REAC/TS
Radiation Emergency
Assistance Center/Training Site

Tactical Combat Casualty Care on the Nuclear Battlefield: Maximizing Survival and Operational Capability After Nuclear Detonation

Mark Ervin, MD

Associate Director, REAC/TS

Oak Ridge Institute for Science and Education
Shaping the Future of Science

NNSA National Nuclear Security Administration

U.S. Department of Energy

Disclaimer

- Dr. Mark Ervin does not have any relevant financial relationships with any commercial interests to report

- The ideas expressed are only the authors and do not reflect the official or unofficial opinions of the US Government, US Department of Energy or any other organization

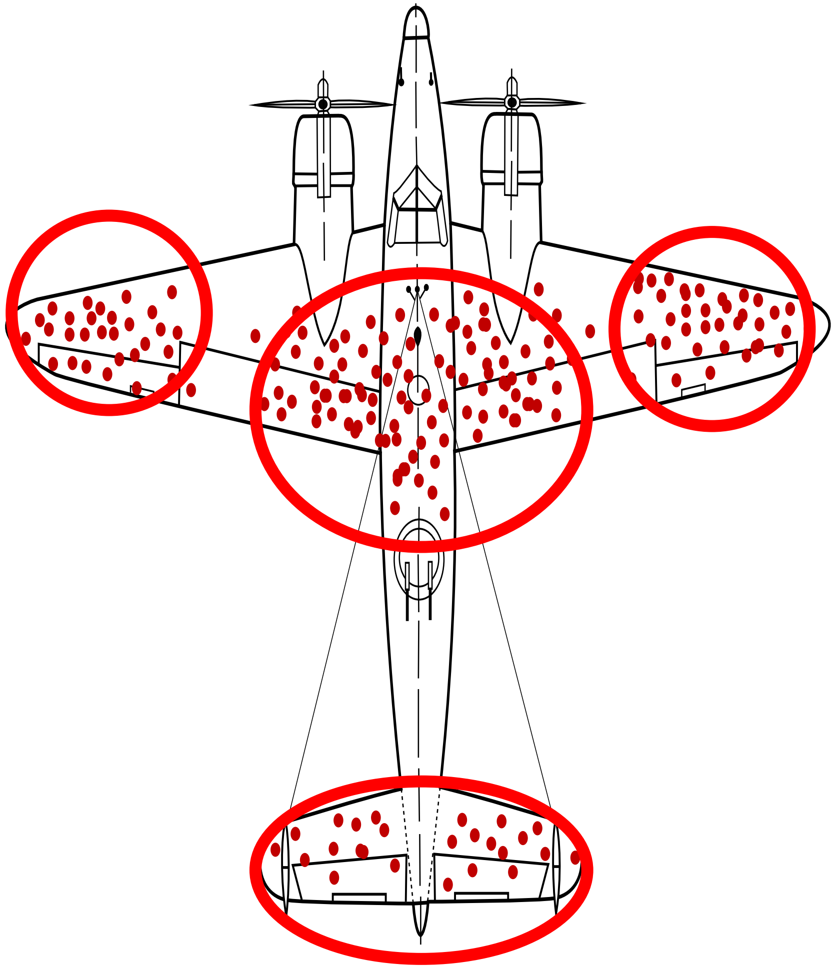
Preamble

- Detonation of any nuclear weapon will lead to unimaginable death and suffering for those within its reach
- By far, the most effective way to reduce suffering and death from a detonation is to prevent it occurrence
- Reducing the risk of use of nuclear weapons is most effective medical countermeasure available

- This presentation addresses how we can mitigate human suffering **if we fail to succeed in the above…**

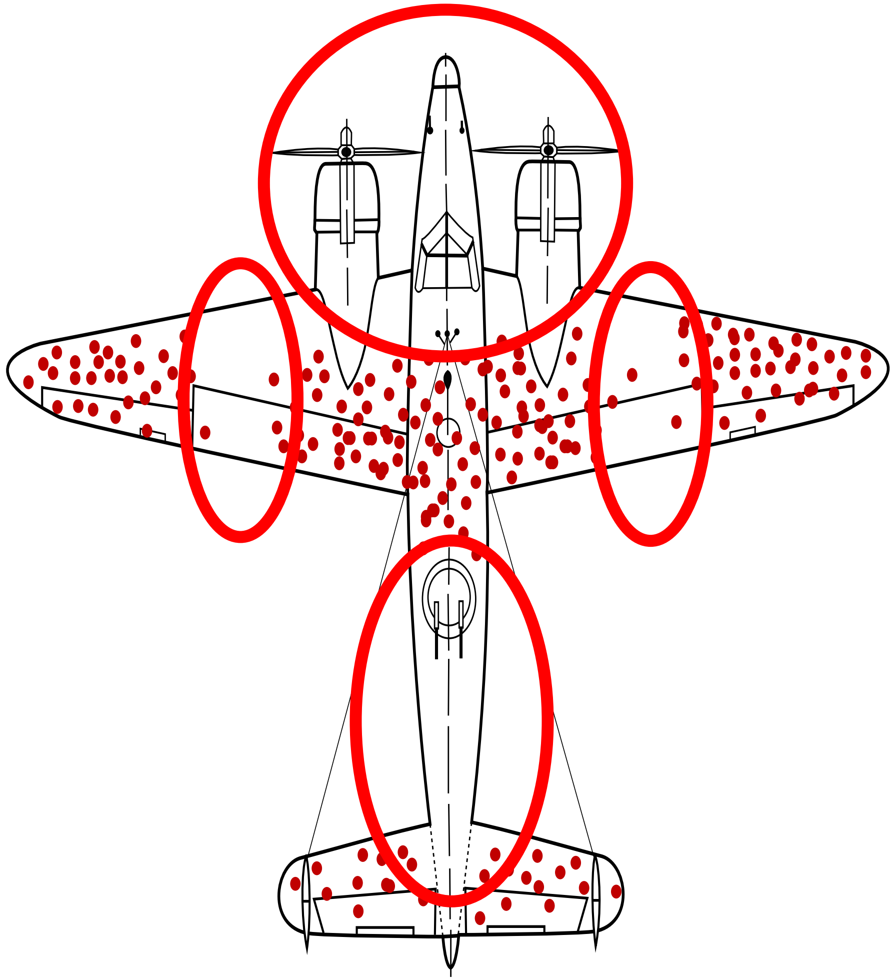
Survivor Bias Error

- During WW II, Allied Forces studied damage to returning aircraft
- Most observers suggest improving protection to sites of heaviest damage …



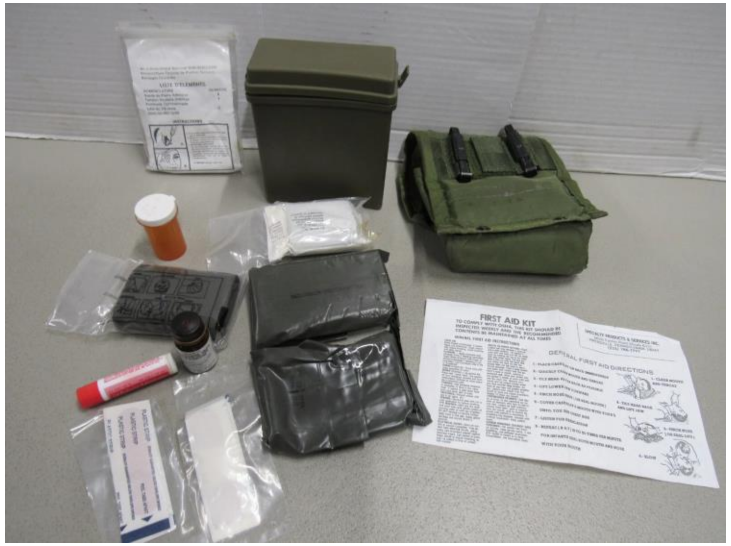
Survivor Bias Error

- During WW II, Allied Forces studied damage to returning aircraft
- Most observers suggest improving protection to sites of heaviest damage …
- Statistician Abraham Wald surmised that the areas without damage indicated critical points on aircraft
- Recommended additional armor be applied to these regions of aircraft to improve survivability in combat



Survivor Bias and the Military First Aid Kit

- Prior to 2005, US military first aid kits provided initial care for injuries seen in field hospitals …
- Landmark studies on autopsies of war fatalities with survivable injuries drove change to modern TCCC IFAK (Individual First Aid Kit)



ORIGINAL ARTICLES

Causes of Death in U.S. Special Operations Forces in the Global War on Terrorism

2001–2004

John B. Holcomb, MD, Neil R. McMullin, MD,* Lisa Pearse, MD,† Jim Caruso, MD,† Charles E. Wade, PhD,* Lynne Oetjen-Gerdes, MA,† Howard R. Champion, FRCS,‡ Mimi Lawnick, RN,* Warner Farr, MD,§ Sam Rodriguez, BS,§ and Frank K. Butler, MD‖*

Background: Effective combat trauma management strategies de-

survivable injuries. Structured analysis identified improved methods of truncal hemorrhage control as a principal research requirement.

ORIGINAL ARTICLE

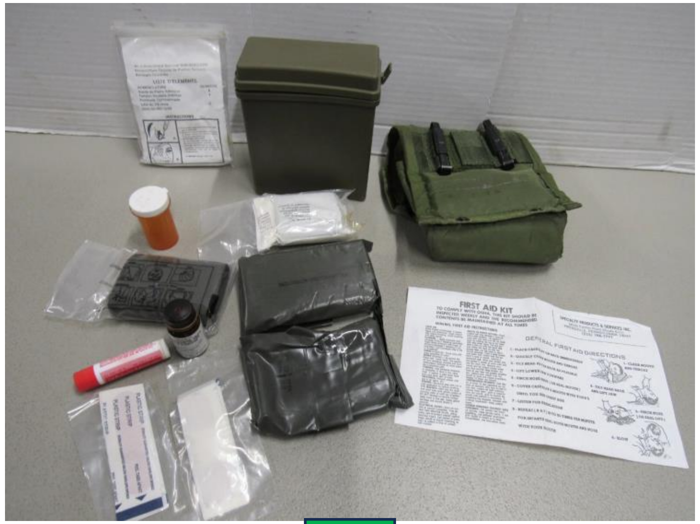
Death on the battlefield (2001–2011): Implications for the future of combat casualty care

Brian J. Eastridge, MD, Robert L. Mabry, MD, Peter Seguin, MD, Joyce Cantrell, MD, Terrill Tops, MD, Paul Uribe, MD, Olga Mallett, Tamara Zubko, Lynne Oetjen-Gerdes, Todd E. Rasmussen, MD, Frank K. Butler, MD, Russell S. Kotwal, MD, John B. Holcomb, MD, Charles Wade, PhD, Howard Champion, MD, Mimi Lawnick, Leon Moores, MD, *and* **Lorne H. Blackbourne, MD**

BACKGROUND: Critical evaluation of all aspects of combat casualty care, including mortality, with a special focus on the incidence and causes of potentially preventable deaths among US combat fatalities, is central to identifying gaps in knowledge, training, equipment, and

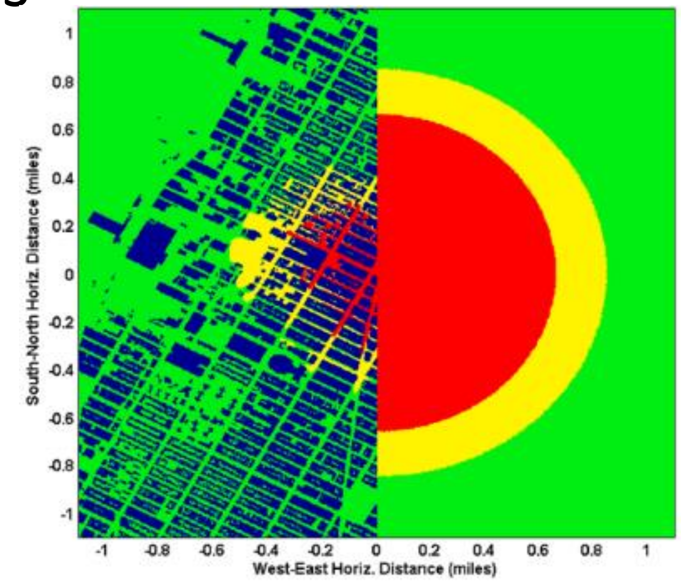
Survivor Bias and the Military First Aid Kit

- IFAK addressed the top three causes of preventable deaths on the battlefield
- Better hemorrhage control/airway protection **“stopped/slowed the vitality decompensation clock”** long enough to reach surgical care
- Employment allowed more seriously injured to survive to advance medical care and ultimately improved Case Fatality Rate and outcomes!

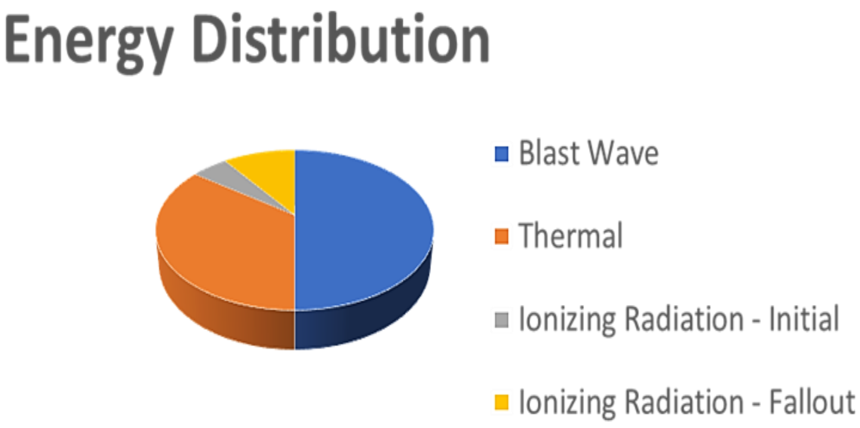


Nuclear Detonation (NucDet) Modeling and Casualty Estimates …

- All Nuclear Detonation models agree … ***"It will be Bad!"***
  - Large casualty numbers
  - Overwhelming casualty streams at established medical facilities
  - Significant percentage of combine radiation trauma/burns
- "Exactly How Bad?"
  - Planners must not wait (or hope) for exact projections
  - Many variables limit the volume and mix of casualty estimates
    - Population density, time of day, local geography change estimates



Harmful Energy from Nuclear Weapons



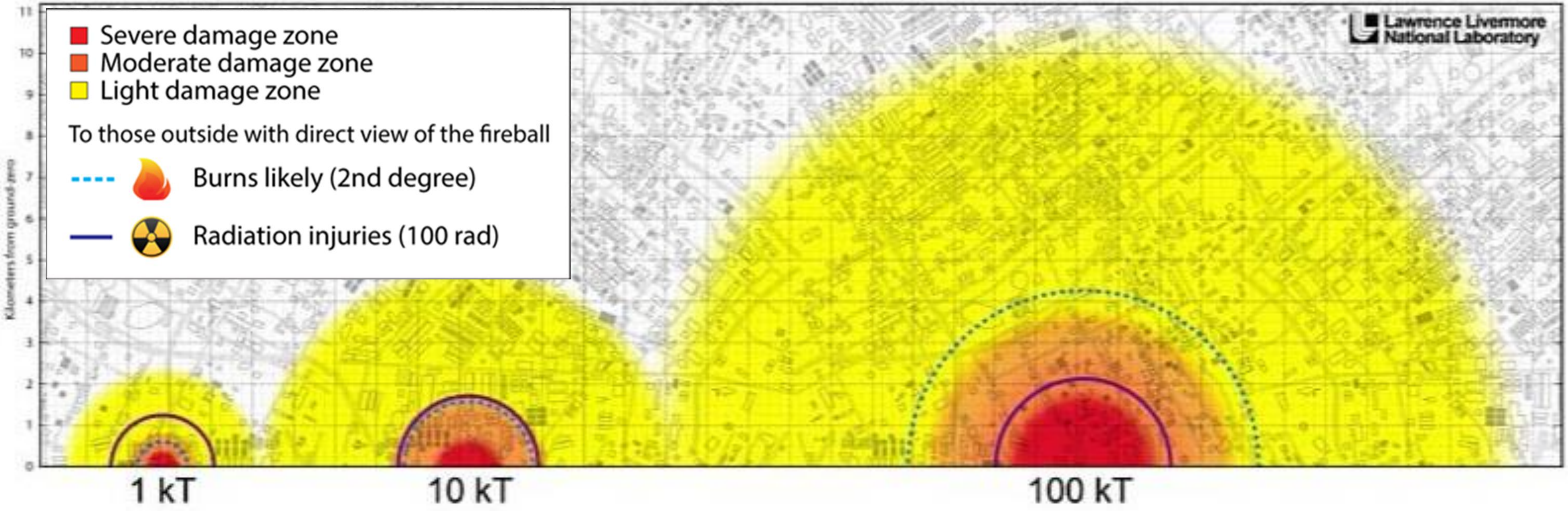
- **Blast wave** (50% of energy)
  - Fractures, lacerations, pneumothorax, alveolar hemorrhage, viscera rupture, pulmonary edema, air emboli

- **Thermal** (35% of energy)
  - Flash/flame burns, flash blindness (reversible), retinal burns

- **Ionizing radiation** (15% of energy) - ***initial (5%) and fallout (10%)***
  - Skin injury, retinal damage and late effects (cataracts, cancer, infertility, fetal abnormalities)

Prompt Thermal vs Radiation

The Role of Detonation Size to Ratio of Burns vs Radiation Injuries



Extent of Thermal Health Threat - - - - - - -   **Extent of Radiation Health Threat** ———

Modeling Nuclear Detonation Casualties

TABLE 13: SUMMARY OF IMPROVISED NUCLEAR DEVICE CASUALTY CATEGORIES.

Yield (kT)	Recover (< 5% Fatalities)	At Risk (5 to 95% Fatalities)	High Lethality (> 95% Fatalities)
10	55%	28%	17%
1	35%	34%	30%
0.1	30%	38%	33%
0.01	32%	42%	26%

TABLE 15. SUMMARY OF DISTRIBUTION OF INJURIES FOR IMPROVISED NUCLEAR DEVICES.

Yield (kT)	Radiation	Trauma	Radiation and Trauma
10	53%	27%	21%
1	61%	11%	28%
0.1	72%	4%	24%
0.01	79%	2%	20%

B.R. Buddemeier, 2011

Modeling Nuclear Detonation Casualties

IMPROVISED NUCLEAR DEVICE CASUALTIES FOR City “X”

Detonation Yield (KT)	**Recover (< 5% Fatalities)**	**At Risk (5 to 95% Fatalities) (Potential Survivors)**	**High Lethality (> 95% Fatality)**	**Immediate Fatalities**	**“Recover” vs “Immediate Fatal” Ratio**	**Potential Survivors %**
10	510,236	301,282	228,780	630,653	0.81	18.0%
1	265,934	258,142	190,856	278,169	0.96	26.0%
0.1	171,514	161,738	83,441	90,830	1.89	31.9%
0.01	64,655	69,149	43,064	9,393	6.88	37.1%

B. R. Buddemeier, 2011

10kT detonation, City "X"

Radiation Injury Only Morbidity	Radiation Dose w/wo Trauma	10kT in Times Square	Assigned mean mortality with care	Assigned mean mortality without care
Sub-clinical / Sub-therapeutic Range	< 0.5 Gy + mild trauma	187,374	1%	5%
	< 0.5 Gy + major trauma	2	8%	40%
	0.5-0.7 Gy	161,971	0%	0%
	0.5-0.7 Gy + mild trauma	17,116	1%	5%
	0.5-0.7 Gy + major trauma	5	8%	40%
	0.7 – 1.25 Gy	208,719	0%	0%
	0.7 – 1.25 Gy + mild trauma	32,875	1%	5%
	0.7 – 1.25 Gy + major trauma	42	8%	40%
Highly Survivable (Minimal Therapy)	1.25 – 3 Gy	190,045	8%	25%
	1.25 – 3 Gy + mild trauma	69,112	8%	25%
	1.25 – 3 Gy + major trauma	664	25%	100%
High Risk Injury	3 – 5.3 Gy	100,336	45%	73%
	3 – 5.3 Gy + mild trauma	50,691	45%	73%
	3 – 5.3 Gy + major trauma	1,543	73%	100%
Commonly Fatal	5.3 – 8.3 Gy	67,712	87%	98%
	5.3 – 8.3 Gy + mild trauma	41,778	87%	98%
	5.3 – 8.3 Gy + major trauma	2,661	100%	100%
Survival Rare	8.3 – 15 Gy	77,144	100%	100%
	8.3 – 15 Gy + mild trauma	66,695	100%	100%
	8.3 – 15 Gy + major trauma	6,679	100%	100%
	> 15 Gy	24,405	100%	100%
	> 15 Gy + mild trauma	23,121	100%	100%
	> 15 Gy + major trauma	3,599	100%	100%

The Queue Effect 2-5X mortality without care

The Queue Effect 2-5X mortality without care

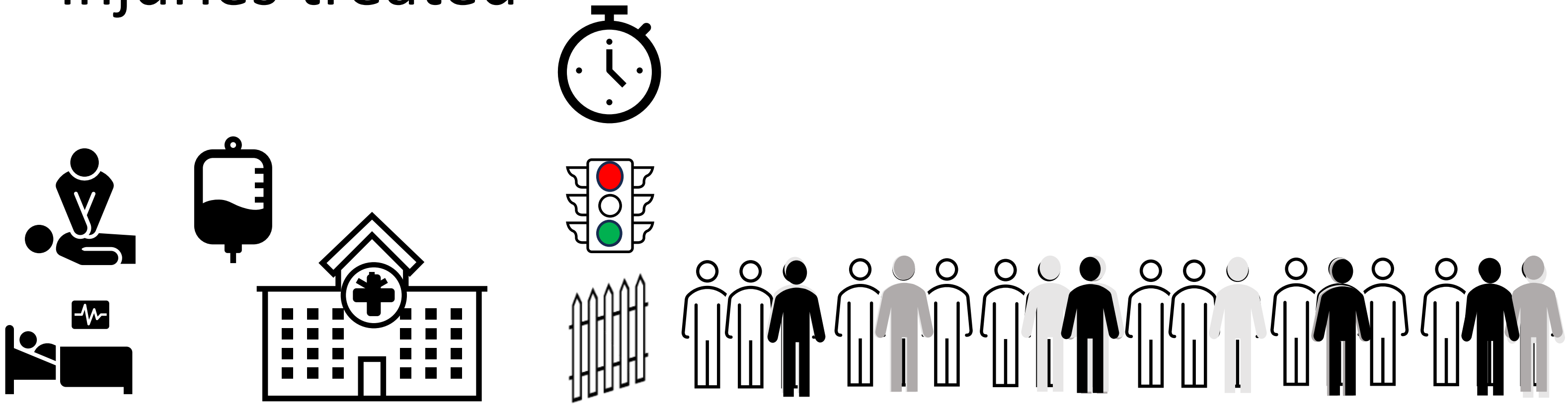
Injured Total: 1,334,291

Does not include prompt fatalities from trauma or burns

Modified: Buddemeier, B., Medical Needs in the Aftermath of Nuclear Terrorism, Lawrence Livermore National Laboratory, LLNL-PRES-677346, September 2015.

Survivor Bias in Nuclear Detonation Modeling

- Modeling assumes massive casualty numbers overwhelming traditional medical resources
- Difficulty in estimating radiation dose in severely injured (burn/trauma) lead to treating many non-survivors
- High numbers of “Died in Queue” while more serious injuries treated



Triage category affected by radiation dose and resource availability
RADIATION ONLY

Radiation Dose* (Gy)				
>10* Likely fatal (in higher range)	Expectant[3] Immediate[2]	Expectant[3]	Expectant[3]	Expectant[3]
6-10* Severe	Immediate[2]	Immediate[2]	Delayed[2]	Expectant[3]
>2-6* Moderate	Immediate[1]	Immediate[1]	Immediate[1]	Immediate[1]
Resource availability:	Normal	Good	Fair	Poor
Standard of care**:	Conventional	Contingency	Crisis	Crisis

Triage Category and Myeloid Cytokine Recommendation Category[X] with Combined Injury (Radiation Exposure ≧ 2 Gy and Trauma/Burn*)

Est. Radiation Dose (gray)	Moderate Trauma	Severe Trauma	Moderate Trauma	Severe Trauma
>10 Gy	Expectant[3]	Expectant[3]	Expectant[3]	Expectant[3]
≧6 Gy - 10 Gy	Delayed[2]	Expectant[3]	Expectant[3]	Expectant[3]
≧2 Gy - <6 Gy	Immediate[1]	Delayed[2]	Delayed[2]	Expectant[3]
	Resource Availability at Medical Venue: "Normal or Good" Standard of Care: Conventional to Contingency		Resource Availability at Medical Venue: "Fair or Poor" Standard of Care: Crisis	

The Lost Survivors

- Severely injured receive care prior to radiation dose estimate
  - Those later discovered to have radiation injury will have poor outcomes
  - Will block access for stable rad/trauma/burn patients
- Care delayed to moderate trauma/radiation injured (<6 Gy)
  - Population most likely to benefit from medical intervention
  - Greatest benefit seen if medical intervention in first 24 hours!
- What can be done for this population

  to **“stop the clock?”**

Triage Category and Myeloid Cytokine Recommendation Category[X] with Combined Injury (Radiation Exposure ≧ 2 Gy and Trauma/Burn*)

Est. Radiation Dose (gray)	Moderate Trauma	Severe Trauma	Moderate Trauma	Severe Trauma
>10 Gy	Expectant[3]	Expectant[3]	Expectant[3]	Expectant[3]
≧ 6 Gy - 10 Gy	Delayed[2]	Expectant[3]	Expectant[3]	Expectant[3]
≧ 2 Gy - < 6 Gy	Immediate[1]	Delayed[2]	Delayed[2]	Expectant[3]
	Resource Availability at Medical Venue: “Normal or Good” Standard of Care: Conventional to Contingency		Resource Availability at Medical Venue: “Fair or Poor” Standard of Care: Crisis	

Burn Blast Interagency Working Group

- Existing conflict in Eastern Europe drove concerns of potential nuclear weapon use or major radiation incident
- NNSA UTF received official demand signal concerning medical implications to the at-risk population
- A Burn Blast Interagency Working Group was commissioned to assess best possible medical countermeasure strategies
- At end of charter, members of original BBIWG transitioned to advisors during the build and deployment of their solutions

Burn Blast Interagency Working Group

- The BBIWG ultimately comprised 16 SMEs:
  - Burn surgeons,
  - Radiation injury specialists
  - Emergency physicians
  - Disaster medicine specialists
- Drawn from US academic medical centers, national laboratories, US and Ukrainian professional societies and study centers, US government agencies, non-governmental organizations, and NATO.
- Focused on field-based civilian providers working in **austere** conditions away from the radiation contaminated zones.

Burn Blast Interagency Working Group

- **BBIWG goals:**
  1. Do the **"most good"** for largest number of people with **survivable** injuries
  2. Facilitate the **discharge/rearward movement** of ambulatory victims
  3. **Maintain patients'confidence in** the country's ability to provide aid to all survivors

BBIWG Findings

- Extract mild/moderate injured from the hospital Queue
- Provide medical countermeasure to delay onset/severity of injury sequalae until able to be seen in less impacted region
  - Provide first dose of once weekly G-CSF
  - Provide symptom relieving oral medications for one week
  - Ensure wound receive initial cleansing and silver impregnated dressings
  - Provide patient guidance and instructions until able to reach advanced care
- Develop structured reception center and train attendants

Burn/Blast Interagency Working Group

- BBIWG designed specialized kits for burns/blast and acute radiation injured
  - Provide best option WHEN traditional hospital care not available
  - Capable of engaging patients separate from traditional medical facilities
  - 50 injured survivors per kit, including pediatric
  - Professional guidance on kit use is included

- Nuclear Detonation Medical Kits able to support 7500+ patients developed, built and deployed to priority locations

Deployment of Nuclear Detonation Medical

- Worked with regional medical leaders
- Established a deployment plan
- Logical issues addressed
- Supported adaptation by other organizations
- Provided training videos and fact sheets

Final hand-off of kits for 7500 casualties!

Thank you!
Questions?

REAC/TS

RadMed

REAC/TS

Radiation Emergency
Assistance Center/Training Site

https://orise.orau.gov/reacts/index.html

Back Up Slides

Concept of Utilization at Reception Center

Community Reception Centers:

- Triage
- **First aid/injury care**
- Contamination screening / decontamination (if needed)
- Radiation dose assessment
- **ARS Care**