofs and debris. The blast wave will also send debris and glass shrapnel flying at high velocities causing grievous injury. Aside from these projectiles hitting them, people themselves will be slammed against buildings. Only reinforced concrete structures (bridges, multi-storey office buildings, etc) will survive up to 20 psi, beyond which they too will begin to be destroyed. At these pressures, any human being out in the open will suffer lung and ear injury.

Given that most of the population is unlikely to be in reinforced concrete buildings, and given the added hazard of injury due to the furious winds, the above considerations indicate that people in a zone where pressures are more than, say, 10 psi are very likely to be killed. Figure 1 tells us that such pressure will prevail up to about 1 km, 1.3 km and 2.5 km for the 10 Kt, 20 Kt and 200 Kt weapons respectively.

Thermal (Heat) Radiation

A nuclear explosion produces, within a fraction of a second, temperatures of tens of millions of degrees in its core, as compared to about 5,000 degrees in conventional chemical explosions. This intense heat is then radiated outwards from the centre. Roughly a third of a nuclear bomb's energy is released in the form of heat. The heat deposited on any exposed surface, as a function of its distance from the centre is given in Figure 2.

The damage done by the heat comes about in two ways. One is the direct impact on people of the electromagnetic radiation (heat and light waves) from the nuclear explosion. These are called 'flash burns'. An unshielded exposure of over 10 calories/cm^2 on a human being will cause third degree burns of sufficient intensity to be fatal. Lesser exposures can lead to second and first degree burns as shown. The other damage is through secondary burns from the fires caused by this heat. In the range where 7-10 calories/cm^2 are deposited, these spontaneous fires started in combustible materials like dry grass, paper and cloth, etc, are likely to coalesce into larger super-fires. These are similar to the firestorms created in the massive conventional bombings of Tokyo and Hamburg during second world war. One can thus set a limit of 10 calories/cm^2 for heat deposition which is likely to be fatal either through direct third degree flash burns or the burns and asphyxiation caused by the firestorm. One sees from Figure 2 that the heat deposition level of 10 calories/cm^2 or more will happen for a 10 Kt, 20 Kt and 200 Kt bombs up to roughly 1.3 km, 1.9 km and 4.5 km distances respectively.

Prompt Nuclear Radiation

When the nuclear fission reaction takes place there is emission of neutrons and the energy released comes partly as gamma rays. The secondary fission products are unstable and emit more gamma and beta rays as they decay. If plutonium is the fissile material used in the weapon, a negligible amount of alpha particles is also emitted. Thus the significant initial nuclear radiation consists of neutrons along with beta and gamma rays. But the betas are not major sources of concern for the bulk of the population not directly at the explosion point, since these rays are rapidly absorbed by the air very near the explosion. Therefore the parts of the nuclear emissions that travel far enough from the explosion centre that matter as hazards are the neutrons and the gamma rays. These two forms of radiation are extremely harmful to the human body, causing a variety of horrible radiation sicknesses which become fatal when the dosage is large enough.[13] A dose of about 450 Rads or more will in all likelihood be fatal for most people in the absence of intensive medical care. Even very much smaller doses can cause long-term illnesses like cancer.

The combined dosage of gamma rays and neutrons received at different distances form the explosion centre are shown in Figure 3. We see that the fatal dosage of 450 Rads or more is received at distances up to 1.2 km, 1.3 km and 2 km for the weapons of 10 Kt, 20 Kt and 200 Kt respectively.

The Inner Zone

Before going on to long-term nuclear fallout, let us collect together from the discussion above the radii of the high fatality regions caused by the immediate effects of the explosion, viz, blast, heat, and prompt radiation. This is done in Figure 4. We see that all the three radii are roughly of the same order, from about 1-2 km for the 10-20 Kt yield and about 2-4.5 km for the 200 Kt yield. The heat and fire hazards reach out a little further in each case. We see that for the 200 Kt case the heat fatality radius has become nearly three times as large as the blast and radiation zone radii.

Since these hazards are fatal up to roughly the same distance for a given weapon tonnage, people likely to be fatally injured by the blast wave are likely also to be badly burnt. They will also receive a fatal dose of radiation, but they would have died before it can act. Some people sheltered from the thermal radiation and who survived the blast and fire later succumbed to the radiation dose. This is what the analysis of the deaths at Hiroshima and Nagasaki shows.

Keeping all this in mind let us define, for the purpose of our civil defence discussion, an "inner zone" for a nuclear explosion of given tonnage, within which any unshielded person will be killed, unless saved by fortuitous circumstances. For the 10-20 Kt weapons – the typical strength of current weapons on the sub-continent – we will take this zone to have a radius of 1.5 km. For the 200 Kt weapon we will take the inner zone radius to be 3.5 km.

In defining such an inner zone, we do not mean to imply either that everyone outside will survive or that everyone inside that zone will necessarily perish. As we cautioned earlier, the effect that a nuclear explosion will have on any individual person is a very complex issue that cannot be captured by just a few parameters like the heat, pressure or radiation dosage expected at his/her location.

A large number of unpredictable factors will govern the survivability of any given person in the neighbourhood. Thus, in Hiroshima which was attacked by a 12 Kt weapon almost everyone died within 0.5 km of the blast centre. But 17 per cent survived in the 0.5-1.0 km range and nearly half the people survived in the 1.0-1.5 km range, both of which lie inside our inner zone.[14] Since the scientific prediction of the heat, pressure and nuclear radiation at those distances, shown in our Figures 1-3 is unlikely to be wrong, the only explanation is that the survivors were shielded from direct exposure to those hazards by fortuitous circumstances. They could have been standing on the other side of a wall or some other structure that shielded them from the direct impact of the heat waves. Or they may have been outside in an open field or digging a trench, in which case the blast will have hurt them less. Conversely, the Hiroshima data also shows that 21.9 per cent of the people in the 1.5-2 km range died, although individually, the effect of the heat or the blast or the initial radiation, while causing them grave injury, should not have killed them. But having to cope with a combination of all three hazards can be fatal even if they are not so individually. It is also important to remember that all people are not equally affected by blast, heat and radiation. The old, the young, the infirm, and the chronically undernourished may all be less resilient.

Despite these many uncertainties in predicting fatality probabilities in different regions, it is nevertheless useful to estimate the size of the fatality zone. It gives civil defence planners some idea of the magnitude of the likely calamity, its area of impact and the approximate number of people likely to be killed. This is what our definition of an inner zone is intended to provide.

Radioactive Fallout

When a nuclear weapon explodes near or on the ground it vaporises much of the earth and other material around the point of explosion. All this vaporised debris rises up in the mushroom cloud and will fuse into particles of various sizes, from 100 microns (the size of very fine sand) to marble–sized chunks. The fused particles will be a mixture of soil, water and whatever material was at the bombsite along with the remnants of the bomb itself. The latter will be composed of radioactive material, such as the un-fissioned part of the fuel, uranium or plutonium, along with the fission products of the nuclear reaction as well as some amount of unstable isotopes generated by the reaction of the neutrons on the debris material.

It is the unstable nuclei in the fused radioactive dust that will decay by beta and gamma rays and is the source of nuclear weapon fallout (the emitted alpha rays are not a concern, unless inhaled and sometimes if ingested). Unlike the primary nuclear radiation which, although very intense, is created only during the explosion lasting only a fraction of a second, the radioactive debris in the mushroom cloud will last for a very long time, slowly emitting its deadly cocktail of radiation. This debris is contained in the mushroom cloud, which even for a 10-20 Kt burst will hover with its bottom at about 3.5 km and its top at about 6 km. From these heights, this debris will slowly sink back to earth, within a day. But during this period, if there are any prevailing winds they will carry the falling debris far away from the blast centre. There will also be some spread in other directions as well due to normal diffusion and wind shear. Thus there will be some spread near the centre even in the upwind direction. The result will be a roughly elliptical or cigar-shaped area of ground on which the radioactive debris will settle.

To give a more quantitative estimate of the fallout radiation and its pattern, recall that the radiation comes from unstable nuclei that decay.Different nuclei in the debris will decay at different rates, but as the decays progress, the amount of parent nuclei available for further radioactivity will decrease and so will the radioactivity. The net radioactivity from this mixed source is empirically found to decrease with time by the factor $(t)^{-1.2}$ with t in hours.

The fallout can extend to great distances for reasonably fast winds. For a 20 Kt fission explosion with prevailing winds of 15 mph (about 24 kilometres per hour), the cigar-shaped contour within which the radioactive dose is 100 Rad/hour or greater, will have a length of about 55 km (34 miles or so) and a width of 3.7 km (2.3 miles).[15] The fallout would reach these distances in just over two hours, and the dose will decrease with distance from the explosion. People within this region, if they are not sheltered at all, will receive a total cumulative dose over two weeks of almost 300 Rads. This is more than sufficient to cause the onset of radiation sickness and in some cases death. Within this distance (and beyond) people who happen to be within the cigar-shaped fallout zone will have to find and stay in a shelter able to shield them from this radioactivity, which will be carried by the air, for long enough for the outside radioactivity to have dwindled down.

If the explosion were sufficiently high above the ground, then the amount of debris stirred up by the explosion will be minimal and there will not be much fallout. The height of the explosion above which there will be no appreciable fallout is given by the formula $H = 180\ W^{0.4}$ feet.[16] For a 15 kiloton weapon this maximum height for fallout is about 540 feet (165 m). In both Hiroshima and Nagasaki, the explosions occurred above this height and the effects of fallout were much less than the other immediate hazards. But of course no civil defence plan can assume that the attack will be a high airburst and so measures to counter the worst possible fallout contamination, corresponding to a ground burst, will have to be taken.

Finally, it must be mentioned that if there were to be rain within a few hours of the explosion, it will tend to carry some of the radioactive material down with it (what was called 'black rain' in the case of Hiroshima – the blackness is primarily because of mixing with the soot produced by the firestorm). Such rain is likely when the humidity is higher, as is often the case with coastal cities, and could even be a source of radioactive fallout even if the explosion is at a height such that fallout would otherwise not be expected. If there is rain, the fallout will not travel as far as on a rainless day, but people living in the rain covered region will have larger radiation doses.

III
The Experience of Past Nuclear Civil Defence Measures

There have been many efforts to think through and in a few cases to try to implement nuclear civil defence measures over the past 40 years. The most well known cases are those of the US and UK, both because of their more open societies and the role of anti-nuclear movements in these countries in challenging such civil defence plans.[17] There is less detailed information available about the efforts of the former USSR, and yet less about other nuclear weapons states. Most western European countries, as members of NATO, had some kind of limited civil defence plans, while Sweden and Switzerland (both non-nuclear weapons states that expected to remain neutral) had more elaborate civil defence plans.[18]

There are two broad parts of civil defence plans. One deals with the protection or relief of the population in case of attack and the other in preparing the public for a possible attack. The former includes three basic measures: shelters against blast and fallout, evacuation or relocation of the population, and provision of emergency relief after an attack. The latter, and in some ways more challenging, part of civil defence plans involves the effective communication to the public of warnings of attack, and educating the public in how to understand and respond to a possible attack.

Blast and Fallout Shelters

The US and the Soviet Union took different approaches to the role of blast and fallout shelters in civil defence. The US build special bunkers for its political and military leaders but did not pursue seriously a programme of building blast shelters for the public, while the Soviet Union sought to provide blast shelters for both its leadership and up to a quarter of its workforce in key industries.[19] But it is clear even the Soviet Union did not seek to protect more than a fraction of its total population. At the same time, it is unclear how reliable the shelters that were built would, in fact, have been.

Sweden's civil defence plans involved extensive blast shelters for the public; the goal in the 1980s was to shelter five million of Sweden's over eight million people and eventually to offer shelter to the whole population, both at work and at home.[20] To meet the cost of this programme, the government offered subsidies of several hundred dollars per person sheltered. This was intended however not to pay for building the shelter but only to meet the cost of converting existing buildings (in schools and health clinics, etc) such that they could serve as shelters if required. The shelters were supposed to offer protection against blast pressures of up to about seven psi (i e at quite some distance from the explosion).

Switzerland had a similar and even more expensive blast shelter system as part of its civil defence plans. The average government contribution to building shelters per person in the 1980s was almost a thousand dollars.[21] These plans sought to take advantage of the many Swiss buildings with reinforced concrete basements. The shelters were meant to be occupied for long periods of time, reflecting the understanding that the population needed to be protected from the radioactive fallout resulting from a nuclear war involving the superpowers fought in Europe.

Most nuclear civil defence plans have focused on fallout shelters rather than blast, since fallout is likely to travel much further from the explosion and endanger far more people. Fallout shelters are meant to protect the population that escaped or survived the effects of the initial explosion from radiation. They require the population to remain inside for up to two weeks or longer to allow time for the radiation to decline; in the 1980s, the US Defence Department civil defence plans assumed that people would need to remain in such shelters for 30 days.[22] It was not clear however how to provide adequate ventilation, water, food, sanitary facilities, etc, to enable people to live in these shelters for so long.

In the early 1960s, the US began a shelter identification programme, during which the government marked (with yellow and black radiation signs) more than a quarter of a million basements, corridors and caves that were supposed to offer protection from nuclear fallout. Some were stocked with water, food and medical equipment, but many lacked adequate ventilation for the large numbers of people who were supposed to take shelter there. The food eventually began to spoil and by the 1970s some of what was left was given away as relief supplies to third world countries, effectively ending the programme.[23] Only the signs on some of the buildings seem to remain.

Recognising that people did not often live close by to where the buildings that had been marked as shelters might be, the US and UK also distributed information on how individual families might make fallout shelters at home. The *Protect and Survive* publication published by the British government contained plans for building an outdoor-do-it-yourself shelter that involved digging a hole in the ground, putting a tent on top of it, and piling dirt on the tent.[24] Other such manuals had more detailed instructions, including how to make, at home, a shelter-ventilating pump from 22 feet of wood, 12 square feet of plastic sheets and pressure sensitive water-proof tape, and there were even designs for a home-made radiation meter.[25] Similarly, Soviet plans suggested using a bicycle connected to a fan to ventilate shelters.[26] It was such self-help measures that in part made nuclear civil defence plans open to ridicule.

Evacuation

Evacuation involves moving people in high-risk areas to low-risk areas before or after a nuclear explosion. In the early years of the cold war, before the advent of long range ballistic missiles, both the US and Soviet Union planned to take advantage of the large, sparsely populated areas of these countries by evacuating civilians from their large cities in the event of a nuclear crisis.

The US had plans where 145 million Americans in high-risk areas would be evacuated using private vehicles to rural areas and be lodged in schools, churches, etc. People were expected to bring their own supplies of food with them as part of the evacuation and to build fallout shelters for themselves in the areas to which they were moved. Under the most optimistic assumptions, this plan was anticipated to take many days to execute. The US national highways were part of making this plan more feasible.

Regardless of whether evacuation preceded or followed an attack, such plans were widely seen as profoundly unrealistic by many. US government studies admitted for example that "evacuation from the densely populated Boston-to-Washington and Sacramento-to. San Diego corridors, with their tens of millions of people and limited relocation areas, may prove impossible."[27] It was hard to imagine or plan in detail for the chaos of such mass movements of people in strained circumstances, or to mobilise the policing resources to make evacuation manageable, to say nothing of what would be involved in feeding and caring for very large numbers of people perhaps indefinitely displaced to remote areas with very limited infrastructure. Recognising these problems, many local and state governments in the US refused to prepare evacuation plans. In 1985, the US Federal Emergency Management Agency, which was mandated to prepare for and carry out the evacuations, abandoned its plans for what it called 'crisis relocation'.[28] Soviet evacuation plans were similarly massive, involving moving out perhaps 100 million people or more from cities believed to be at risk of nuclear attack. But there were questions about the viability of such plans also. It was estimated that there were only about 10 million vehicles in the country and a poor road network, while the railway lines clearly would not be able to cope with the demands of such traffic. It was perhaps no surprise that there were reports of "widespread apathy or outright mockery" among Soviet citizens of such civil defence ambitions.[29]

Other countries seem to have had little if any sustained faith in the feasibility of mass evacuation. UK made plans in the 1950s to evacuate 45 per cent of its densely populated areas, which after several years of debate became reduced to an option to relocate just women and children from major cities. This too eventually gave way by the early 1970s, as British government civil defence plans urged people to 'stay at home' because the government would "not help you with accommodation or food or other essentials".[30] Sweden also made detailed plans for evacuating its cities in the 1950s and 1960s, but over time moved towards reliance on a system of shelters and more limited evacuation. Switzerland did not consider evacuation at all, choosing to rely instead on its shelter programme.

Warnings

Regardless of whether civil defence planning relies on a system of shelters or on mass evacuation, the population will need timely warning that they are in danger and that the government is implementing its civil defence measures. There are two kinds of warning which are possible: short-term warning, measured in minutes, that a nuclear attack is on its way, and longer term warning, of hours or days, to the effect that an attack may be possible or imminent.

The nature of the warning will limit what measures are practical. Prior to the development of intercontinental ballistic missiles, the US and Soviet Union assumed that there could be many hours of warning of an attack under way. With missiles however, this warning time was reduced to less than the 30-minute flight of a missile from one country to the other. For nuclear missiles fired from submarines, which could approach close to the coast, the warning times were further reduced. In these latter cases, there was no prospect of starting and completing an evacuation. It was only in case of a growing sense of crisis, and a judgment that it may worsen to the use of nuclear weapons within a few days, that evacuation plans had any significance. There is course always the risk of misinterpreting a crisis situation and the danger of ambiguous or false warnings. In some cases, warnings may actually make the crisis worse and create public panic.

In the US, during the cold war, there was a national warning system that was supposed to be able to transmit warnings to over 1,200 federal, state and local warning points, that are meant to operate 24 hours a day. The local warning points were to use sirens and other means to alert the public. It was estimated that about only half the US population would be in areas where such warnings could be received within 15 minutes of a national alert.[31] The public response among those who heard such sirens was by no means reliable: sirens that went off in 1955 in Oakland, California, were apparently identified as an attack warning but were nonetheless ignored (rightly) by 80 per cent of the residents.[32]

Britain had a fairly extensive warning system to warn the public about an incoming nuclear attack and about fallout patterns after the explosion. The warning would be transmitted to major police stations that would sound sirens. 8,000 sirens were to be used meant to warn the public to take cover; although, again, the public response was far from certain – it is reported that the response of most people in Coventry to a 1984 early morning siren was to turn over and go back to sleep.[33]

Along with communicating the warning, the UK Warning and Monitoring Organisation had the added responsibility of managing a network of 870 stations to take readings of radioactivity after an attack, and predict fallout patterns.[34] However, it was not clear how the communication and monitoring system would itself withstand the effects of nuclear war.

Public Education

Civil defence inherently relies on popular participation and support. If people do not know or trust the warning signals or government plans concerning shelters and evacuation, or are unaware of how to protect themselves from fallout the whole plan is pointless. It may even be counter-productive. The education of the public about of the effects of nuclear weapons and the nature of fallout have been part of nuclear civil defence plans, but have met with limited success as the examples outlined above suggest. The most famous civil defence education effort may well be Britain's 1980 brochure, 'Protect and Survive'. The brochure noted that "If the country were ever faced with an immediate threat of nuclear war, a copy of this booklet would be distributed to every household as part of a public information campaign which would include announcements on television and radio and in the press".[35] It's goal was to tell people "how to make your home and family as safe as possible under nuclear attack" by informing them of the steps to take to protect themselves from the blast and fallout of a nuclear explosion.

After a fairly cursory description of the effects of nuclear weapons, the brochure contained instructions on what to do on hearing an attack warning siren, an all-clear siren or a fallout warning siren. A checklist was provided with each brochure such that families could know whether they had the necessary ingredients for a survival kit, including foodstuffs ("which can be eaten cold, which keep fresh, and which are tinned or well wrapped") and water for drinking and washing for 14 days, along with a portable radio and spare batteries, and utensils.[36] The family with its survival kit were to take shelter in the fallout room that the brochure gave instructions on how to construct. The 'Protect and Survive' report was met with derision. It served only to fuel a massive anti-nuclear movement in Britain that called for unilateral nuclear disarmament, arguing that the more certain defence against nuclear attack was for Britain not to have nuclear weapons of its own.[37]

A final judgment may be had from the experience of the US. Despite the bitterness of the cold war and many severe crises between the US and USSR, and the certainty that nuclear weapons would be used in any major conflict between them, a report for the US Congress concluded that "Faced with technological change, moral and philosophical questions about the desirability of civil defence, and budgetary constraints, Federal plans have been marked by vacillation, shifts in direction, and endless reorganisation."[38] It seems neither people nor government seriously believed that any real protection against nuclear attack was possible.

IV
Feasibility of Civil Defence in South Asia

For a number of reasons, efforts at civil defence in India and Pakistan will likely be much more difficult to prepare and implement than was the case in the US, Soviet Union, the UK (that all have nuclear arms) and non-nuclear countries such as Sweden and Switzerland that expected to be caught in the crossfire of a nuclear war involving other states. There is little detail available about civil defence plans in India or Pakistan in case of nuclear war. What little there is consists of well meant but mild generalities more appropriate to a conventional bomb attack. There is for instance a list of "Do's and Don'ts" prepared by the Civil Defence Directorate in Bangalore.[39] Among other things, for people in the open, it advises:

(a) Lie flat into a fold in the ground, if available, or flat on the ground face down; (b) plug ears with cotton or cloth; (c) keep a rolled-up handkerchief or cloth between your teeth (which can be damaged in the impact); (d) avoid running for cover if there is no time. For those near a building it suggests: (e) run to nearest shelter if time permits, otherwise act as if in the open; (f) avoid leaning directly against a wall. And for those inside buildings: (i) stay near an inside wall, not outside wall; (j) never stand in the direct line of a door or window.

Rather than engage with this level of planning, we look at the basic elements of nuclear civil defence we have earlier described in other states and see whether any of them could be feasible in south Asia. We do not examine the costs of such possible civil defence measures, but leave that to others.

Blast and Fallout Shelters

India has responded to the threat of nuclear war with plans for shelters for senior officials. It is reported that India's Nuclear Command Authority has decided to build two bunkers to protect the union cabinet in the event of a nuclear strike.[40] Similar plans in Pakistan are not known of, but may be likely.

There are a set of challenges unique to south Asia to overcome in any nuclear shelter programme for the public. It seems there are no current plans for the widespread provision of blast or fallout shelters in many other major Indian or Pakistani cities at this point.[41] Maharashtra's home secretary is reported to have said that this would be "too expensive a proposition for a city the size of Mumbai."[42] However, it is claimed that underground shops, parking lots, and warehouses in the city could be converted into shelters in case of an attack.[43] As part of Delhi's nuclear civil defence plans for the public, it is reported that "the Delhi government has issued instructions to the Delhi Metro Rail Corporation that the underground tunnel being constructed in the city be damage proof against any possible attack".[44] But Mumbai, Lahore, Chennai and Karachi have no subways as of now. The Delhi subway, which is quite limited in extent, has already cost $ 2.25 billion and it may be a long time before there are funds to build similar systems in other cities, let alone to have a dedicated underground shelter building programme.[45]

In the US and some other countries, the basements of many large and small buildings could have served a secondary function as shelters. Considering that most buildings in India and Pakistan are not built with basements, this is not a major option. More significant still is that a substantial proportion of the south Asian urban population lives in slums, which tend to be far away from the reinforced concrete and brick private and public buildings where people could find some kind of shelter.[46] The slums themselves offer no significant shelter: it is estimated that of the homes there 70 per cent are made of cement or brick, 10 per cent are made of mud, wood and thatch, while 20 per cent are somewhere between the two.[47]

There is also, of course, an acute shortage of urban housing, leaving many with no shelter at all. Were shelters to be built in places accessible to the poor, it is likely people would move into them as their primary source of shelter. What would then happen in a nuclear crisis? Would the government lock and defend empty shelters from homeless people – only to let them in if there is a nuclear attack?

To be useful, a fallout shelter must be prepared to sustain people for perhaps two weeks or more. If the bare necessities of life were not available in them, suffocation, lack of water and starvation would eventually kill the sheltered people anyway. The best way to have uncontaminated food and water available in a fallout shelter during a crisis would be to have it stored there in advance. It is hard to see how, given large-scale hunger and poverty in both India and Pakistan, the government or individual poorer citizens can create and maintain such stocks. Obviously the millions of poor urban residents of India and Pakistan who live on daily wages that can barely sustain their basic needs cannot afford to stock up on non-perishable food and water for safe-keeping in a shelter.

Evacuation – When, How and to Where?

If evacuation is to be a option, the government must decide when to begin an evacuation. If there is only a build-up of tensions between countries before a nuclear attack, should the government call for the evacuation of a city it believes may be in danger? Or should it wait until there is evidence of an imminent attack?

Interpreting and managing the course of military crises is no easy matter and there is evidence to suggest that India and Pakistan have done badly at this. It is well known that both the 1965 and 1971 India-Pakistan wars involved significant misapprehensions by Pakistan on the likely course of events. Recent studies have found severe misperceptions on the part of both India and Pakistan during the 1986-87 Brasstacks crisis.[48] A follow-up investigation found a similar set of "misperceptions of the adversary's actions, and misjudgments of his perceptions" was at work again in the nuclear crisis involving the two states in 1990.[49]

Even when there is warning, things seem to go badly. There is some experience with natural disasters that suggests governments in India and Pakistan squander warning times before impending disasters and are poorly prepared. Every year, cyclones affect some of the coastal Indian states such as Orissa, Gujarat and Andhra Pradesh. The death toll from the 1999 Orissa 'super-cyclone' was unofficially estimated to be around 20,000.[50] It has been noted that "The meteorological department had predicted the cyclone four days before it hit coastal Orissa. But when the storm actually hit the people, the state government had just 21 concrete storm shelters to protect the people".[51] Pakistan's government does little better at dealing with the floods that regularly afflict that country.

Evacuation to be practical would have to be highly coordinated and require significant and well-functioning infrastructure. A nuclear attack is certain to create mass panic and damage the transportation infrastructure (train stations, tracks, roads, buses, airports, petrol stations, etc) in the city that is attacked. The problem is compounded by the low availability of transport in India and Pakistan. The Delhi Transportation Corporation, for example, has only 2,400 buses running every day for 13 million people[52] Even if all buses were intact after a nuclear explosion, there would not be enough for the millions that would need to be evacuated quickly. These problems would be exacerbated by devastated roads making portions of the city unreachable, people who would not be willing to leave their homes, and the chaos.

Where would people they be evacuated to? Rural areas in India and Pakistan are much poorer than urban areas, have much less infrastructure (housing and other kinds of shelter, water, electricity, health services). They would not be able to sustain the massive influx of people from the cities.

Warnings

The warning times to activate civil defence measures in India and Pakistan may be very short. India and Pakistan have aircrafts or/and ballistic missiles that could be used to deliver nuclear weapons. Ballistic missiles may take as a little as five minutes to travel the 600 km that separates possible launch points close the border from major cities in the other country. The time increases to about 13 minutes for a 2,000 km range flight that would take a missile from Pakistan deep into India or from a base deep in India to a city in Pakistan.[53]

India and Pakistan seem to have recognised from their previous wars that some kind of public warning system is necessary to activate any civil defence plan, no matter how limited and feeble it might be. Many Indian and Pakistani cities have air raid sirens and in some cases warning plans exist for nuclear attack. In Bangalore, for instance, the plans are that: "The moment a raid begins, the 15 sirens located in Bangalore will go off for a good two minutes: Warbling notes or intermittent blasts on sirens or hooters will denote the air raid warning while two minutes of continuous hooting will signal all clear".[54]

It is worth noting that these 15 sirens are meant to service a city with an area of over 482 square kilometres and a population of about six million.[55]

But even the limited the civil defence communication system that exists is archaic in places and may not be able to even receive or communicate instructions to activate a public warning system. For instance, in the Indian city of Amritsar, close to the border with Pakistan: "The civil defence wing, responsible for the protection of civil installations and assistance to civilians in case of exigency, has only one telephone connection in its office".[56]

The sirens that exist are in a poor shape and some have not been used in almost three decades.[57] Again, in Amritsar: "The reliability of the outdated hand-operated sirens, which the [civil defence] wing claims to have distributed to 78 of its employees, is also questionable. The wing has only one point-to-point connection with the Air Force office which sends the warning message so that sirens could be sounded to alert the population".[58]

There is also problem that even if the siren system works it will be ignored. During an air raid siren test in Pune, several people mistook the air raid siren as "the normal siren which anyway is blown every day," and many others did not hear it at all.[59]

During a siren test in Delhi: "While the civil defence control centre claimed it sounded sirens from 75 different places simultaneously, at 10 a m over a period of 10 minutes, most people this paper contacted seemed not to have taken the exercise seriously." [60]

Public Education

To be feasible, whatever warnings and plans exist must depend on public awareness concerning the effects of nuclear weapons: if people are not aware of these dangers, they may not be willing to go along with whatever civil defence measures are put in place. It is hard to imagine that desperately poor slum dwellers will be willing to abandon their meagre home and few possessions to seek shelter in a building or accept orders for evacuation unless they appreciate just how grave and enduring is the danger they would be in because of a nuclear attack.

In India and Pakistan, most people lack even basic information about nuclear dangers. In India, a November 1999 post-election national opinion poll survey found just over half of the population had not even heard of the May 1998 nuclear tests.[61] In the 2002 crisis, the BBC reported the level of awareness of the nuclear risk among the Pakistani public was "abysmally low".[62] In India, the BBC found that "for many, the terror of a nuclear conflict is hard to imagine."[63]

Countries such as the US, Soviet Union, UK, Sweden and Switzerland have populations that are fully literate and with almost universal access to modern electronic media such as television and radio. This makes it relatively easy to disseminate information on nuclear civil defence plans – although, as noted earlier, such plans were not taken seriously. In marked contrast, a significant portion of the population in India and Pakistan is unable to read publications about emergency measures to take before or after an attack or take instruction from television or radio.

In summary, our discussion shows that none of the major nuclear civil defence measures considered and partly put into operation in Europe, the US and Soviet Union, such as citywide evacuation or the provision of nuclear blast-proof or fallout shelters are feasible in south Asia. Warning and communication systems such as sirens would have to be greatly improved beyond what is being contemplated in the few tentative announcements we have heard of so far in the subcontinent. But even if such limited nuclear attack warning measures were to be put in place, it is hard to imagine that the public in Pakistani and Indian cities would respond as civil defence planners might wish.

V
Conclusions

Having acquired nuclear weapons, governments in India and Pakistan have started to consider civil defence plans, notwithstanding that other nuclear weapons states have given up on them. We have examined the spectrum of possible civil defence measures to see if any of them could be feasible given the circumstances of the subcontinent. We have looked at the effects of typical nuclear weapons believed to be in the arsenals of India and Pakistan, if used against a city. We showed that there is a combination of blast, thermal and prompt nuclear radiation that creates an inner zone around the nuclear explosion, out to distances of 1.5 km for a 10-20 Kt weapon, and about 3.5 km for a 200Kt weapon. Our analysis shows that for people unfortunate enough to be within this inner circle and exposed to the full impact of the explosion, there is no defence.

The sort of civil defence measures that could possibly have saved them, such as nuclear bomb proof shelters and evacuation are simply not feasible in south Asia. Taking shelter in existing homes and commercial building will not help as they probably will be destroyed. Some people could survive in this inner region but only through some fortuitous protection. Such protection cannot be planned for.

Any civil defence plan can aim at best only at saving some lives outside this region. At these larger distances from the explosion, the direct weapon effects and the secondary dangers of building collapse and fires inside buildings are reduced. Seeking shelter in existing buildings may mitigate some injuries from blast and fire, and may offer some protection against radioactive fallout (the prompt nuclear radiation coming directly from the explosion decreases rapidly with distance and will not be a factor outside the inner zone). This requires no large-scale construction of nuclear shelters.

But even in the regions outside the inner zone the strategy of seeking shelter has limited value. It must be remembered that one cannot know in advance where or when the bomb will fall, or the pattern of prevailing winds and rainfall that will determine the region affected by radioactive fallout – which can extend up to many tens of kilometres. This means that one cannot know the locations where taking shelter will help. One can only make generic, citywide, recommendations for civil defence measures that could mitigate some of the worst effects. Some measures can be ruled out. The lack of adequate transportation infrastructure and places to go to means that the people in the cities cannot be evacuated. It is also not feasible to have people stay indoors for two weeks after a nuclear attack to protect against fallout, for lack of basic needs such as food and water.

Nevertheless, our analysis suggests that there may be possible benefits from the following measures:

(1) Each city having a reliable, recognisable warning system that can alert the population.

(2) People promptly seeking shelter in a nearby building upon receiving the warning.

(3) Each city having emergency radio stations scattered around the city to instruct people who have taken shelter.

(4) These broadcast stations being designed to survive a nuclear attack and to serve as radiation monitoring centers.

(5) Stockpiling emergency medical supplies at schools throughout the city.

A few cities in south Asia have sought to pursue some of these measures, such as installing warning sirens. But these existing efforts, as we have seen, are totally inadequate; sirens are neither widely recognised nor marshal any public response. This suggests there is a basic lack of appreciation on the part of governments and public of the magnitude of the consequences of a nuclear attack. Nuclear civil defence requires unprecedented official competence and public discipline in extremely adverse circumstances. This in turn calls for a shared knowledge of the detailed, local consequences of nuclear attacks among government officials, civil society organisations, and the public in all major cities and surrounding areas. Such awareness can only come about through open public discussion of the hazards of nuclear war.

To make any civil defence possible, governments at the centre and in each major city must engage directly with their people about what would happen in case of a nuclear attack. Until now official discussion of the nuclear issue in south Asia has rarely moved beyond military and diplomatic strategies. This must change. It is time to face the awful reality of what the bomb can do. This will mean confronting the consequences of nuclear war, in all its horror. This must involve all those who would be responsible for civil defence in each city, e g, local officials responsible for infrastructure, transportation, healthcare, law enforcement, and education, as well as NGO groups. There are many studies by independent scientists around the world of the destruction by hypothetical nuclear attacks on specific cities that can be used as a guideline to inform such efforts – in the case of the south Asia, the pre-eminent example is the study *Bombing Mumbai*.[64]

There is no doubt that these measures will not come to the rescue of many people. But there may be some fortunate ones for whom such measures may make the difference between life and death. Even for such survivors, however, there may be little solace. They may well recall Soviet premier Nikita Khrushchev's famous observation that after a nuclear war "the living will envy the dead." But this is the best that civil defence can do.

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Notes

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