School of Public Health and Community Medicine

The CBRNE Prehospital Major Incident Environment - Recent Advances and Persistent Gaps Impacting Casualty Treatment, Medical Operations, and Decontamination Operations

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Scope

- Introduction
- Prehospital CBRNE environments
- Prehospital CBRNE medical approaches
- Casualty treatment
- Medical operations
- Decontamination operations
- Conclusion

Introduction

CBRNE medicine is not simply toxicology in the field – unique features and considerations

Siloed within specialist organisations

Traditional focus of CBRNE Defence in reducing human impacts has been:

- Detect, warn and avoid
- Medical treatment and countermeasures
- PPE/Protection

Gradually increasing likelihood of population exposures to CBRNE agents

All-hazards approaches hold sway

CBRNE Environment - Chemical Threats

Nerve agents

- E.g. Tabun, Sarin, Soman, VX

Pulmonary Oedemagens

- E.g. Chlorine, Ammonia, Phosgene

Cyanides

- E.g. Hydrogen Cyanide, Cyanogen Chloride

Vesicant agents

- E.g. Mustard Agents, Lewisite

Halabja, Iraq, 1988. G Series NA

Jonestown 1979 - Potassium Cyanide

WWI - Phosgene

WWI – Mustard (ocular injury)

CBRNE Environment - Chemical Threats

Toxic Industrial Chemicals and Materials

- Wide range of possible compounds
- Most commonly Pulmonary Oedemagens or Vesicants

Incapacitating Agents

- E.g. Opiates, Anaesthetics, Pharmaceuticals, Irritants

Riot Control Agents

- E.g. Tear Gas, Pepper spray

CAN KILL

Bhopal 1984. Methyl-isocyanate and other agents

Moscow Theatre Siege 2002. Fentanyl ± Halothane

Tear Gas

CBRNE Environment – Biological Threats

Bacterial Agents

- E.g. Anthrax, Plague

Viral Agents

- E.g. Viral Haemorrhagic Fevers (Ebola), Smallpox

Fungal Agents

- T3 Mycotoxin

Toxins

- E.g. Botulinum neurotoxin, Clostridium toxin, Staph Enterotoxin B

Exotic/Novel/Chimeric

- Endocrine modulators, Neuropeptides, Transgenics, Nanoagents

Anthrax (cutaneous here)

Smallpox

Botulism

CBRNE Environment – Radiological Agents

The University Seven:

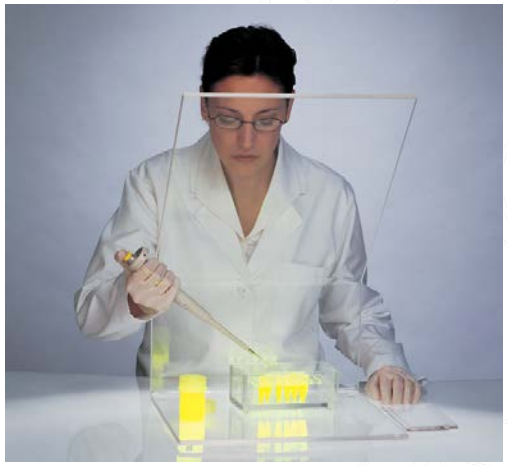
- ^{3}H, ^{14}C, ^{32}P, ^{60}Co, ^{125}I, ^{131}I, ^{252}Cf
- Isotope labelling/Research purposes (e.g. biochemistry)

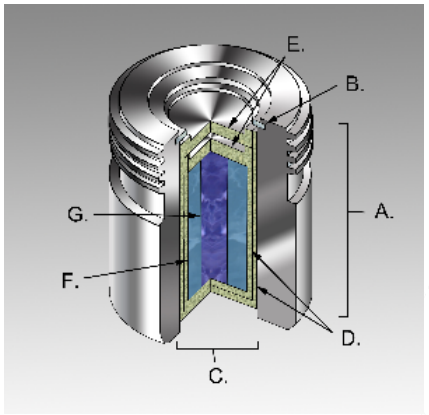
The Industrial Three:

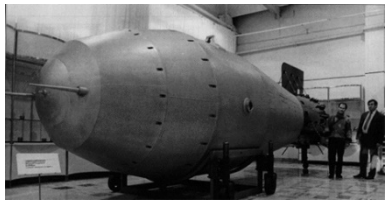
- ^{192}Ir, ^{137}Cs, ^{60}Co
- Industrial scale X-Rays, Food Sterilisation

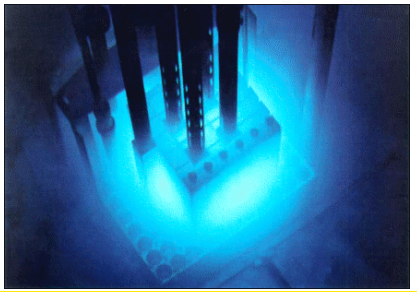
The Military Four:

- ^{3}H, ^{235}U, ^{239}Pu, ^{241}Am
- Nuclear Weapons Development and Manufacture









CBRNE Environment - Explosive Threats

- Improvised explosive devices
- Formed charges
- Certain forms of mines
- Area effects conventional weaponry
- Indirect fires
- Focussed energy devices

Individual vs Systems

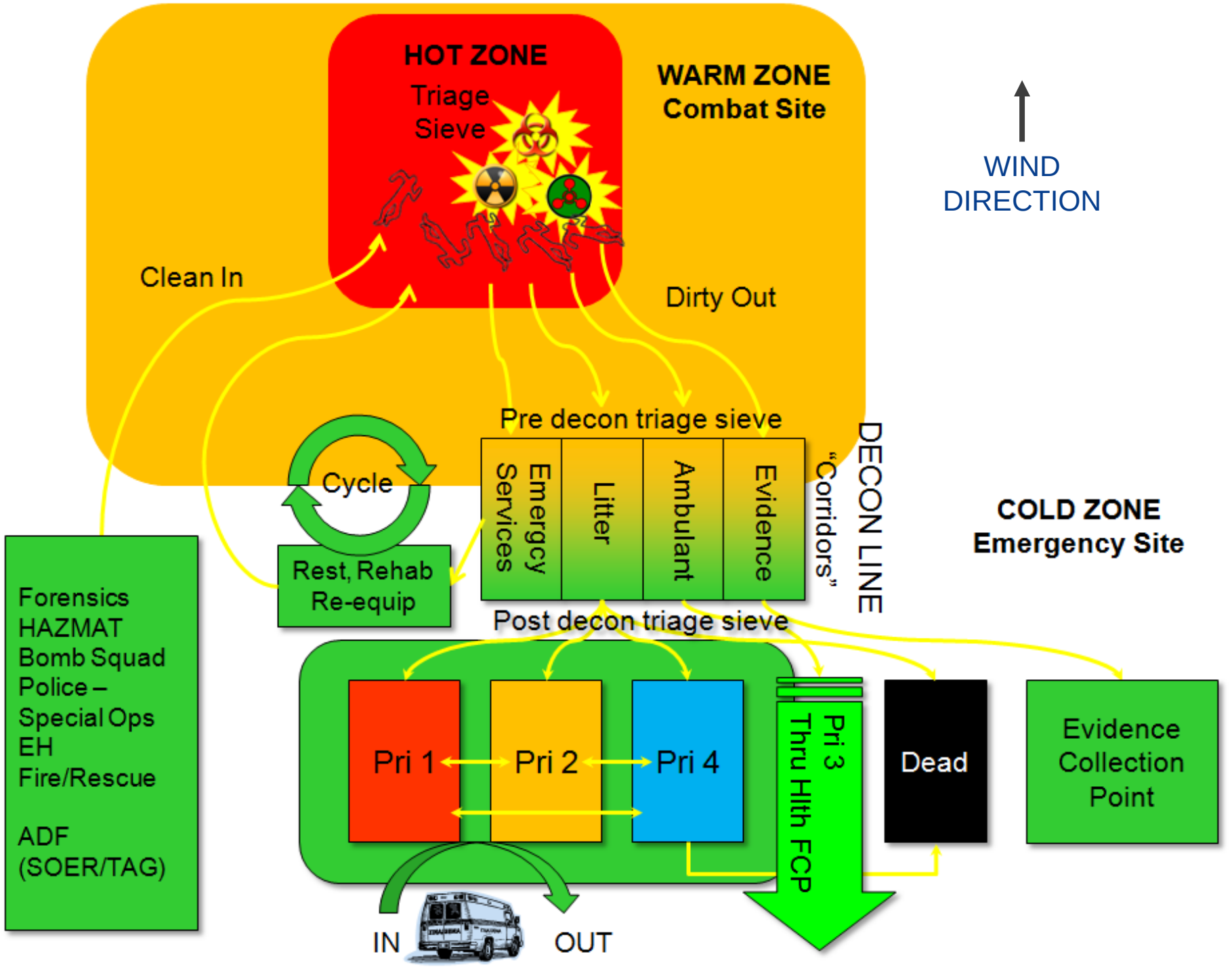
CBRNE Medicine usually discussed at an individual casualty level, in isolated context

Factors relating to health system integration poorly considered:

- Resource requirements
- Personnel requirements
- Training requirements
- Multiple casualty situations
- Managing novel or unknown agents
- Decontamination contexts
- Outcome measures
- Test and evaluation
- Ethics and Law

The Prehospital environment

- Austere
- Remote
- Complex
- Exposed
- Variable


HOT ZONE
Triage Sieve
WARM ZONE
Combat Site
WIND DIRECTION
Clean In
Dirty Out
Pre decon triage sieve
Cycle
Rest, Rehab Re-equip
Emergcy Services
Litter
Ambulant
Evidence
"Corridors"
DECON LINE
COLD ZONE
Emergency Site
Forensics
HAZMAT
Bomb Squad
Police – Special Ops
EH
Fire/Rescue
ADF
(SOER/TAG)
Post decon triage sieve
Pri 1
Pri 2
Pri 4
Pri 3
Thru Hlth FCP
Dead
Evidence Collection Point
IN
OUT

Additional Siting Considerations

Plume

WIND DIRECTION

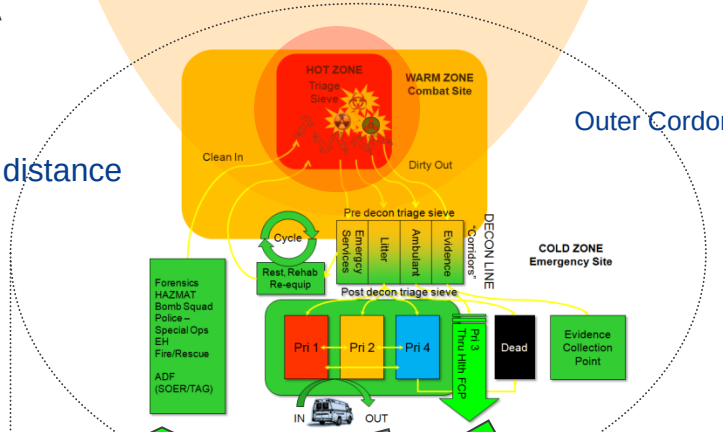
Crowd Control

Rubber neckers

(un)helpful volunteers

On site personnel: Ultimately 100s

Variable distance



ADF Comd

Fire Brigade Equip And Access

Site Control Multi Agency Incident Management Team

EOC

Litter

Walking

Road evac

RWAME

Assembly Area

Parking

Police, Holding

Evac Area

Life Support (Food, Water, Lighting)

Logistics

Emergency Response Risk Management

- Achieve risk reduction while completing the mission
- Minimising the modifiable risk
- Accepting the unmodifiable risk
- Avoiding exposure altogether if possible
- Appropriately using risk controls
- Minimising harms

Protection Factors

Pre event

- Physical training
- Medical training
- Point of injury countermeasures
- Vaccinations
  - Pathogens
  - Toxins
- Casualty Management System rehearsals
- Emergency treatments in place
- Knowledge updates

Peri/Post Event

- Rapid countermeasures
- Rapid diagnosis
- Rapid decontamination
- Rapid evacuation
- Rapid stabilisation
- Definitive Care
- Identify lessons learnt
- Adjust to improve:
  - Medications
  - Training
  - Doctrine
  - Command decision loop
  - Tactics and Techniques

CBRNE Medical Risk Reduction Strategies

The CBRN Hostile Threat Environment

- Chemical agents
  - CWA
  - TIC/TIMs
- Biological agents
  - BWA
- Radiological agents

- Any other noxious environmental threat

UNACCEPTABLE RISK

Intrinsic Measures

- Natural immunity
- Natural physical protective measures
- Physiological mechanisms
- Protective behaviours, both automatic and otherwise

Deliverable Measures

- Pre-event:
  - Information Systems
  - Early Warning
  - Medical Force Protection
  - Training and Drills
  - Clinical Skills Training
  - Command Training
  - Logistics Planning
- Post-event:
  - IPE
  - Countermeasures
  - Casualty Regulation Systems
  - Emergency Treatment
  - Evacuation
  - Risk Analysis and Decision Support

SYSTEMATIC RISK REDUCTION

Outcomes Effects & Capabilities

- Emerg Response:
  - Force Projection
  - Sustainability
  - Mission options
  - Predictability
  - Readiness
  - Operational risk reduction
  - Survive and operate
- Medical:
  - Improved survival
  - Early Return to Duty
  - Decreased health logistic burden
  - Improved long term rehab outcomes

ACCEPTABLE RISK

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The Prehospital Environment

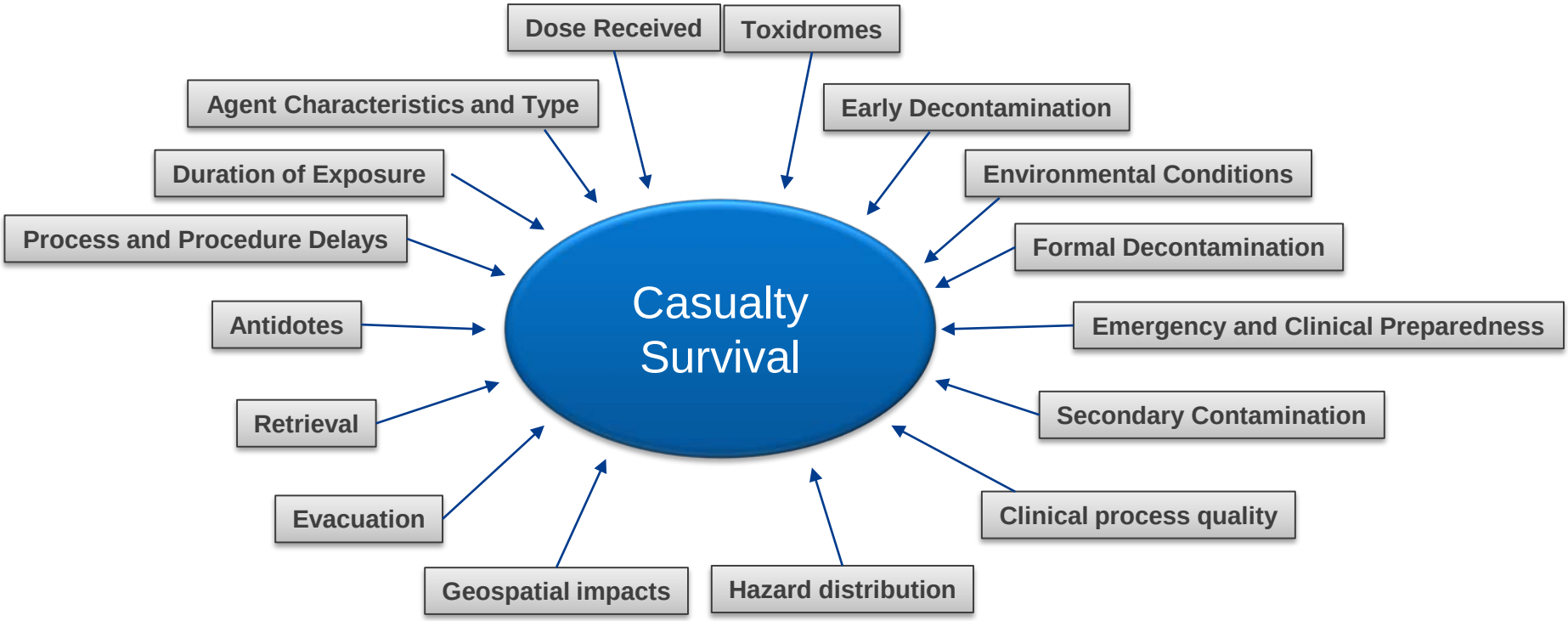
Austere (i.e. resources):

- Needs will not match available resources:
  - Personnel
  - Equipment
  - Consumables
  - Transport Assets
  - Environmental conditions
  - Logistic support
  - Bystanders
- Plays for time may be unavailable – leading to forced decision making

Remote (i.e. time):

- Impacts on event occurrence times:
  - Time to self/buddy aid
  - Time to initial evaluation
  - Time to triage
  - Time to retrieval
  - Time to initial decontamination
  - Time to evacuation to higher care
  - Time to key treatment Decision Points
- Impacts on processes involving delay:
  - Duration of initial treatment
  - Duration of retrieval
  - Duration of decontamination
  - Duration of resuscitation/treatment
  - Duration of evacuation

Factors influencing casualty survival



Psychological Reaction

Psychological Impacts

Comorbidities

Combined injuries

Paediatrics

Communication

Genetics

Resilience

Social Factors

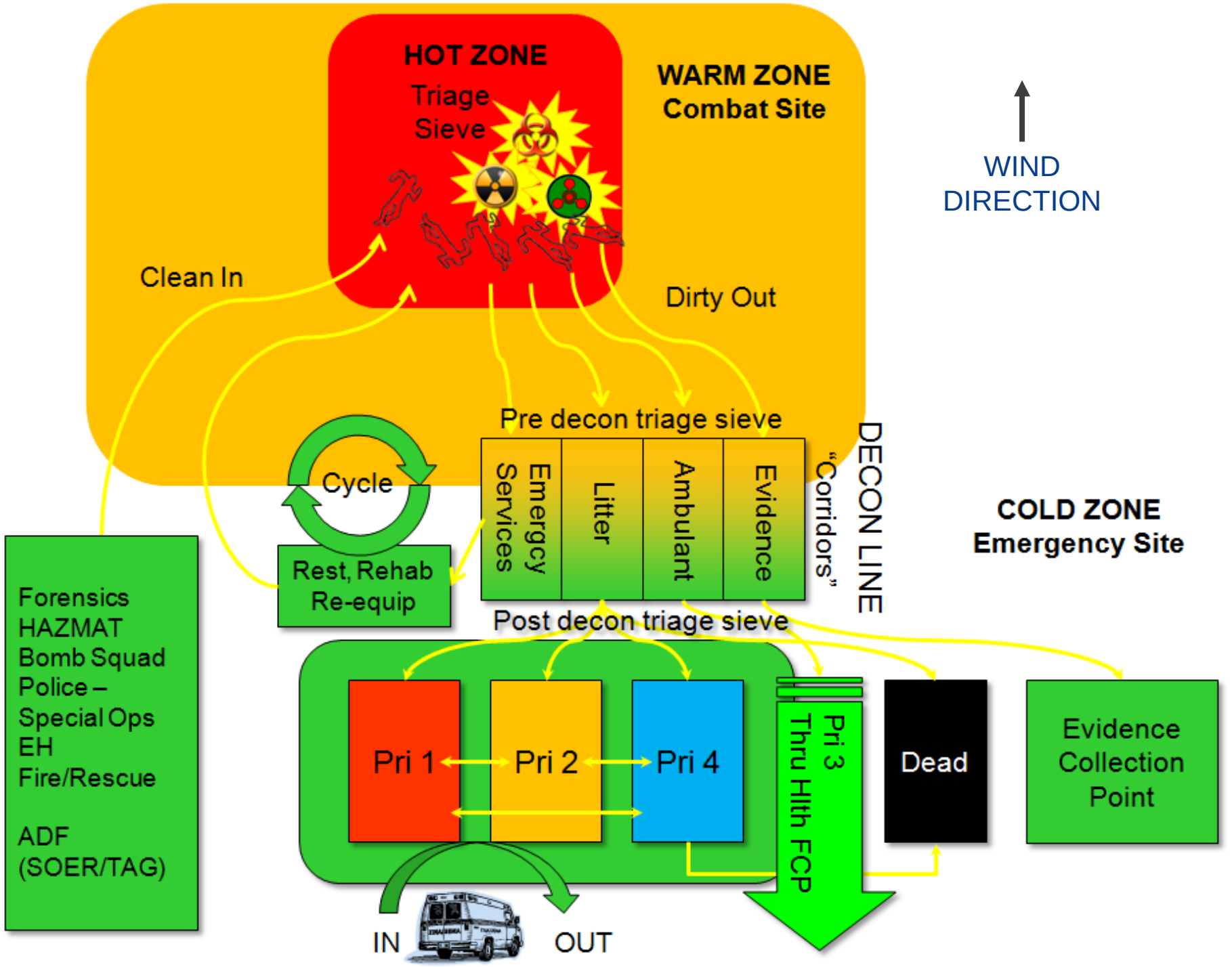
Vulnerable populations

Pregnancy

Logistics and Resources

Non expert training

Cultural Factors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Thru Hlth FCP
Dead
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IN
OUT

Generic Concept of Prehospital Management Per patient

Applicable to a variety of CBRNE incident contexts:

- HAZMAT
- TIC/TIM
- Biological
- Chemical weapon
- Other (combined, complex, novel)
- Unknown exposure

Applicable in a variety of contexts

- Humanitarian Assistance
- Disaster Relief
- Combat
- Civilian
- Mass gathering

Exposure

Self/Buddy Aid

Removal from further exposure

Initial Medical Care

Initial Decontamination

Retrieval

Formal Decontamination

Handover to further care

Key Concepts for CBRNE Med Ops

PRE RELEASE/EVENT

Know your enemy

- Robust information gathering and analytical capability (surveillance)
- Broad and deep technical training continuum

Build resilience and resistance

- Selective vaccination
- Medical countermeasures
- Rigorous standardised survival training

Install risk controls

- Avoidance strategies
- Technology
- Better IPE
- Operational and Risk planning

POST-PERI RELEASE/EVENT

Chain of Survival

- From Point of Injury to Definitive Care

Prevent Further Casualties

- Do the most good for most casualties
- Avoid exposing other personnel
- Protect medical workforce

Ensure risk controls work

- Monitoring systems
- Accountability
- Feedback loops

Typical Prehospital CBRNE Medical Approaches

Personal (carried on person):

- Nerve agent antidotes
  - Oxime (various types) im
  - Atropine im
  - Diazepam im
- Cyanide antidote
  - Amyl nitrite
- Trauma pack
- Hasty decontamination options

With accompanying medical support:

- Forward medics and complex retrieval
- Resuscitation
- Critical care stabilisation and transportation
- Wound debridement and decontamination
- Various antidote options
- Monitoring and testing
- Follow on medications
- Evacuation

Key Concepts in Austere Environments

Logistics

- Canisters/Respirator supplies
- Individual Protective Ensemble
- Replacements

Personnel

- Fatigue
- Heat Stress
- Psychological Effects
- Task overload

Medical Resources

- Mass Casualty Environment
- Inadequate resources
- Contaminated equipment

Evacuation

- Implications of contaminated evac
- Decontamination standards
- Deteriorating or unstable casualties

Mortuary Affairs

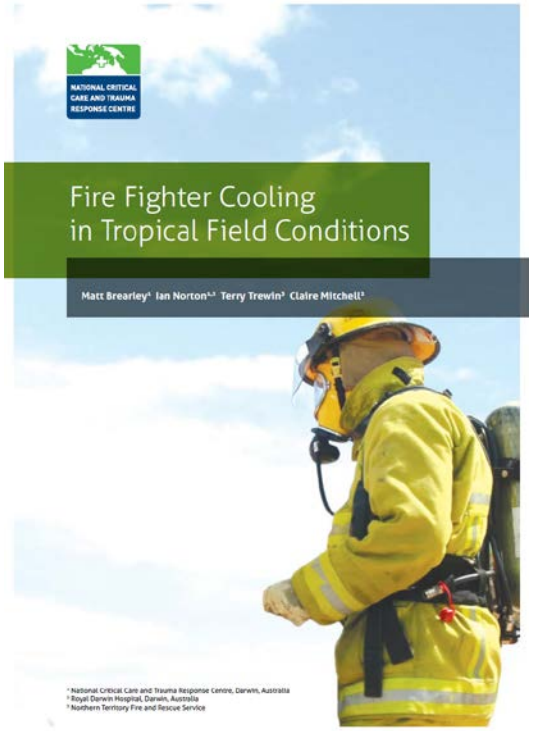
- Repatriation
- Evidence preservation, Legalities

Prehospital CBRNE systems performance

Clinical Task or Event	Response System Prepared & Tailored	Response System Prepared Generic	Response System Unprepared Tailored	Response System Unprepared Generic
Self Aid	Drilled Very rapid	Rapid	Standard	Minimal
Buddy Aid	Drilled Very rapid	Rapid	Standard	Minimal
Removal from further exposure	Standard	Standard	Standard	Delayed
Initial Medical Care	Targeted	Standard	Standard	Standard
Initial Decontamination	Standard	Limited	Standard	Minimal
Retrieval	Selective Rapid	Standard	Delayed	Very Delayed
Formal Decontamination	Rehearsed Rapid	Standard	Delayed	Very Delayed
Handover to further medical care	Rehearsed Rapid	Standard	Standard	Standard
System Flexibility to Novel Challenge	Medium	High	Medium	Low

Tropical Conditions

- Temperate water immersion is more effective in lowering core temperature than shade, crushed ice ingestion or use of a misting fan during rest periods.
- For protracted incidents requiring strenuous work, a rehabilitation centre with medical support, hydration and cooling inclusive of temperate water immersion is recommended.
  - Issues:
    - Practicality
    - Cost
    - Mission impacts
    - Resource requirement
    - Personnel requirement
    - Support requirement
    - Unintended systems effects



Current Assumptions

- All hazards approaches to CBRNE incidents are sufficient to manage such incidents well
- Point of injury to formal decontamination care systems will function across the range of CBRNE exposures and agents
- The deterioration or death of casualties during prehospital care is manageable within existing frameworks
- Prehospital providers are adequately trained, resourced and prepared to manage the range of prehospital CBRNE casualty deterioration pathways possible
- Variation in CBRNE expertise in clinicians is insignificant, and can be addressed with just in time training
- Generic care prior to arrival of specialised CBRNE assets is sufficient to prevent mass casualties.
- Variation in standards of care from usual business during a CBRNE MCI incident will be minimal
- CBRNE MCI standards of care have been developed, and are widely understood, within jurisdictions at risk of major incident.
- Centralised decision making on major incident operational and medical policies applicable in CBRNE incidents is effective.
- Current clinical approaches to CBRNE casualties provide sufficient differentiation, across the range of casualty severity, to prioritise scarce medical resources in an MCI context

Decontamination Operations

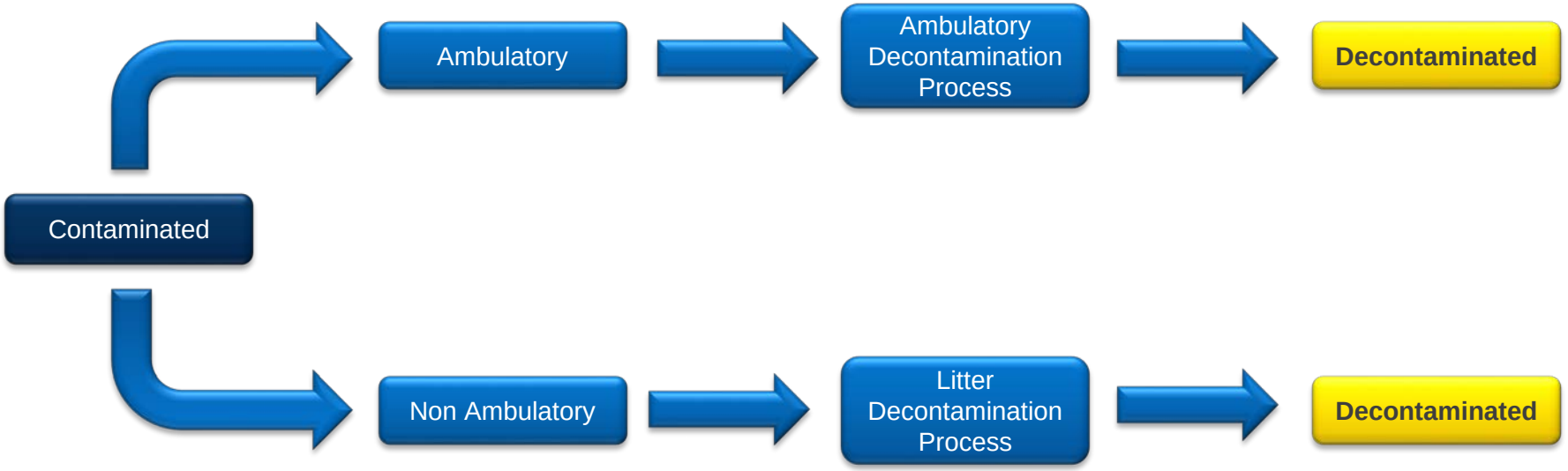
Value:

- Medical necessity
- Reduces spread
- Returns personnel to service
- Returns equipment to service
- Psychological effects
- Scene control
- Investigation efforts
- Saves resources

Wikipedia commons

Kaszeta, 2012

Decontamination in policy



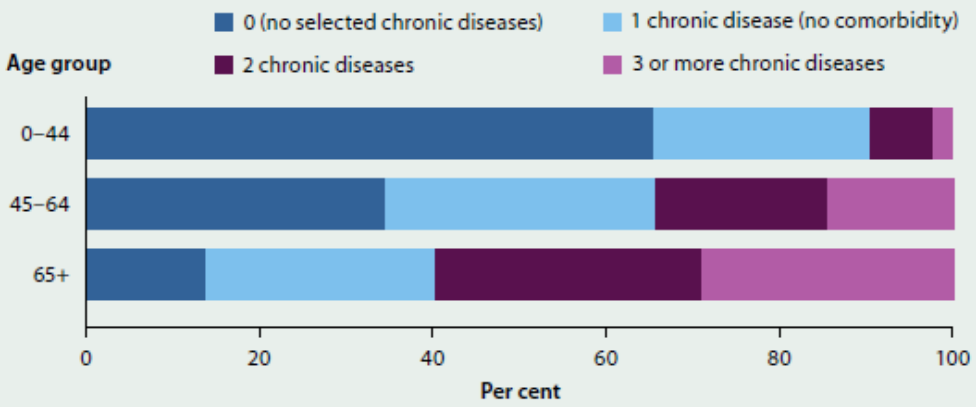
Population assumptions:

- “normality”
- Nil cultural variation, obedient and adherent
- Fit young adult population (male)
- Minimal medical comorbidities
- Once process started, not interrupted

Decontamination reality - Population

Civilian population norms:

- Multiple comorbid conditions
- High prevalence of mental illness
- Varied education levels
- Varied literacy levels
- Elderly
- Disabled
- Children
- Culturally diverse
- Obesity
- Culturally sensitive situations/issues
- Personality and mental illness



Plus management of:

- Prisoners
- Management of dead bodies
- Personal items
- Perpetrators
- Emergency Services/Key Staff

ABS 2015. National Health Survey: first results 2014–15. ABS cat. no. 4364.0.55.001. Canberra: ABS

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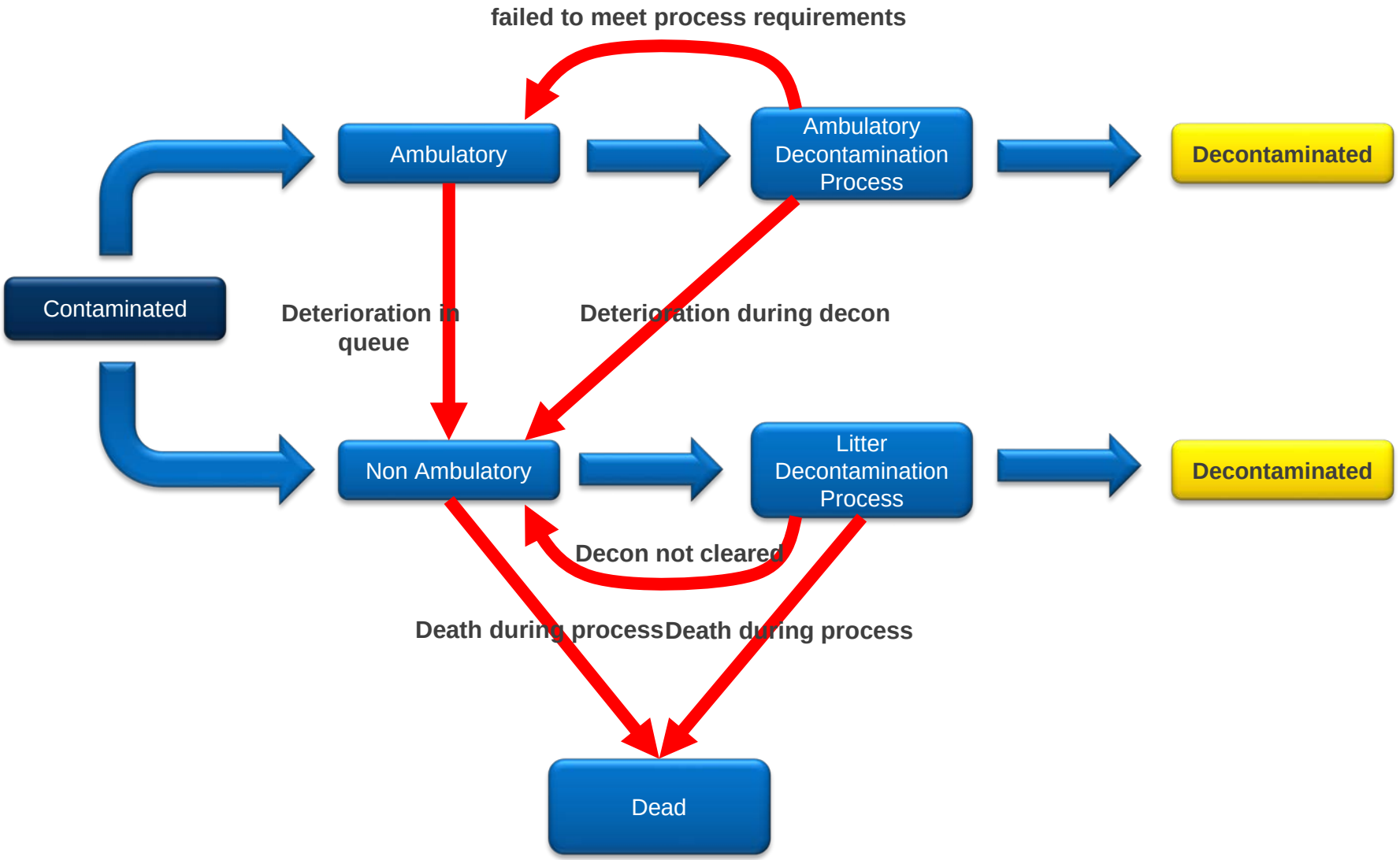
Decontamination reality - operators

- Preparedness and fitness
- Comorbid conditions
- Exposure/Environment
- Heat injury
- Psychological impact
- Worried well
- Special populations
- Rapid deterioration
- Large numbers of litter casualties
- Rotation of personnel
- Equipment and medical resource resupply
- Passage of essential medical information

USAF

Decontamination reality



Advances and Gaps

Recent Advances:

- Automation processes
- Self contained systems
- EMR
- Novel Antidotes
- Active Cooling
- Physiological Monitoring
- Decon evaluation techs
- Modelling and Simulation to answer operational questions
  - Agent Based/Hybrid
  - Combinations of real world and computational

Persistent Gaps:

- Decon line command and control
- Medical care during decon
- Medical device swap out
- Optimum operator numbers
- Logistics support options
- Waste water management
- Complex injury management
- Handling of in queue casualty decline or collapse
- Handover standards

Conclusions

- Prehospital CBRNE environments are unique
- Technical solutions have been research focus over many years
- Policy is based on assumptions – de-linked from reality of CBRNE environment
- Major gaps:
  - Exploring performance of prehospital CBRNE systems under real world conditions, or closer to real.
  - Developing new test and evaluation paradigms
  - Operations and technical research approaches
- New technologies are providing some solutions e.g. computational modelling
- A return to traditional methods are also required (but come with costs)

WADEM CBRNE Special Interest Group

- Join the WADEM CBRNE SIG
- Specialist CBRNE Medicine stream at the WADEM Biennial conference
- Launch to be confirmed in the coming months…

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