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Reducing the Consequences of a Nuclear Detonation.

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ABSTRACT

The 2002 National Strategy to Combat Weapons of Mass Destruction states that *"the United States must be prepared to respond to the use of WMD against our citizens, our military forces, and those of friends and allies."* Scenario #1 of the 15 Department of Homeland Security national planning scenarios is an improvised nuclear detonation in the national capitol region. An effective response involves managing large-scale incident response, mass casualty, mass evacuation, and mass decontamination issues. Preparedness planning activities based on this scenario provided difficult challenges in time critical decision making and managing a large number of casualties within the hazard area. Perhaps even more challenging is the need to coordinate a large scale response across multiple jurisdictions and effectively responding with limited infrastructure and resources.

Federal response planning continues to make improvements in coordination and recommending protective actions, but much work remains. The most critical life-saving activity depends on actions taken in the first few minutes and hours of an event. The most effective way to reduce the enormous national and international social and economic disruptions from a domestic nuclear explosion is through planning and rapid action, from the individual to the federal response. Anticipating response resources for survivors based on predicted types and distributions of injuries needs to be addressed.

INTRODUCTION

The Cold War specter of strategic thermonuclear war and mutually assured destruction, with the possibility of hundreds of nuclear strikes on our major cities and the majority of the United State covered with lethal fallout is thankfully greatly diminished. However the possibility of nuclear terrorism still exists through the use of a relatively crude, low yield nuclear device in a modern city. The United States government has made impressive investments to prevent this through non-proliferation activities overseas and by improving our ability to detect such a device as it moves across or within our borders. Even so, as stated in the 2002 National Strategy to Combat Weapons of Mass Destruction; *the United States must be prepared to respond to the use of WMD against our citizens, our military forces, and those of friends and allies. We will develop and maintain the capability to reduce to the extent possible the potentially horrific consequences of WMD attacks at home and abroad."*

If a nuclear detonation were to occur in a modern US city, the greatest reduction of casualties is achieved through actions taken by citizens themselves and their state and local officials. The most critical decisions are those made in the first few minutes. Unfortunately the "potentially horrific consequences" of a domestic nuclear explosion are exactly the reason that preparing for it seems impossible. Many consider such an event to be so catastrophic that local response planning may be useless. There is a misguided impression that there would be no responders left after the detonation or that the initial response would be a federal government responsibility. Without planning, this might be a self fulfilling prophecy with hundreds of thousands of additional potential casualties as a result. By the nature of their work, response organizations are distributed throughout a community and the vast majority of the response base would survive. However, without a basic level of large-scale emergency planning, these response organizations will not know how to apply their skills safely and effectively. Although considerable federal capabilities exist, it is unlikely that comprehensive assets would arrive in the first day and may be further delayed by national actions to prevent or mitigate further attacks.

NUCLEAR DETONATION EFFECTS

The basic anatomy of a nuclear explosion is well known and documented in literature such as Glasstone's *The Effects of Nuclear Weapons*[1] and NATO documents[2]. Mitigating the impact of a domestic nuclear explosion requires a basic understanding of key effects. These effects can be broken into two main components: prompt and delayed. As an example, the effects identified below are approximate for a 10 kiloton (kt) nuclear explosion in a large city like Washington, DC. This is consistent with the national planning scenario #1 and with early nuclear weapons such as those used on Hiroshima and Nagasaki.

Primary among prompt effects is blast. A 10kt explosion is equivalent to 5,000 truck bombs like the one used to destroy the Murrah building in the 1995 Oklahoma City bombing[3]. Blast will damage or destroy most buildings within ½ mile of the detonation location and it is unlikely that the population in this area would survive. From a ½ mile to about a mile out, survival will mostly likely depend on the type of structure a person was in when the blast occurred. Even at a mile, the blast wave will have enough energy to overturn some cars and severely damage some light structures.

A mile from the detonation is also the approximate distance that a person outdoors could get a significant exposure of initial ionizing radiation. The closer to the detonation point, the higher the exposure. The same is also true for an outdoor individual's exposure to the thermal pulse from the detonation, which may also cause burns to exposed skin out to this range and possibly further on a day with good visibility. Both of these effects are reduced for people inside buildings.

In addition to ionizing and thermal radiation, the detonation creates a brilliant flash of light that can cause temporary blindness to those outdoors over 5 miles away. This effect could go further if there is good visibility, clouds to reflect the light, or if the event occurs at night. "Flash blindness" can even occur if the victim is not looking in the direction of the detonation. It can last several seconds to minutes. Although this effect does not cause permanent damage, the sudden lost of vision to drivers and pilots could cause a large number of traffic casualties and make many roads impassable.

Another, poorly understood, long range prompt effect is glass breakage. Most of the injuries outside of the Murrah building in the 1995 Oklahoma City bombing were caused by this phenomenon[4]. Extrapolating from more recent work on conventional explosives[5], a 10kt explosion could break certain types of windows (e.g., large monolithic annealed) over 8 miles away. Also noted in this same study was the tendency for glass to fail catastrophically even at extreme ranges, causing severe injury to those behind it. NATO medical response planning documents[2] for nuclear detonations state that "… missile injuries will predominate. About half of the patients seen will have wounds of their extremities. The thorax, abdomen, and head will be involved about equally." A significant number of victims from Nagasaki arriving at field hospitals exhibited glass breakage injuries[6].

Other effects, such as the electromagnetic pulse (EMP) and fires, also need to be considered in response planning. For a ground level detonation most EMP effects will be limited to within a mile, with a few, random, longer range disruptions occurring out to a few miles. Although the possibility of a "firestorm" is unlikely given modern construction, there will be a large number of small, disparate fires started from thermal and blast effects (generally around the 1 mile perimeter) which could spread and coalesce if not mitigated.

The primary delayed effect from a ground level nuclear detonation is from "fallout." Fallout is generated when the dust and debris excavated by the explosion is combined with radioactive fission products and drawn upward by the heat of the event. This cloud rapidly climbs through the atmosphere, up to 5 miles high for a 10kt, and highly radioactive particles coalesce and drop back down to earth as it cools. It is important to note that Hiroshima and Nagasaki did not have significant fallout because their detonations occurred at altitude.

The hazard from fallout comes not from breathing the particles, but being exposed to the ionizing radiation they give off after they have settled on the ground and building roofs. Radiation levels from these particles will drop off quickly, with most (55%) of the potential exposure occurs in the first hour and 80% occurs within the first day. Although it is highly dependant on weather conditions, the most dangerous concentrations of fallout particles (i.e., potentially fatal to those outside) occur within 10 miles downwind of the event and are clearly visible as they fall, often the size of fine sand or table salt.[7]

Unlike prompt effects which occur too rapidly to avoid, fallout health impacts can be mitigated by leaving the area before it arrives or by sheltering. Although some fraction of ionizing radiation can penetrate buildings, the 1) shielding offered by walls and 2) distance from outdoor fallout particles can easily reduce exposures by a factor of ten or more for urban buildings (see **Table 1**).

Table 1: Transmission factors for various shelter locations[1]

Shelter Location	Transmission Factor
3-feet Underground	0.0002
Frame House	0.3-0.6
Basement	0.05-0.1
Vehicle	0.5-0.7
Apartment (Upper stories)	0.01
Apartment (Lower stories)	0.1
Concrete Blockhouse	
9-inch walls	0.007-0.09
12-inch walls	0.001-0.03

The smaller the transmission factor, the lower the dose that a sheltered person would receive compared to an unsheltered person in the same area. For example, a person in the lower stories of an apartment building would receive only 10% of the dose that someone outside would receive. Someone on the upper floors would receive only 1% of the dose. In fallout areas, this could determine whether someone lives or dies.

LACK OF GUIDANCE

Although it may be initially unsafe for responders to enter significant fallout areas, the majority of prompt effects survivors will not be in these contaminated areas. Most response organizations lack fundamental awareness and planning to understand a nuclear event. Given a daytime population density of a city like Washington DC, initial casualties could easily be in the hundreds of thousands and timely medical intervention could greatly improve the prognosis of the injured[2, 8, 9, 10, 11, 12, 13, 14, 15, & 16].

Unfortunately response planners face a lack of federal guidance and scientific consensus on the correct actions to take. The 2006 Federal Register Notice published by the Department of Homeland Security[17], which clarified how existing protective action guidance can be applied for radiological and nuclear terrorism, did not specifically address guidance for the acute effects of a domestic nuclear explosion[18].

The Cold War civil defense program can help with some insights and advice, but many of the paradigms no longer apply. For example, the concept of a fallout shelter worked well with a few minutes warning of incoming missiles but is far less effective for an attack with no notice. There also appears to be a lack of scientific consensus on the appropriate actions to take after a nuclear detonation. The recommendations of the Department of Homeland Security's ***Ready.gov***, which are consistent with the recommendations of the National Academy of Sciences[19], were recently criticized by the Federation of American Scientists[20] because of conflicting recommendations with a RAND study[21 22].

Work needs to be done to update our Cold War guidance to address the asymmetric threat we now face. Both our society and our cities have changed significantly over the last half century and new preparedness guidance is required.

The issue is gaining attention in Washington, as stated in House Report 110-107[23]; "The conferees are concerned that cities have little guidance available to them to better prepare their populations to react in the critical moments shortly after a nuclear event." This report also provided direction to the Department of Homeland Security and the Department of Health and Human Services to improve preparedness programs for responding to a nuclear attack.

UPDATING PREPAREDNESS

The Department of Homeland Security has extensive preparedness activities, including preparedness grants to states and urban areas totaling billions of dollars. The Department's preparedness programs and strategies favor an "all hazards approach" that stresses mitigating the effects of a variety of events[24]. In this regard, preparedness for the low yield nuclear detonation scenario will create important capabilities for a number of catastrophic events that require:

- coordinated regional response,
- time critical decision-making,
- mass casualty response,
- crisis communication, &
- resource prioritization.

The Department of Homeland Security's National Preparedness Guidance[24] states; "Because major events will undoubtedly have a regional impact, there is no greater necessity than to collaborate on a regional basis to leverage expertise, share specialized assets, enhance capacity, and interoperate cohesively and effectively." Planning for the regional response to a nuclear detonation can be just the type of preparedness tool that can bring communities together for a common goal.

Since so many lives depend on actions taken by citizens and responders in the first few hours, the capability to make decisions and disseminate guidance quickly is essential for a large number of rapidly unfolding catastrophic events. A process must be in place to avoid the paralysis that can occur in the initial phases of an event when action needs to be taken and uncertainty about the nature of the event is high.

As noted above, the sheer number, type, and distribution of injuries around a detonation represents a significant challenge to public health and emergency medical response. Technical issues and uncertainty regarding contamination also complicate the medical response. In order to be effective, concepts such as field triage, reception centers, field hospitals, and resource prioritization need to be considered in advance. With the large number of prompt injuries, methods to stabilize and identify viable patients will be essential. There will be insufficient resources to treat everyone, and prioritization planning will be required to respond and help a community manage mass casualty events.

CONCLUSION

Preparing a response to national planning scenario #1 can help bring a region together to address a number of difficult issues. The capabilities gained through this process can facilitate an effective response to a variety of natural and manmade catastrophic events involving large-scale incident response coordination, mass casualty, mass evacuation, and mass care.

However, before preparedness activities like those identified by Congress[23] can begin, scientific consensus and federal guidance must be developed to support preparedness planning strategies.

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Nuclear deterrence, though much changed, is as relevant today as ever. If its material and manner of application have evolved, its usefulness has (...)Â Scenarios in which nuclear war could be unleashed by accident or as a result of a series of technical errors have no plausibility whatsoever. In terms of their release for use, nuclear weapons are the best-protected and most controlled category of armament in existence. [6] On the other hand, escalation of an armed conflict from the conventional to the nuclear level is an ever-present possibility, especially if the conventional forces of a nuclear weapons state should find themselves facing catastrophic defeat, or if an armed conflict threatens the survival of the regime of one of the combatan The uncertain consequences of nuclear weapons use. Michael J. Frankel James Scouras. George W. Ullrich.Â 1 Early concerns that a nuclear detonation might â€œigniteâ€ the atmosphere were largely dismissed based on a detailed analysis by the time of the test. See E. Konopinski, C. Marvin, and E. Teller, Ignition of the Atmosphere with Nuclear Bombs, Los Alamos National Laboratory Technical Report LA-602 (Los Alamos, NM: Los Alamos National Laboratory, 1946). If a nuclear detonation were to occur in a modern U.S. city, the best way to reduce casualties6 during the response phase (post detonation) would be by reducing exposure to fallout radiation. This can be accomplished through early, adequate sheltering followed by informed, delayed evacuation.7 However, the most critical decisions must be made in the first few minutes.Â Recent research indicates than many potentially lethal effects of a nuclear detonation can be greatly mitigated by the urban environment. Urban shadowing and shielding can significantly reduce the range of prompt thermal and ionizing radiation, and, although fallout continues to be a significant issue, adequate shelter can easily be found in the urban environment. A 10-kiloton (kT) nuclear detonation within a US city could expose hundreds of thousands of people to radiation. The Scarce Resources for a Nuclear Detonation Project was undertaken to guide community planning and response in the aftermath of a nuclear detonation, when demand will greatly exceed available resources. This article reviews the pertinent literature on radiation injuries from human exposures and animal models to provide a foundation for the triage and management approaches outlined in this special issue. A nuclear detonation in a US city would have profound psychological, social, and behavioral effects. This article reviews the scientific literature on human responses to radiation incidents and disasters in general, and examines potential behavioral health care provider (BHCP) contributions in the hours and days after a nuclear detonation. In the area directly affected by the blast, the immediate overarching goal of BHCP interventions is the support of lifesaving activities and the prevention of additional casualties from fallout.Â The following section examines what is known from research on and experience with the consequences of a nuclear detonation. Reactions to a nuclear detonation. Radiation Is a Particularly Dreaded Hazard, and the Fear Associated With It Is Powerful.