THE FUNDAMENTALS OF NUCLEAR DISASTER PLANNING

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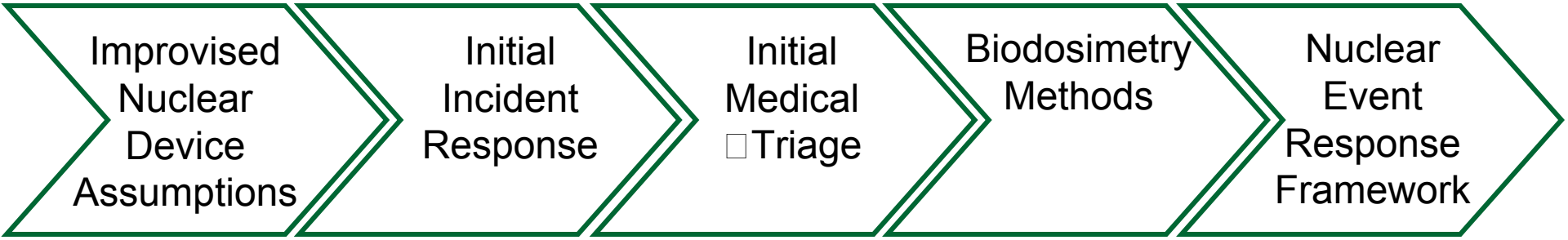
Overview


Improvised Nuclear Device Assumptions
Initial Incident Response
Initial Medical Triage
Biodosimetry Methods
Nuclear Event Response Framework

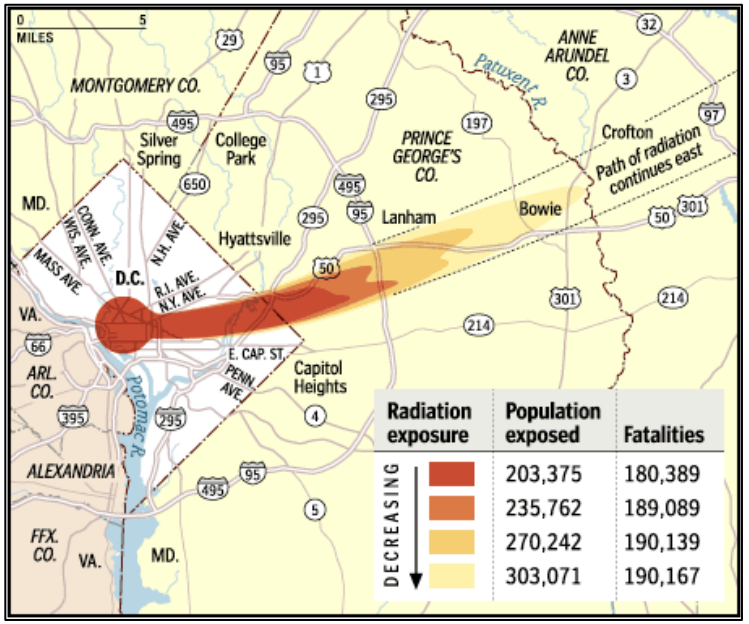
Improvised Nuclear Device Assumptions

National Planning Scenarios and Detonation impact

National Planning Scenarios
(10 kt Improvised Nuclear Device Detonation)

Affects wide geographical area

- Initial blast radius 1-5 km
- Fallout deposition thousands of km^2



Washington Post, 2007

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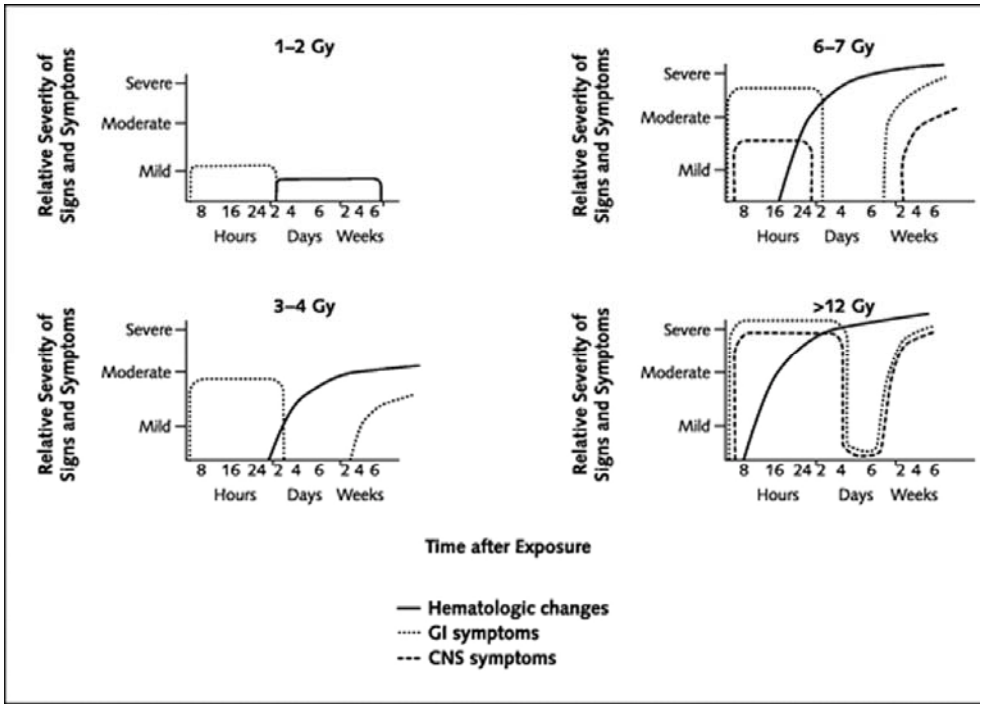
3. Waselenko JK, MacVittie TJ, Blakely WF, Pesik N, Wiley AL, Dickerson WE, Tsu H, Confer DL, Coleman CN, Dainiak N. Medical management of the acute radiation syndrome: Recom-mendations of the Strategic National Stockpile Radiation Working Group. *Ann. Intern. Med.* **140**, 1037–1051 (2004).

Improvised Nuclear Device Assumptions

Acute Radiation Syndrome (ARS)

- Hematologic changes
- Gastrointestinal symptoms
- Central nervous system symptoms



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Improvised Nuclear Device Assumptions

Adversary to Adversary (e.g. rogue state or terrorist)

- Attack comes without warning or notice
- Ability control time and location of detonation
- Maximize destruction and loss of life, create panic
- Hundreds of thousands directly affected from initial blast
- Millions displaced from fallout evacuation
- Years and hundreds of billions of dollars to recover

1. Gougelet RM, Rea ME, Nicolalde RJ, Geiling JA, Swartz HM . The view from the trenches: part 1 – emergency medical response plans and the need for EPR screening. Health Phys 98(2): 118-127; 2010.
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Improvised Nuclear Device Assumptions

Compounding Factors for Response

Challenges faced by first responders

- Overwhelming scene and needs for search & rescue, evacuation, and PRIMARY DECON
- Level of destruction, compromised command & control, degraded infrastructure and access denial
- Disruption to communications channels and infrastructure hindering coordination

Multiple mechanisms of injury

- Mechanical: translocation and crush
- Burns: prompt detonation and fires
- Radiation: exposure and contamination

Combined injury complicates medical management

Differing sources of radiation

- Initial: Prompt neutron and gamma
- Intermediate: short $t_{1/2}$ high energy gamma
- Long term: fallout long $t_{1/2}$ low energy gamma

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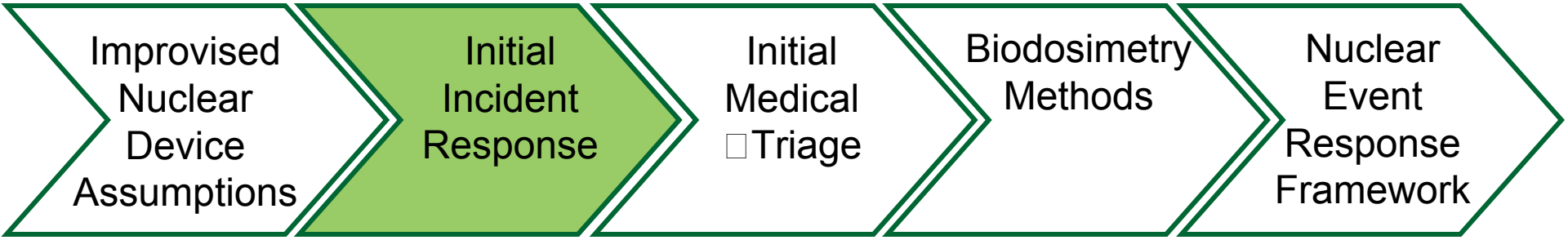
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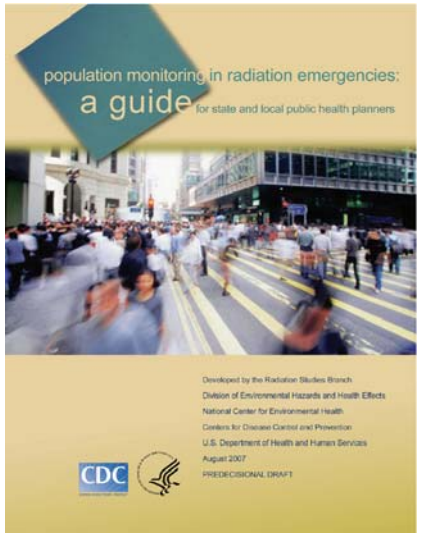
Initial Incident Response

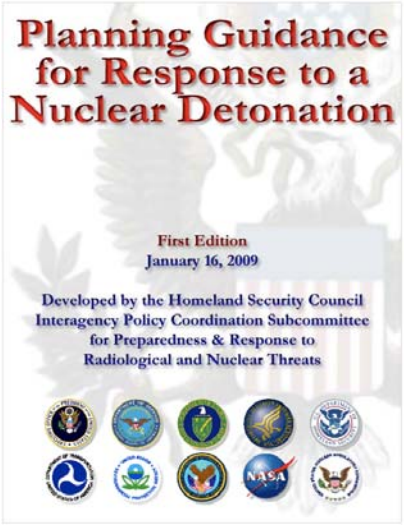
Mobilization and Community Based Response

Initial response by local community first responders (Fire, Police, EMS, MMRS, Mutual Aid)

Mobilization of federal resources requires 48-72 hours (NRF, NIMS, DMAT, NMRT, DoD)

Community based strategies for response





- CDC Population Monitoring Guide
- DHS Planning Guidance
- Modular Emergency Medical System

Use existing all-hazards systems to meet medical surge and mass care needs

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Initial Incident Response

Protecting the General Public – Immediate Actions

Shelter in place

- Buildings provide substantial protection from radioactive fallout
- Centers of multi-story buildings provide best protection
- Radiation levels highest first hour following detonation
- Possible need to shelter in place 24-48hrs

Evacuation

- Provide routes and traffic control for self-evacuation
- Identify and protect special needs populations
- Locate and remove the injured
- Protect response workers – ALARA

(**A**s **L**ow **A**s **R**easonably **A**chievable)

1. Armed Forces Radiobiology Institute. Medical management of radiological casualties handbook. Available at: http://www.afrri.usuhs.mil/outreach/pdf/2edmmrchandbook.pdf. Accessed February 6 2010.
2. U.S. Department of Health and Human Services (HHS). Radiation event medical management, U.S. Dept. of Health and Human Services – REMM. Available at: http://www.remm.nlm.gov/. Accessed Februar y 6 2010.
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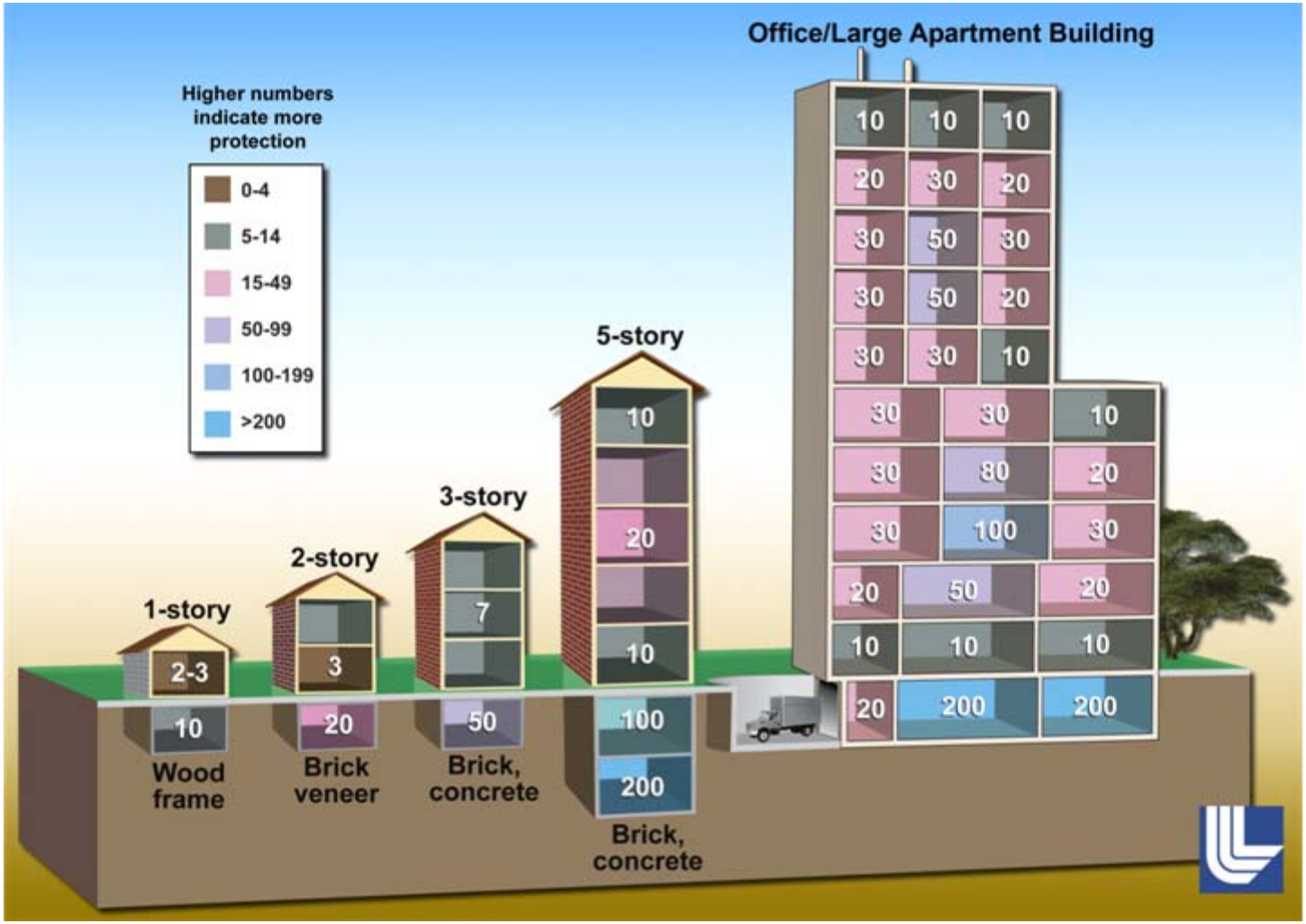
Initial Incident Response

Shelter in Place – Building Protection



1. Buddenheimer, B. Lawrence Livermore National Laboratory

Initial Incident Response

The “Concerned Citizens” – Complicating Response and Triage

Many patients not ill or injured from event will become anxious, triggering underlying medical conditions

These unaffected will seek medical assistance and treatment in addition to those who are truly ill or injured

Ratio of concerned citizens to unaffected likely between **5-to-1** to **10-to-1**

Similarity between signs and symptoms for ARS and psychological distress

- Nausea and vomiting typical early symptoms of ARS
- Nausea and vomiting also common for patients in psychological distress
- Effect of close proximity to others with nausea and vomiting

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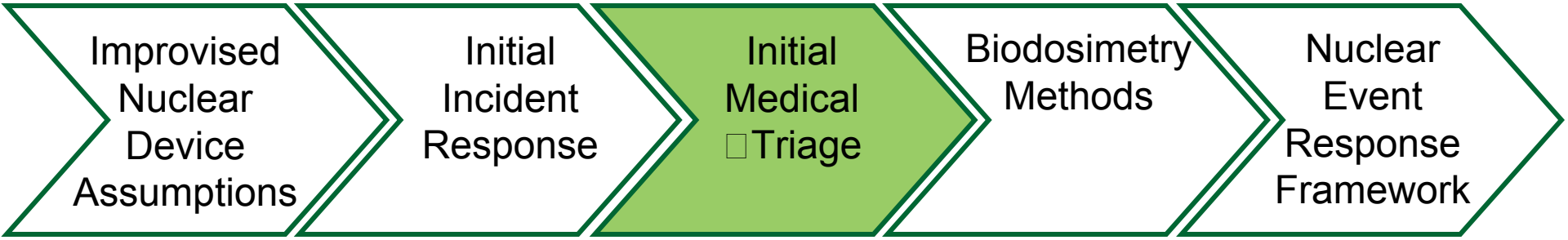
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Initial Medical Triage

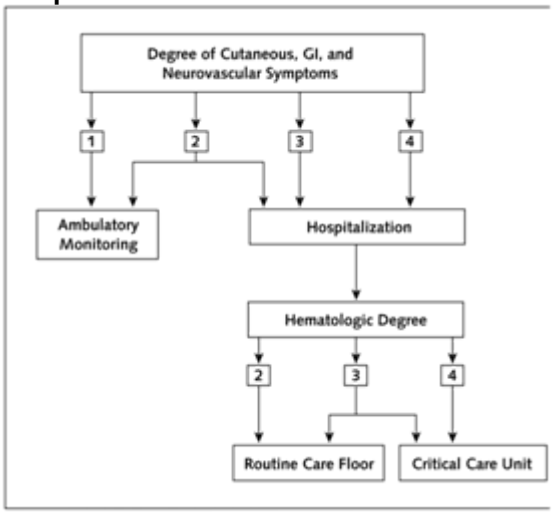
Dose Screening and Triage based upon signs and symptoms

Time to emesis

- Dose estimation based upon time to vomit (minutes to hours) post-exposure
- Imprecise with high false positive rate

Clinical signs and symptoms

- Triage based upon time-developed signs and symptoms
- Hematologic monitoring of lymphocyte depletion



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4. Armed Forces Radiobiology Institute. Medical management of radiological casualties handbook. Bethesda: Armed Forces Radiobiology Research Institute (AFRRI); 2003.

Initial Medical Triage

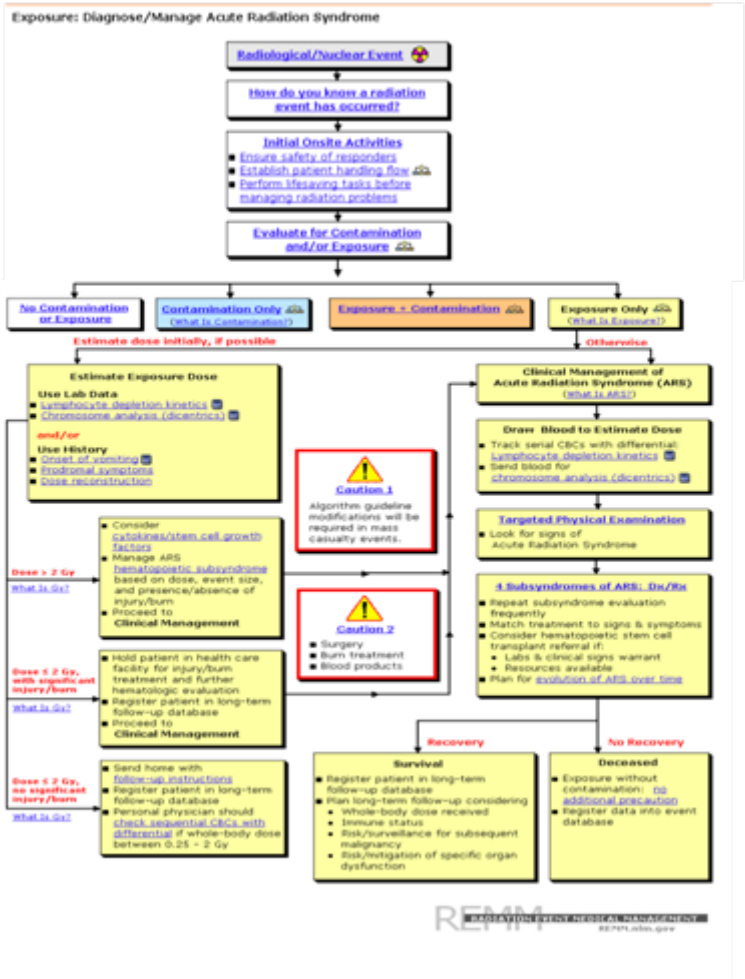
Medical Management Acute Radiation Syndrome - REMM

External decontamination and management & treatment of internal contamination takes precedent and follows separate process

Estimate Exposure dose using history, clinical signs & symptoms, and **biodosimetry**

2 Gy cutoff for those most likely require Acute Radiation Syndrome management

Considerations in process for combined injury, monitoring of symptoms & lymphocyte depletion and ARS subsyndromes



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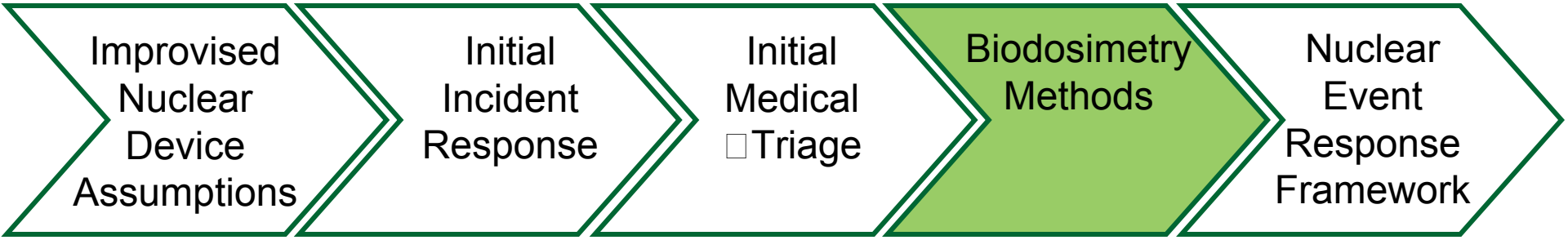
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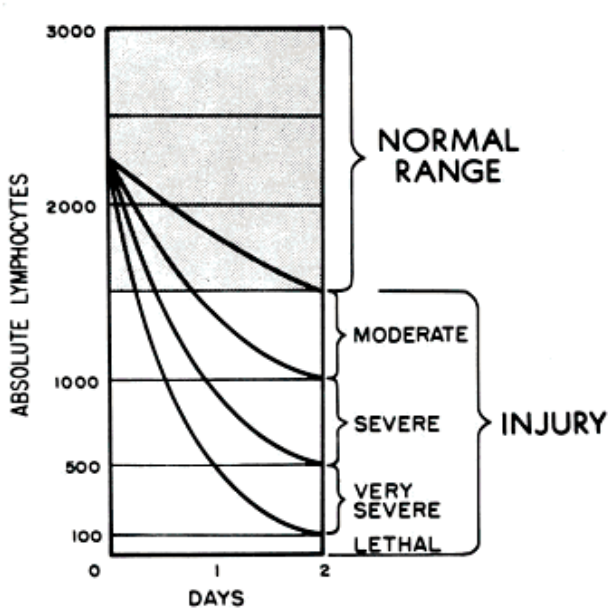
Biodosimetry Methods

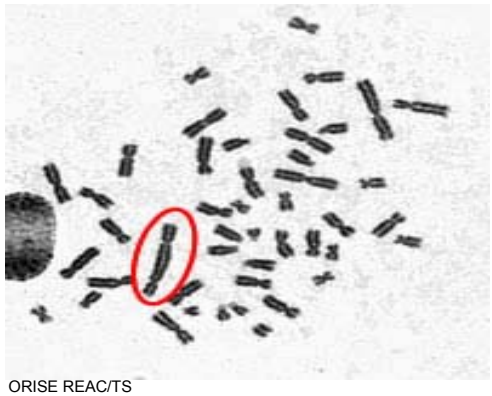
Desirable Qualities for Population Screening

Lymphocyte depletion kinetics



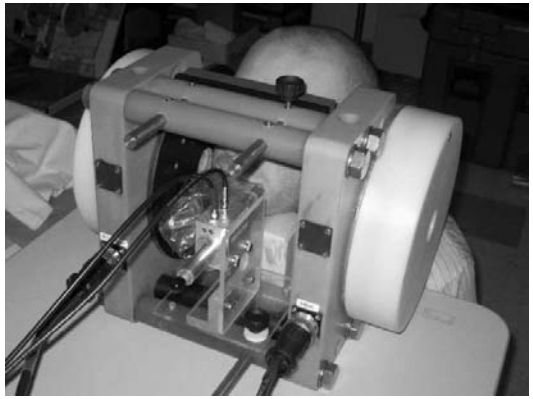
Andrews et al., 1965

Cytogenetics (physiologic markers)



ORISE REAC/TS

Physical methods (EPR, OSL, others)



Electron **P**aramagnetic **R**esonance
Optically **S**timulated **L**uminescence

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2. Oak Ridge Institute for Science and Education Radiation Emergency Assistance Center/Training Site. Cytogenetics biodosimetry at ORISE – The process. Available at: http://orise.orau.gov/reacts/cbl-process.htm. Accessed February6 2010.

Biodosimetry Methods

Desirable Qualities for Population Screening

- Non-invasive
- Based on a physical process
- Uses the subject's tissue as the physical dosimeter
- Not affected by biological processes such as stress or repair mechanisms
- Not affected by concurrent injuries or burns
- Applicable to individuals
- Can provide output immediately after the measurement
- Measurements at any interval after irradiation up to several weeks
- Unaffected by dose rate
- Provides dose measurements at clearly delineated positions
- Can operate in a variety of environments
- Can be operated by minimally trained individuals
- Minimal cost per measurement

1. Wilcox DE, He X, Gui J, Ruuge A, Li H, Williams BB, Swartz HM. Dosimetry based on EPR spectral analysis of fingernail clippings. Health Physics 98(2): 309-317; 2010.

Biodosimetry Methods

Desirable Qualities of EPR Dosimetry

- **Non-invasive**
- Based on a physical process
- Uses the subject's tissue as the physical dosimeter
- **Not affected by biological processes such as stress or repair mechanisms**
- Not affected by concurrent injuries or burns
- Applicable to individuals
- **Can provide output immediately after the measurement**
- Measurements at any interval after irradiation up to several weeks
- Unaffected by dose rate
- Provides dose measurements at clearly delineated positions
- **Can operate in a variety of environments**
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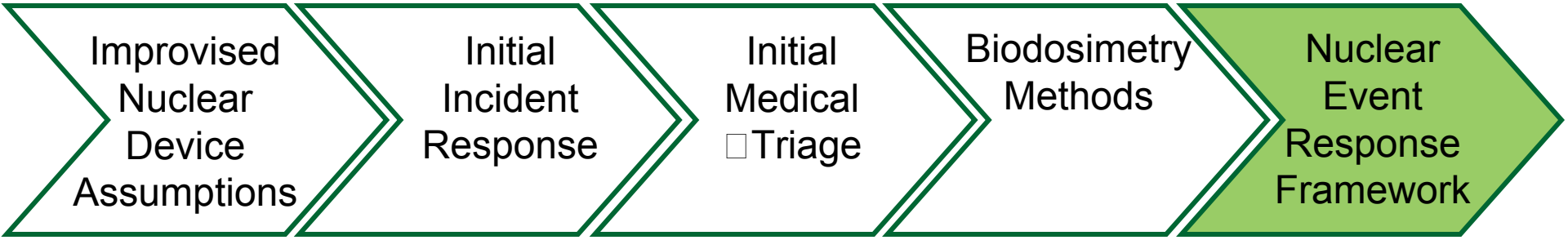
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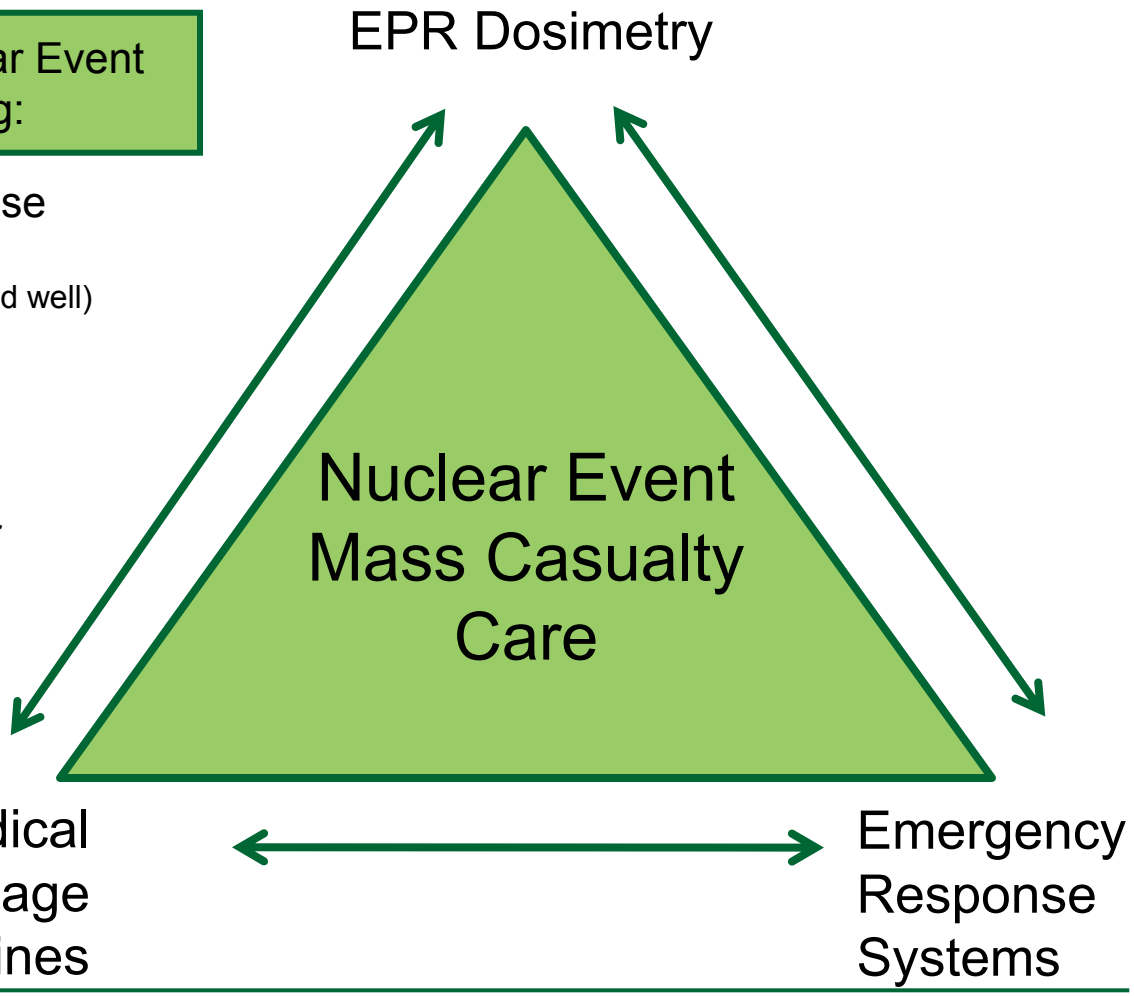
Nuclear Event Response Framework

An Interrelated System

An Interrelated System for Nuclear Event Mass Casualty Care Incorporating:

- Guidelines for ARS exposure dose screening and triage
(effectively screen those affected from worried well)
- Community, local and federal systems for emergency response
(patient tracking, electronic medical records)
- Biodosimetry methods suited for Population screening such as EPR dosimetry



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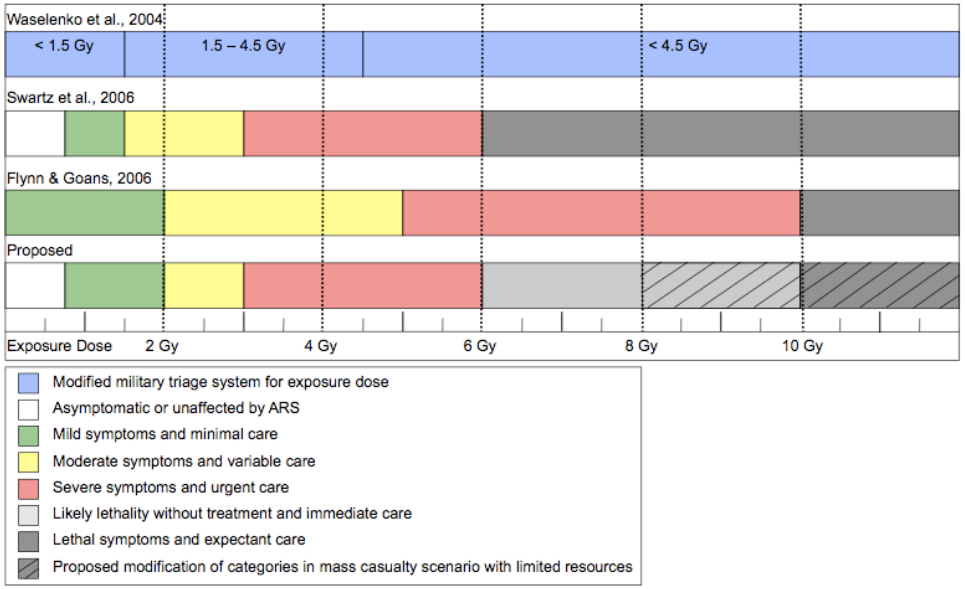
Nuclear Event Response Framework

ARS Medical Screening & Triage Guidelines

- Revision to broad NATO triage categories (<1.5 Gy, 1.5-4.5 Gy, <4.5 Gy)
- Considers qualities of biodosimetry methods such as EPR dosimetry (high accuracy, high throughput, immediate result)
- Correlates exposure to expected symptoms and appropriate care setting
- Balance available medical surge needs with survival likelihood in mass casualties



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Nuclear Event Response Framework

Emergency Response Systems

Emergency triage and pre-hospital treatment
(Community response centers, Screen concerned citizens, intake affected into EMS system)

Medical surge
(Resource allocation, system capacity, ARS screening by non-medically trained operators)

Medical equipment and supplies – management and distribution
(SNS, portability & consumable materials)

Integration of bidosimetry methods
(Exercise based evaluation process, accuracy, cycle time)

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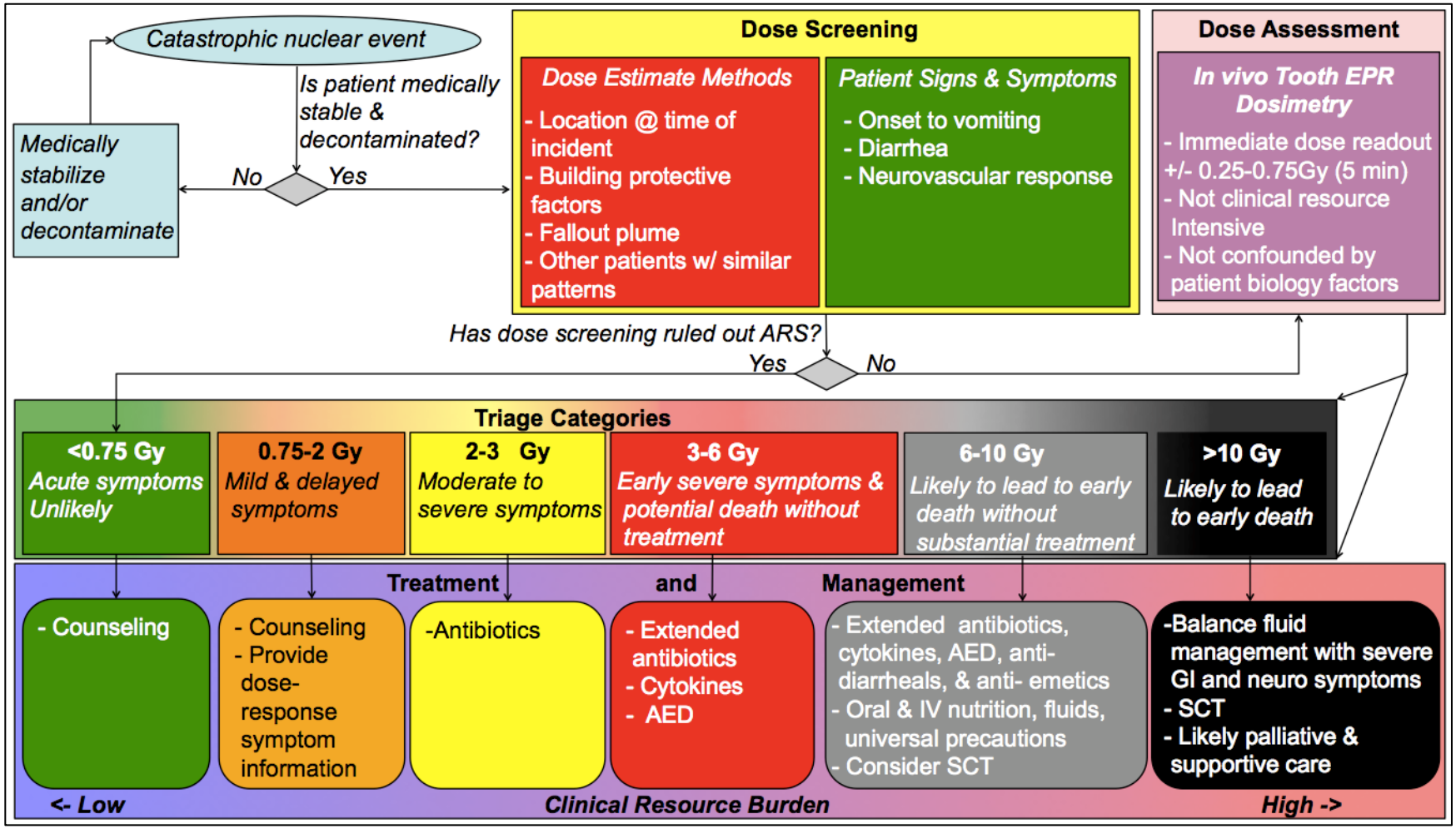
Nuclear Event Response Framework

Population Based Screening Process Using EPR Dosimetry Screening



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Nuclear Event Response Framework

Key Priorities

An effective response to an overwhelming disaster

Must move quickly to save lives and protect the public

Citizens must become responders and facilitators for the effort

Surround the affected area with responders to receive evacuees and safely decontaminate & medically manage

Establish effective tracking mechanisms for long term medical needs and employ national systems for treatment and care

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QUESTIONS?

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