

Commentary

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Bolstering Mass Casualty Preparedness and Response to Nuclear, Radiation, and Explosive Incidents during Mass Gatherings

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Abstract

While emergency preparedness preparations are typically focused on the most commonly occurring events such as natural disasters, disease outbreaks, and small-scale human-made disasters, concern for disasters involving mass gatherings is growing, particularly with previously less common nuclear, radiological, and explosive incidents. An example is provided of potentially useful preparedness for these events with the upcoming FIFA World Cup 2026TM, expected to be one of the largest sporting events in USA history. Trainings and protocols are reviewed, with a specific suggestion of a scorecard for prioritizing preparedness. Particular focus is also given to integrated surge pathways in this response. By combining evidence-based risk communication, burn surge planning, and the scorecard approach to prioritize and coordinate actions across host cities, organizers can reduce preventable morbidity and mortality.

Introduction

Health system preparedness for dispersed mass gatherings such as the FIFA World Cup 2026TM is often focused on natural disasters, disease outbreaks, and human-made disasters resulting in mass casualty incidents. In the near future the USA is hosting the FIFA World Cup 2026TM followed by the 2028 Summer Olympics. Both events are likely to be some of the largest USA sporting events in recent history. Across the world, emergency response and health systems have become familiar with handling many types of incidents associated with mass gatherings. In the USA, the devastating effects of the Boston Marathon bombing are a reminder of the value of preparedness and response readiness.¹ However, there is less experience in preparations for and responses to nuclear, radiation, and explosive incidents.²

A key challenge for the FIFA World Cup 2026TM is the geographically dispersed nature. This could result in resources rapidly becoming overwhelmed without preparation for a Black Swan event. Historically the probability of a nuclear, radiation, and explosive incident at a mass gathering has been relatively low but recent vulnerability appears to be rising, and the result could be a devastating impact on human life and health system capacity.^{2,3} The rapid evolution of artificial intelligence has provided those with extreme ideological beliefs the opportunity to rapidly build undetected knowledge and capabilities within existing laws and resources. This changed landscape highlights the need to expand and bolster mass casualty preparedness and response to include nuclear, radiation, and explosive incidents. Imperative to this will be a shift towards networks across disciplines and industry to enhance health sector readiness.⁴

Arguably the greatest threat to mass gatherings for the United States and many other countries is lone offenders and small groups motivated by a spectrum of ideological beliefs. There are a range of examples of this risk escalating over the past year. For example, 4 people were arrested on December 15, 2025, for the planned use of improvised explosive devices on New Year's Eve in Southern California,⁵ a terror-related mass shooting at a Hanukkah event on December 14, 2025, at Bondi Beach in Australia,⁶ the use of Molotov cocktails at the "Run for Their Lives" event in Boulder, Colorado, on June 1, 2025,⁷ and a New Orleans truck attack on January 1, 2025.⁸ The Bondi Beach mass shooting occurred despite some of the strictest gun laws in the world. This event and others were different in design but demonstrated the capability of domestic actors and even foreign terror organizations to find ways to create chaos and harm innocent civilians, highlighting the need to bolster preparation for nuclear, radiation, and explosive incidents.

Vulnerabilities and Perceived Risks

One of the most significant vulnerabilities in responding to nuclear and radiation-related incidents is the virtual certainty of the debilitating fear that will result, not only in the public but also in the emergency response and health system community. This fear factor can be expected due to a lack of familiarity with the previously low-incidence high-casualty events, coupled with widespread misconceptions about actual risk from these events.⁹ Indeed, a survey of emergency medical personnel on perceptions of risk from treating patients from nuclear detonations revealed that, despite the very low level of actual risk to responders, these professionals were more likely to refuse to respond to radiation emergencies than to far greater demonstrated hazards with other mass casualty events.¹⁰ Of course, this would likely be expected to negatively impact the already adverse ratio of medical care personnel to patients even further. One example of specific overestimated injury risk is the widespread perception that there is significant risk to fetuses of mothers exposed to nuclear detonation or nuclear reactor meltdown-generated radiation. This notion is not supported by the extensive database of these exposures at Chernobyl and Fukushima, where there were no radiation-related fetal abnormalities. As a result, the stated and current medical consensus is that there is not an appreciable risk for fetal abnormality from exposure to radiation expected from the widespread nuclear fallout.^{10–15}

Beyond the risk considerations, many emergency response and health system personnel sense an overwhelming futility in management of casualties during nuclear and radiologic mass incidents. This mindset has been historically linked to the perceptions of multitudes of catastrophic injuries and radiation exposure effects being not survivable following such incidents. Over the last decade, published works have largely debunked this and have shown that large numbers of casualties previously counted among the presumed mortality numbers will in fact have survivable injuries and exposures amenable to timely medical and surgical management.^{2,9,16–18}

Triage Realities and Burn Surge

In the case of the increasing likelihood of responding to a nuclear detonation, there will be a harsh reality of nuclear detonation triage created by the very large number of nuclear detonation casualties relative to available medical personnel.¹⁶ Further vulnerability in response can be expected within the casualty category of thermal burns, which demand far more personnel resources relative to the trauma and radiation injury categories. A great concern in this mass casualty triage will be that the majority of patients selected by triage for treatment will be the trauma victims, with the rejection of the large number of thermal and radiation patients due to the adverse patient/medical personnel ratios and lack of familiarity of emergency personnel with mass casualty thermal burn protocols.¹⁶

In order to address these significant vulnerabilities in response, planning for medical and public health response to these events will be greatly facilitated by the prediction of the likely distribution of the different categories. This includes the degree of severity of casualties in order to enable rational planning of the response needed and possible with existing resources.¹⁹ For example, the location of accessible numbers of trauma victims from broken glass on the periphery of blast zones is a casualty distribution which is a favorable prediction for productive action for a range of explosive events, including those also involving radiation.¹⁷ In this manner, it can be a source of hope to be able to plan and respond in selected areas identified by predicted casualty distributions.

A Scorecard Approach to Prioritize Preparedness

A first step toward bolstering preparedness could be the application of a validated scorecard method.^{18–26} The Scorecard is supported by the United Nations Office for Disaster Risk Reduction (UNDRR),²⁷ and members of this team have applied this in a range of local and national settings around the globe. This has included testing a nuclear and radiation Scorecard at a preparedness workshop for the Alabama Department of Public Health in July 2024. Funders for this method have included the World Health Organization (WHO),²⁸ the U.S. Department of Agriculture (USDA),²⁹ the UK Foreign, Commonwealth and Development Office (FCDO),³⁰ and the Japan Science and Technology Agency (JST).²⁴ The scorecard approach is versatile, scalable, and designed to inform decision-making processes and increase capacity by systematically leveraging local insights to inform the development and implementation of locally informed action plans. It is well-suited to garnering and synthesizing grassroots-level ideas and concepts for addressing complex challenges such as bolstering mass casualty preparedness and response to nuclear, radiation, and explosive incidents during mass gatherings. The process would lead to feasible and innovative actions and strategies that are sustainable, scalable, and feasible across FIFA World Cup 2026™ host cities and could be applied for the 2028 Summer Olympics.

Training and Protocols

Overcoming limitations in preparedness regarding the emergency response and health systems readiness for nuclear and radiation explosive incidents requires a multimodal approach. Fear and angst that predispose to limiting health professional engagement during such incidents demand access to education and training that addresses risks and also the benefits in response. Overcoming the perceived risk compared with the actual risk is an important component to strengthening response capability.²

Meeting the clinical demands of these casualties will be determined largely by the availability of medical personnel and facilities that can augment the capacity and capability of wound and burn injuries. An alternative workforce will be needed in the vast majority of cities and metropolitan areas to address these patient populations. Beyond human resource typing is the need for alternative care sites and locally available cache of medical supplies and durable goods. Building this expansion of health care infrastructure is not complicated and the means to train up such an augmented workforce is doable in most municipalities in the USA. The principal rate-limiting step is deciding to prioritize readiness and move beyond the “doomsday” rhetoric that cloaks the issue.

Mandatory continuing education is factored into the employment schedules of healthcare providers and hazard responders almost universally, providing substantial opportunity to address familiarity gaps in these matters. A staggering breadth of subjects can be initially and periodically made available to these individuals, ranging from wound care to radiation exposure, to supply targeted educational topics anticipating these disasters. Improved data gathering and management can provide every responder with a communications device and “just in time” summaries of positioned resources for patient evaluation and treatment for diverse settings ranging from combat support hospitals on the front lines to Level 1 trauma hospitals and burn facilities. This could enhance accuracy in determining levels of evacuation for the acutely ill and injured to a facility capable of providing both initial evaluation and perhaps

completion of care, and then movement of patients to higher levels of examination and treatment.^{2,9,16}

Integrated Surge Pathways

Surge pathways are needed that can be activated rapidly, scaled locally, and coordinated regionally. It is recommended that the scorecard approach be applied to systematically identify surge pathway options. These need to be under unified command and, for example, could include:

- Alternative care sites with predefined triggers, supplies, and staffing models to decompress emergency department and inpatient units.
- Augmented workforce models. For example, burn extenders, just-in-time training, and tele-consult networks to expand capacity where specialist availability is limited.
- Data and communications tools that push just-in-time checklists, referral directories, and patient movement guidance. This could reduce decision latency and misallocation.
- Interagency guides with initiation triggers, recruitment and deployment pathways, and unified command protocols across fire, emergency response services, public health, hospitals, emergency management, and psychosocial support.

Advances in mapping and surge-capacity planning and training for likely overwhelmed resources such as emergency department triage and initial care areas, staff and equipment, and burn victim care areas enable plans to be enacted quantitatively. For example, the selection of patients that would receive life-saving cytokine medications (in short supply) for lethal exposure (without treatment) to radiation would likely be based on the calculated geographic zone the patient was in at the time of exposure. The upcoming mass-gathering events this year offer the opportunity to enable the use of these advances in mass casualty planning, and by intent to avoid the deficiencies in response that would otherwise occur.

Finally, it is essential that all agencies that may play a role in response to these disasters work with the highest levels of protocol initiation, recruitment, deployment, and oversight in all related emergency care. This includes disciplines ranging from firefighting to paramedicine to psychosocial support and beyond. Doing so helps optimize and coordinate these separate yet overlapping public assistance agencies into increasingly seamless entities whose coordination bolsters the opportunities for success in responses. Through this combination of agency identification, education, and coordination, the authors feel that the greatest possible good may be achieved for the greatest number, here in this time of increasing risk following the hazards presented by enhanced data mining across populations.

Conclusion: From Awareness to Action

Planning and active preparedness for mass casualty events is recognized as essential and yet has been shown to often be lacking in key elements, especially for “less likely” scenarios involving nuclear, radiological, or explosive events. By combining evidence-based risk communication, burn surge planning, and the scorecard approach to prioritize and coordinate actions across host cities, organizers can reduce preventable morbidity and mortality. Next steps should include: adopting the scorecard across all host jurisdictions to baseline capabilities and generate prioritized action plans; coordinated tabletop and functional exercises focused on nuclear, radiological, or

explosive triage, burn surge, and intercity patient movement; creation of inventory and plans to augment burn capacity (beds, supplies, staff); deploying just-in-time guidance tools and standardized communication scripts for responders and the public; and formalizing multiagency protocols. Through disciplined prioritization and deliberate practice, the greatest good for the greatest number becomes a realistic objective, even for complex and dispersed mass gatherings.

Competing Interests. The authors declare none.

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