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A Review of the Research on Response to Improvised Nuclear Device Events

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The scenarios we discuss today are so hard for us to contemplate and so emotionally traumatic that it is tempting to push them aside. However, now is the time to have this difficult conversation.
—Joseph Lieberman[1]

Following the events of September 11, a litany of imaginable horribles was trotted out before an anxious and concerned public. To date, government agencies and academics are still grappling with how to best respond to such catastrophes, and as Senator Lieberman's quote says above, now is the time to plan and prepare for such events. One of the nation's worst fears is that terrorists might detonate an improvised nuclear device (IND) in an American city. With 9/11 serving as the catalyst, the government and many NGOs have invested money into research and development of response capabilities throughout the country. Yet, there is still much to learn about how to best respond to an IND event. Understanding the state of knowledge, identifying gaps, and making recommendations for how to fill those gaps, this paper will provide a framework under which past findings can be understood and future research can fit.

The risk of an improvised nuclear device (IND) detonation may seem unlikely; and while this is hopefully true, due to its destructive capability, IND events must be prepared for.[1] Many people still live under the Cold War mentality that if a city is attacked with a nuclear weapon, there is little chance of survival. This assumption, while perhaps true in the case of multiple, thermonuclear weapons exchanges, does not hold for the current threat. If a single IND were detonated in the United States, there would be many casualties at the point of impact; however, there would also be many survivors and the initial response by two major groups will mean the difference between life and death for many people. These groups are the first responders and the public. Understanding how these two groups prepare, react and interact will improve response to nuclear terrorism.

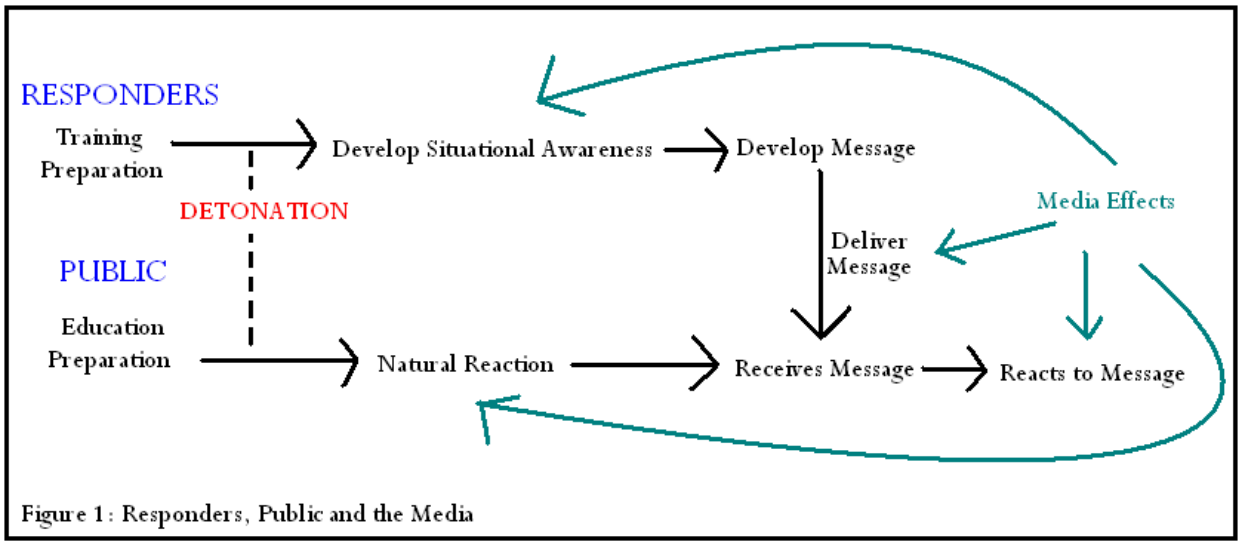

Figure 1: Responders, Public and the Media

Figure 1 provides a visualization of the response timeline of an IND event. For the purposes of this assessment, it is assumed that to accurately inform the public, three functions need to be fulfilled by response personnel, namely planning, developing situational awareness, and

[1] For more on the reasons to prepare see: US Congress, Office of Technology Assessment: Proliferation of Weapons of Mass Destruction: Assessing the Risks. *Office of Technology Assessment, Document OTA BP. ISC:559* 1993.

developing a public message. Planning varies widely from city to city, and to date no comprehensive study has been completed to assess how individual cities are progressing with preparation plans. Developing situational awareness about an IND detonation has been well researched over the years, yet it is far from fully understood. While messaging is an integral component to response, it is one that suffers from a dearth of knowledge. The public will have a certain level of education and preparation. After the detonation the public will respond naturally and upon receiving the responders' message will react to the message and may modify their behavior accordingly. Reviewing the nodes under both headings, responders and public will help better prepare the country to meet the challenges of an IND attack.

Responders

Training and Preparation:

While the detonation of an IND in the United States is unlikely, it is clear that preparing for the unexpected is necessary in today's world. The G-7 declared that "special attention should be paid to the threat of utilization of nuclear, biological and chemical materials, as well as toxic substances, for terrorist purposes."[2] In 2001, before 9/11, a Department of Energy task force found that "the most urgent unmet national security threat for the United States today" is the threat that weapons of mass destruction could be stolen from Russia and sold to terrorists desiring to attack "American troops abroad or citizens at home."[3] Moreover, there is a corollary to preparing for an IND event: if a locality prepares for an IND, they also prepare for any event that would require coordination of regional response, time critical decisions, responses to mass casualties, communication during times of crisis, and resource prioritization.[4] Because of these benefits, it is necessary that response plans are created and understood by local authorities. Developing national guidelines, while potentially beneficial, should not supplant local meetings and preparations, since each community has unique needs that only local authorities know about.

Developing Situational Awareness:

Responders developing an accurate and effective situational awareness will ascertain what the situation is, where they are within the situation, and what their role should be for the remaining crisis period. It is therefore necessary to define the magnitude and scope of an IND event.[5] Because an IND event will cause massive destruction, it is beneficial to understand the conditions responders will face on the ground after an IND detonation. Establishing situational awareness quickly can allow responders to respond effectively and save as many lives as possible.

Prompt Effects	Delayed Effects
Blast Overpressure Ionizing Radiation Thermal Radiation Others: Glass Breakage Flash Blindness	Fallout (Residual Radiation) Others: Fires

Figure 2: Effects of an IND Detonation

If a 10kt IND (roughly equivalent to 5,000 truck bombs) were detonated in a major city, there would be near total destruction within half of a kilometer of ground zero.[6] Beyond that range though, there is potential for survival, which many citizens and responders themselves do not realize.[7] Those people that do survive the initial detonation would have varied types and degrees of injuries caused by the effects of the IND detonation. With a nuclear detonation, there are two broad categories of effects: prompt and delayed (See Figure 2). The prompt effects are those which occur in concordance with the initial detonation and include blast overpressure, ionizing radiation, and thermal radiation.[2] For each of these effects, as the distance from ground zero increases the intensity of the effects decreases. The majority of injuries that result from an IND will be "missile injuries" and "about half of the patients seen will have wounds of their extremities. The thorax, abdomen, and head will be involved about equally."[8] Burns from thermal radiation will complicate these trauma related injuries. Third degree burns will be seen as far away as 1.5 km for a 10kT detonation.[9] In addition, to these classic prompt effects there may be other health effects associated with prompt effects, including flash blindness and glass breakage. During the 1995 Oklahoma City bombing, most of the injuries were caused by glass breakage.[10] In addition, a significant number of victims of the 1945 Nagasaki bombing presented at field hospitals with glass-related injuries.[11]

The second broad category of effects from a nuclear weapon detonation is delayed effects. The most important delayed effect in a nuclear attack is fallout. The nuclear detonation will create "a large cloud of radioactive dust & water vapor which fall back to earth contaminating horizontal surfaces." These contaminated particles will give off penetrating radiation that can injure unprotected people.[12] Thus, beyond the challenges of a normal emergency, following a nuclear detonation, responders will have to monitor and be aware of radiation levels. The Department of Homeland Security Preparedness Directorate provides a guideline for how much exposure is acceptable for emergency responders. Borrowing from the EPA's Manual, the Department of Homeland Security (DHS) advises that 1 to 5 REMs is within a normal range of exposure; up to 10 REMs is acceptable if all precautions are taken to minimize risk and the operation is to protect valuable property or save lives; and between 10 and 25 REMs is only an acceptable exposure if it is to save lives. 25 REMs is DHS's recommended turn-back line, at which point no responders should pass.[13] Tools are becoming available to assist responders in developing situational awareness and translating raw observations and radiation measurements on the ground into assessments of burst parameters (i.e. yield and height of burst).[14]

Another important aspect to consider when studying initial response is the willingness of first responders to actually respond. While research in this field is nascent, initial findings suggest that responders may not be as willing to respond to emergencies as previously thought. Qureshi et al. surveyed health care workers in New York City and found that 86% of health care workers were willing to respond when there was a snow storm. That high percentage of willing responders contrasts sharply with the 57% of health care workers willing to respond to a radiological incident.[15] This finding may indicate a need to increase first responder training about the true risks of radiation.

Messaging:

Assuming that situational awareness has been obtained, it is necessary to develop and deliver a message to the public. Within this task there are three elements. First, a standard

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[2] For more on the effects of a nuclear weapon see "The Effects of Nuclear War." *Office of Technology Assessment*. 1979. Available at http://www.fas.org/nuke/intro/nuke/7906/index.html

message must be developed before the event occurs. Next, officials must determine the best means by which to deliver the message. Finally, estimating natural public response and public response to the message is necessary to craft an effective event-specific message and approve it for dissemination. Following a process, such as the one Fischhoff has developed, would be very helpful in developing messages for IND events. Fischhoff's model begins with developing an expert model, then developing an open-ended protocol, and then conducting open-ended interviews. Following that process, a structured questionnaire is created and administered leading to the creation of a communication. Finally, a questionnaire is administered following the communication to evaluate the communication's effectiveness. [16] While this sort of method would be impractical *during* an IND event, it is necessary that this method or a similar one be followed when creating a message *before* an event occurs that can be used as a guide during a real event.

The first step in communicating with the public is deciding on what information is correct. The major debate in IND response planning over the past decades has been over whether to shelter or evacuate the public. Today, the scientific community is coalescing around a shelter and then staged and informed evacuation strategy. [3] According to Cham Dallas, "The natural inclination is to flee . . . [but] most people should not flee because they won't be affected." It is therefore necessary to incorporate this information into response plans. Moreover, it is likely that the public will not receive any official information within the first minutes of a disaster; therefore, it is necessary to educate the public before an IND event occurs so that they know how to react immediately.

Looking at risk communication failures of the past, one finds that one of the most damning mistakes is to send mixed, or worse, conflicting, messages to the public during a crisis. In a study looking at communications aspects of disasters, LeVerle Berry et al. found that during the 1979 Three Mile Island (TMI) nuclear power plant emergency "utility spokesmen offered explanations that were confused and often at odds with the views of the Nuclear Regulatory Commission." These "conflicting statements brought swarms of reporters to TMI to probe what looked like an industry cover-up."[17] The study found that the conflicting reports contributed to the public's sense of helplessness and confusion. Thus, it is imperative that during the crisis the public is given clear and consistent information.

Synthesizing the findings from both historical and experimental research by others[4], reveals that there are three fundamental aspects to communicating with the public. The three Cs (Clear, Constant, Correct) can be used as a shorthand for response planners to evaluate and develop messages so that messages are effective in informing the public. Clear means that the information provided is easy to understand and unambiguous. Constant refers to two important aspects of risk communication during crisis. First, official information needs to be issued continually in regular updates. Second, information issued needs to be consistent. Correct means that the information is as accurate as reasonably possible and represents expert opinion. By following these three Cs of risk communication during a crisis, responders can more effectively provide citizens with pertinent information.

Public

Preparation and Education:

The first node under the Public heading is preparation and education. Individual

[3] There are those who disagree. Chief among them is the Rand Corporation which says to "avoid radioactive fallout: evacuate the fallout zone quickly." However, even this may not be at odds with the majority.

[4] This information has been synthesized from the findings of Dennis Mileti in "Evidence-Based Guidance for Public Risk Communication and Education." START. September 2006.

preparation for an attack of this scale differs significantly. Looking at why an individual may not follow the advice of Homeland Security in developing a shelter with proper supplies, H. Keith Florig and Baruch Fischhoff, find that building or preparing a shelter could be cost-prohibitive or not worth the money.[18] Hurricane Katrina serves as a real life example of what can happen if individuals are not prepared and the government is not aware of the unpreparedness. Following Hurricane Katrina, it was discovered that numerous individuals had not developed an evacuation plan prior to the emergency.[19] It is unclear how many people are truly prepared for an IND, and a study should be conducted to ascertain this information, as it would be beneficial for the government to know approximately how many people are prepared and why others are not prepared.

Education programs on IND events are few and far between. One of the few studies that looked at the public's beliefs about radiological events found that the public is very ignorant about radiological events. Administering a questionnaire about terror risk communications, Fischhoff et al. found that 90% of people believe that if a dirty bomb were detonated the best thing to do would be to "get away as fast as humanly possible."[20] As was established above, the best response would be to shelter and then evacuate as authorities determine the proper way and method of evacuation. At the very least, studies need to be conducted to learn what the public knows and what it does not.

Natural Response:

Another piece of the response puzzle following an IND detonation is how the public will respond. Thomas Glass's "Understanding Public Response to Disasters" provides a relatively clear picture of how the public responds to emergencies and how best to deal with that public response. Glass finds that following an emergency the public is very resourceful and saves the majority of survivors. These two points of interest, the public's resourcefulness and the fact that the public often plays the role of first responder, leads Glass to recommend that EMS be trained how to work with the public instead of trying to work against them. Also according to Glass and other empirical evidence from many historical disasters[21], completely irrational behavior (i.e. panic) in an emergency is rare. [22] However, if the public does not trust the authorities, people may act differently than authorities expect. Looking at the Three Mile Island accident of 1979 (TMI), Erickson found that the "evacuation shadow" phenomenon can be a very important aspect of a catastrophe. Two days after the news broke of an accident at TMI, an evacuation advisory was issued for pregnant women and young children within a five mile radius of the nuclear power plant. In reality, "for every person advised to leave home, almost 45" people actually evacuated. [23] This shadow evacuation effect is one that should be understood as not only a result of faulty communications but also a reaction of an uninformed, confused, and frustrated public.

Important, though often ignored effects of an improvised nuclear device (IND) detonation are those under the heading of psychological and social effects. Baratta points out that incidents involving invisible agents (such as the radiation associated with an IND detonation) can produce disasters whose primary effects are social, psychological, and economic.[24] Several researchers agree that the public's reaction to an IND event could be quite different than expected because of these psychological and social issues. Baratta and Becker, for example, believe that the public will demand more decontamination efforts following an IND than are currently planned. This could prove to be a source of tension in response efforts.[25, 26]

Long-term psychological issues caused by an IND event can include post-traumatic stress disorder (PTSD), radiation stigma, and Informed Radioactive Contamination Syndrome (IRCS). While PTSD is being studied and is often included in long term response planning, the radiation

stigma and ICRS that an IND could produce is often omitted from planning and, as Baratta argues, "First responders and health care workers need to be educated in how to deal with the psychosocial dimensions of a nuclear terrorism event."[27] The presence of radiological stigma has been seen following radiological disasters (e.g. Goiania, Fernald[28]). This stigma can develop against individual people who have been exposed and those who were near the area of contamination. A study conducted by Green at al. looked at individuals living around the Fernald nuclear facility during the late 1980s. Residents who found out that they had been exposed to radiation experienced a very unique psychological experience. They exhibited symptoms paralleling those of post-traumatic stress disorder; yet, unlike PTSD, in these cases the stressor was ever-present, leading to the naming of IRCS. This research shows how important the lasting effects of an IND can be on individual psyches.[29]

Not only individual psyches will be affected long term. Communities, neighborhoods and even the entire nation will be affected by an IND detonation. Research suggests that entire geographical locations can garner a radiological stigma. Easterling et al. found that following the TMI disaster, there was a five-million dollar loss in tourism in the first month alone.[30] It is also likely that large amounts of people would have to be relocated following an IND event. Mass relocation can fragment both the community being relocated and the communities that absorb the refugees. It is, as yet, unclear how an IND detonation would affect the nation as a whole and research on this aspect of the effects of an IND event should be conducted. It is important that studies be conducted to understand how an attack would affect citizens' confidence in authorities and future economic and social activities. For by understanding the potential effects, steps can be taken to mitigate those effects.

Receiving and Reacting to Messaging:

Much of the literature regarding reaction to messaging has already been discussed; however, there is another important and often neglected aspect of communicating with the public. Lindell, argues that ethnicities and social groups can respond to the same message in different ways. In his study comparing Mexican-American responses to those of white Americans, Lindell found that Mexican-Americans were "more skeptical than whites about believing warning messages, no matter how specific the message." Mexican-Americans also "interpreted the same warning messages as indicating lower levels of personal danger" than white Americans. Lindell's study shows that it is necessary to study ethnic and community responses to warnings to ensure that messages are crafted for optimal efficacy.[31]

Media Effects

The media can aid first responders in developing their situational awareness by providing coverage or information directly to the responders. The media also affects how the public will naturally react. Many citizens will hear about the nuclear catastrophe from the media first, and how that presentation is made can determine how individuals perceive the risks involved. Once responders have developed the message for the public, the media will be instrumental in the delivery of that message. Television and radio being the primary means of information dissemination, those outlets will have an integral role to play in the crisis. The media's reaction to the official message can then have a profound effect on how the public reacts to the message. The media may cast doubt on the message causing the public to doubt the message, or the media may offer its unconditional support for the message. With all of these interactions in mind, it is necessary to look at the media and crisis communications in some detail.

Matthew Dombroski et al. found in their study "Predicting Emergency Evacuation and

Sheltering Behavior: A structured Analytical Approach" that compliance with official instructions during a disaster can be affected by the media's level of support. They found that in a radiological emergency 70-80% of individuals would comply with an evacuation order and 60-70% of people would comply with a sheltering order. The study found also that if the media were skeptical of the order, compliance with either recommendation could decrease by 10%.[32] The media must also be understood in terms of interacting with the event and the public directly. Two minutes after the Alfred P. Murrah Federal Building in Oklahoma City was bombed, media were covering the story.[33] The media's role must be recognized in disaster situations for the media can both aid and impede response. During the 1993 World Trade Center bombing, the media served as an emergency line to people still in the Towers. When the buildings' communications failed, people inside the buildings turned on battery power televisions and radios and even called local media to find out what was happening. On the whole, the media was helpful to those trapped. The New York Times reported that "throughout the afternoon and evening, New York City newscasters gave out emergency phone numbers, urged calm on those trapped inside, and praised the work of the city's emergency crews."[34]

Media can also hinder rescue efforts though. During the 1993 World Trade Center Bombing, one reporter told people in the building to break out their windows to get fresh air. Some listened and acted resulting in "inch-thick splinters sharp as knives [falling] toward the sidewalks . . . at fifty miles per hour."[35] The media have an important role to play in response to any disaster; however, their actions can be useful or detrimental. More needs to be studied when it comes to the media's relation to the public and emergencies. The media's message is likely to be the first source people hear following a disaster and by engaging the media beforehand and working with them during the disaster the government can ensure that the proper message is delivered.

The State of Knowledge on IND Response

The state of knowledge in responding and communicating is a mixed bag. Some aspects of an IND attack are well understood, some are not, but much is left to synthesize. The effects of an IND would be devastating, yet much can be done to mitigate those effects through education, preparation, and research. A major current gap in knowledge is how to effectively communicate with the public before an attack. Little research on the effectiveness of public education has been done, but it is likely that educating the public about the effects of an IND and how to best protect oneself could save many lives.

Response to an IND also needs to be synthesized and organized. Response during the first few hours after an IND detonation is critical since the severely injured could be saved during this time and the uninjured would be confused and looking for official information and advice. Realizing the fact that federal assistance may be days away, local responders should develop response plans that can effectively save lives in the first few hours. Much information exists about how to best respond, but it seems that little has been done to utilize the information that has been found. While this review of findings serves as a crucial first step in that synthesization, local communities will need to take the lead in taking research findings and putting them to use in response plans, for they are the only ones that can do it. Each community is different and as such their needs for response planning are different. Nevertheless, all cities share one common element in response planning and that is the *necessity* to plan. The effects of an IND would be devastating; however, much can be done to mitigate those effects through education, preparation, and planning.

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