Letter to the Editor

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Federal Nuclear Preparedness and Response Measures Reflect New Modeling Paradigms

We, the authors, would like to thank Dr. Robert Harney for advancing the dialogue on nuclear preparedness in his recent article "Inaccurate Prediction of Nuclear Weapons Effects and Possible Adverse Influences on Nuclear Terrorism Preparedness" which was published in the September 2009 issue of this journal.

We agree with Harney's main conclusions that the size of a nuclear attack by terrorists in the current era is likely to be much smaller than what was conceivable in the Cold War era, and that while the devastation would still be enormous, the attack presents the opportunity and responsibility for robust planning and effective response. As Harney says, "terrorist attacks, no matter how devastating, should not be made to appear hopeless" and "people should not be persuaded to believe that a terrorist-initiated nuclear attack is the end of the world."[1] We also agree that appropriate actions of local, state, and federal governments in the hours and days after the attack will be critical for the survival of many, that short-term sheltering-in-place will reduce casualties caused by fallout, and that the average citizen can undertake steps to improve personal preparedness in advance that will help mitigate the consequences of the attack.

Although we agree with Harney on some counts, we strongly disagree with three themes running through his article:

1. That if nuclear attack consequence estimates produce too many casualties, preparedness and planning efforts will be abandoned;
2. That the federal government is using seriously flawed models to guide response preparations; and

3. That the estimates advanced in his article are more accurate than what is currently being used for national medical planning.

Effectiveness of Response Strategies, Not the Precise Number of Casualties, Drives Federal Preparedness Actions

Dr. Harney argues that numerically accurate predictions of casualties from a nuclear attack are critically important because if the attack produces more than a certain number of casualties, it would be considered too daunting to plan for. In contrast, because there are so many uncertainties related to the enemy acquiring, deploying, and detonating a nuclear device in the U.S., appropriate federal planning must consider a range of possible assumptions leading to a variety of casualty scenarios, even those that suggest a very large number. Furthermore, when considering the *risk* of a nuclear attack by terrorists, the uncertainty in the consequences of an attack is dwarfed by the uncertainty in the probability that the attack will occur at all. Even though the risk of an attack is uncertain, it is important to note that the federal government is expending effort to prepare and plan for a nuclear attack because it is recognized that even a relatively small detonation would result in an inordinate number of casualties. It is useful to plan carefully and thoughtfully to minimize the consequence of any nuclear event, even those in which the potential number of lives saved is small compared to the number of lives lost.

Although federal studies typically utilize a 10 kT detonation for planning purposes, a variety of weapon yields and heights of burst are being considered. That being said, the worthiness of preparedness efforts is determined by the lives saved by effective actions, not the lives lost in the attack. It is for this reason that the exact number of casualties is secondary to the relative effectiveness of the response itself. Some readers of Harney's article may mistakenly believe that because a nuclear attack may, in some unlikely scenarios, produce millions of casualties (unlike Harney's estimates), that government preparedness efforts amount to capitulation.[2]

The fact that many of the preparedness actions being taken by the federal government are not public may have led Harney to suggest that the U.S. government is not actively planning for an attack. In fact, the federal government is actively engaged not only in preventing, but in planning for a coordinated, effective response to a nuclear attack. This work is challenging and complex, but necessary and is an integral part of the U.S. government's "all hazards" response paradigm.

The authors of this letter agree with Harney that a nuclear event would initially overwhelm local and regional hospital capacity, and therefore, the federal government actively plans for establishing an effective, coordinated national-level medical treatment response with state and local governments in coordination with the U.S. Departments of Homeland Security, Health and Human Services, Veterans Affairs, Transportation, and Defense and all agencies identified in the National Response Framework.

While much remains to be accomplished, actions taken to date that support nuclear response include:[3]

- Funding model development and analysis of urban nuclear attacks impacts;
- Developing guidance for state and local governments regarding local preparedness and response to a nuclear attack;[4]
- Developing playbooks, which are currently being updated and revised based on the newest modeling results, to help define how the federal response supports state and local response to a nuclear incident;
- Developing a federal nuclear strategic plan, and response concept plan (currently in draft form);
- Providing guidance for worker health and safety, and long-term restoration;[5]
- Augmenting FEMA's capabilities to respond to a nuclear attack;
- Providing guidance on the medical management of radiation injury (Radiation Event Medical Management web portal (REMM), developed by HHS);[6]
- Developing guidance to provide the greatest level of care in a setting in which resources are scarce while minimizing the risk posed to medical responders;[7]
- Improving the coordination of the evacuation of victims from major incidents;
- Tracking the availability of hospital bed capacity across the U.S., diverting patients to hospitals with adequate capacity and adding additional capacity, including specialty care for radiation injury;[8]
- Developing systems for the tracking of victims who have been evacuated to facilitate reunion with their families;
- Identifying which medical resources are likely to be in the shortest supply after an attack and supplementing these resources with federal and local caches;[9]
- Supporting the development of biodosimetry capacity to identify victims who should be given aggressive care to minimize radiation injury and maximize resource utilization;
- Ensuring connectivity of emergency communications;
- Developing and promulgating sound guidance related to evacuation vs. sheltering in place;
- Ensuring continuity of government (COG), continuity of operations (COOP), and continuity of essential services (COES) planning at the federal, state, and local levels;
- Developing stockpiles of resources and conducting research and development for more effective medical countermeasures;[10]
- Developing means to work with the private sector to ensure the acquisition and deployment of cost-effective and adequate supplies of countermeasures against acute radiation sickness.

Planning and Preparedness Efforts of the Federal Government are Based on Realistic Modeling

Casualty modeling (prediction of casualty numbers, locations, and types) in support of response planning, while imprecise, has improved greatly in recent years, and these numbers certainly inform the strategy and tactics behind the evolving federal response strategies. Using current models, planning is underway to maximize the efficient use of the limited number of health care providers and resources, ensure that responders know how to respond to radiation events, consider the operational difficulties of the post-nuclear blast environment, develop strategies to bring casualties to facilities with extra capacity, and carefully and ethically consider the use of scarce resources. For these efforts, accurate models are important, which, is why we found Harney's comment disturbing: "Such 'excessive' estimates have been used to establish emergency response planning guidance. It remains to be seen whether this will result in over-preparation or under-preparation. Neither is desirable."[11] We believe good fidelity casualty estimates are critical to planning, and we believe the federal government has done the most comprehensive analysis of urban nuclear detonation impacts to date.

Despite the importance of accurate models, Dr. Harney concluded that the federal government is performing shoddy modeling. Because he doesn't explain his claim, we are unsure what information was used to support his conclusion. The specific document he cites for his claim that "excessive" estimates have been used to establish emergency planning guidance is the federal interagency "Planning Guidance for Response to a Nuclear Detonation" published by the Executive Office of the President.[12] This document was designed to assist state and local emergency response officials in developing local response plans to a nuclear attack and therefore does not discuss model details of little interest to policymakers. It is, however, based on extensive modeling and analysis.

We recognize that Dr. Harney does not have the benefit of the most current analyses of urban nuclear impacts that served as the technical underpinnings for the "Planning Guidance" he references. Under contract[13] to the Department of Homeland Security and the Department of Health and Human Services, the nation's nuclear weapons laboratories have undertaken detailed and in-depth modeling , simulation, and analysis of nuclear impacts on the urban cityscape and on human health, accounting for blast resilience of numerous building structural types, glass varieties in building construction, the attenuation of prompt neutron and gamma radiation by urban structures, rubble generation, fire potential, EMP, fallout generation and deposition from a ground-level explosion, and impacts on critical infrastructure. Optimized post-detonation shelter and evacuation strategies are being developed. Investigators are leveraging Cold War nuclear test data and Japanese data to validate results and numerous other data sources were mined in this effort, and with application of the most current modeling techniques the

authors believe this work constitutes the most comprehensive analysis of the urban nuclear attack to date.

That being said, we question why Harney concluded that the modeling used to support this document was erroneous. In fact, comparison of Harney's casualty estimates and those from the "Planning Guidance" reveals close agreement. For example, Harney wrongly assumes that federal guidance assumes an airburst, whereas the blast effect distances provided in the "Planning Guidance"[14] are based on surface bursts. The estimates for blast effects in the document match those for a surface burst provided by Harney.[15] (Compare Harney's estimate of 5psi at 0.97km to 5psi at 0.9km in the guidance.)

It should be clear that the "Planning Guidance"[16] and most post-9/11 federal planning documents primarily consider terrorist-delivered surface nuclear detonations rather than airbursts from warheads delivered by missiles or aircraft. Because these models consider ground-level detonations, the models consider attenuation of the prompt thermal and ionizing radiation caused by buildings and a slightly attenuated blast wave. Nonetheless, various altitude bursts as well as a wider range of yields than those discussed by Harney have also been investigated and modeled to ensure preparedness for a wide range of possible scenarios.

Casualties Produced by a Nuclear Weapon Will Likely Exceed Harney's Estimate

There are several factors that will significantly contribute to the number of casualties that Harney may not have adequately considered in his models. First, fallout could generate many casualties if victims do not receive or cannot perform the recommended protective actions, like sheltering-in place. Dr. Harney appears to agree that fallout may produce more casualties than the other effects of the bomb. He suggests (and we do not dispute) that a 20 square kilometer area may be blanketed with enough fallout to kill inadequately sheltered victims after a few hours exposure in some scenarios. Although effective evacuation of the target city could greatly reduce fallout casualties, all studies of the evacuation of cities[17] (and practical experience from the evacuation for hurricanes and daily rush hour) suggest that great numbers of potential victims will likely be trapped for hours in their motionless cars (poor shelters against fallout) or attempt to walk out rather than sheltering in heavy buildings. To improve the chance that the public will understand and follow actions to reduce their exposure to fallout, education and communication programs are currently in progress. Nonetheless, responsible planning and preparedness measures must consider that many victims will present with acute radiation sickness caused by fallout. For these victims, research is underway to develop effective treatments and to effectively deploy today's medical countermeasures.

Second, regarding thermal injury, Harney discounts burn victims based on the fact that opaque objects effectively block the thermal energy from a detonation. Some

models indicate that the number and severity of prompt burn cases will be substantially diminished in a ground burst. However, he fails to consider that the source of the thermal energy, the fireball, rises very quickly. In fact, a detailed, publicly available analysis has shown that, although a weapon may be detonated on the ground, the burst may cause burns distant from the point of detonation in a modern city because the fireball will rapidly rise above the height of buildings.[18] Depending on meteorological conditions, thermal energy can also reflect off clouds and burn those without line of sight to the source (called "sky shine"). Furthermore, burns substantially reduce survivability when combined with any other injury type. Similarly, although the prompt ionizing radiation emitted by the detonation is attenuated by solid objects, scattering can cause substantial non-linearity through a city, leading to surprisingly high doses even behind robust structures. Unpublished analysis by Applied Research Associates, in which energetic particles emitted in a nuclear detonation were traced through a three-dimensional model of a U.S. city, estimated how much dose an individual would receive in various distances from the detonation via direct line of sight and scattering.

Third, Harney appears to omit the contribution of temporary flash blindness to the casualty pool. Although retinal scarring will occur only in those with a direct line of site of the detonation, many may be temporarily blinded by the bright flash even if they do not directly view the explosion. Although flash blindness victims will recover their eyesight after a brief period, many are likely to be driving at the time resulting in a significant number to auto accidents. The distance out to which temporary blindness occurs is a function of the ambient brightness (as the iris contracts in the day but is wider at night), albedo (the reflectivity of the sky on a cloudy or clear day), and any eye protection (sunglasses or tinted windows). Models in use consider that this effect could extend ten miles from the epicenter, and further at night. And, fourth, the lack of medical resources may contribute to significant loss of life from otherwise treatable conditions, such as infections, although this is difficult to quantify.

Finally, we, the authors, hope this letter has helped advance the dialogue on nuclear preparedness by clarifying that U.S. government preparedness strategy is based on sound consideration of the best science related to an urban nuclear attack. Further, we hope we emphasized that the federal approach to preparedness is suitable to various types of nuclear incidents, including those that produce many more and many fewer casualties than what some may consider the "most probable" scenario. Lastly, we feel it is important to emphasize that, even if we disagree on the magnitude of the impact of an attack, the federal government's approach does not in any way include capitulation or appeasement, but accurate analysis and robust planning.

The opinions, findings and conclusions in this letter are those of the authors and do not necessarily represent the views of the federal government, its departments, or components.

[1] Robert C. Harney, "Inaccurate Prediction of Nuclear Weapons Effects and Possible Adverse Influences on Nuclear Terrorism Preparedness," *Homeland Security Affairs* V, no. 3 (September 2009): 17 and 18.

[2] Ibid. See Harney's discussion of the dangers of appeasement on page 18.

[3] Citations are provided for examples with reference material in the public domain. These are preparedness efforts only, and do not reflect the countless nuclear attack prevention efforts being taken by the federal departments.

[4] Available at: http://www.hhs.gov/disasters/discussion/ planners/planningguidanceforresponse.pdf.

[5] Federal Emergency Management Agency (FEMA), "Planning Guidance for Protection and Recovery Following Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents" *Federal Register* 73, No. 149 (August 1, 2008), http://ogcms.energy.gov/73fr45029.pdf.

[6] Available at: http://remm.nlm.gov.

[7] Some of these products can be viewed at: http://www.iom.edu/en/Reports/2009/DisasterCareStandards.aspx, http://www.ahrq.gov/prep/ and http://emergency.cdc.gov/.

[8] Some relevant tools are available at: http://www.ahrq.gov/prep/havbed/ and http://www.nmdp.org/RITN/index.html.

[9] For more information on the Strategic National Stockpile, see: http://www.bt.cdc.gov/stockpile/.

[10] Additional details available at: http://www.hhs.gov/aspr/barda/.

[11] Harney, "Inaccurate Prediction," 1.

[12] FEMA, "Planning Guidance for Protection and Recovery."

[13] Contributors to this work include Los Alamos National Laboratory, Lawrence Livermore National Laboratory, Sandia National Laboratory, ARA Inc., Gryphon Scientific, the Institute for Defense Analysis, and the Defense Threat Reduction Agency.

[14] Homeland Security Council, "Planning Guidance for Response to a Nuclear Detonation," January 16, 2009, www.hsdl.org/hslog/?q=node/4662.

[15] Harney, "Inaccurate Prediction," 9.

[16] FEMA, "Planning Guidance for Protection and Recovery."

[17] R. Goldblatt and K. Weinisch, "Evacuation Planning, Human Factors and Traffic Engineering" *TR News* (May-June 2005); Thomas Urbanikll, "Evacuation Time Estimates for Nuclear Power Plants" *Journal of Hazardous Materials* 75, issue 2-3 (June 2000): 165-180; and American Highway Users Alliance, "Emergency Evacuation Report Card, 2006," http://www.highways.org/pdfs/evacuation_report_card2006.pdf.

[18] R.E. Marrs, et al., "Thermal Radiation from Nuclear Detonations in Urban Environments" *Lawrence Livermore National Laboratory Report UCRL-TR-231593* (June 7, 2007).