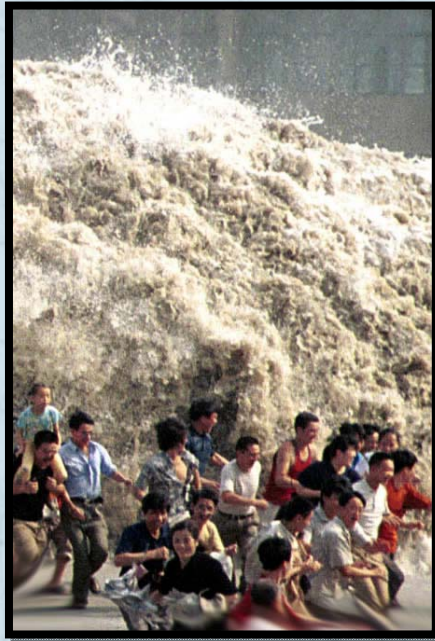


Challenges to the Critical Care Provider in Disasters

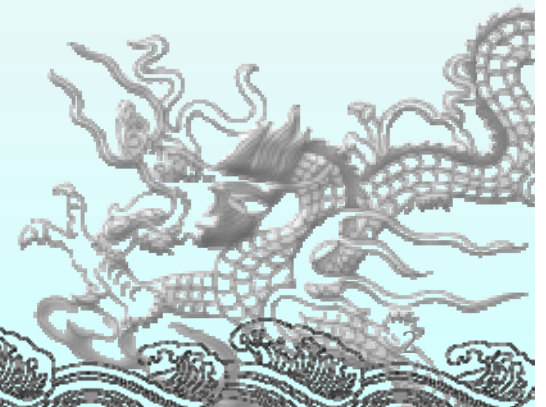


Dr. C. H. Chung
Chief of Service
A&E Department
North District Hospital



Definition of Disaster

- ◆ Latin: *evil + star*
- ◆ Centre for Research on the Epidemiology of disasters database entry criteria: -
 - ◆ 10 or more human death
 - ◆ 100 people affected
 - ◆ State of emergency declared
 - ◆ Call for international assistance
- ◆ External/ internal



Natural Disaster



Natural Disasters



Primary Natural Disaster
e.g. volcanic eruption



Secondary Natural Disasters
e.g. earthquake, forest fires, tsunamis, landslides, avalanches, flooding

Secondary Technological Disasters
e.g. utility damage, transportation failure, structural disruption

Secondary Man-made Disaster:
intentional/unintentional
e.g. violence, epidemics

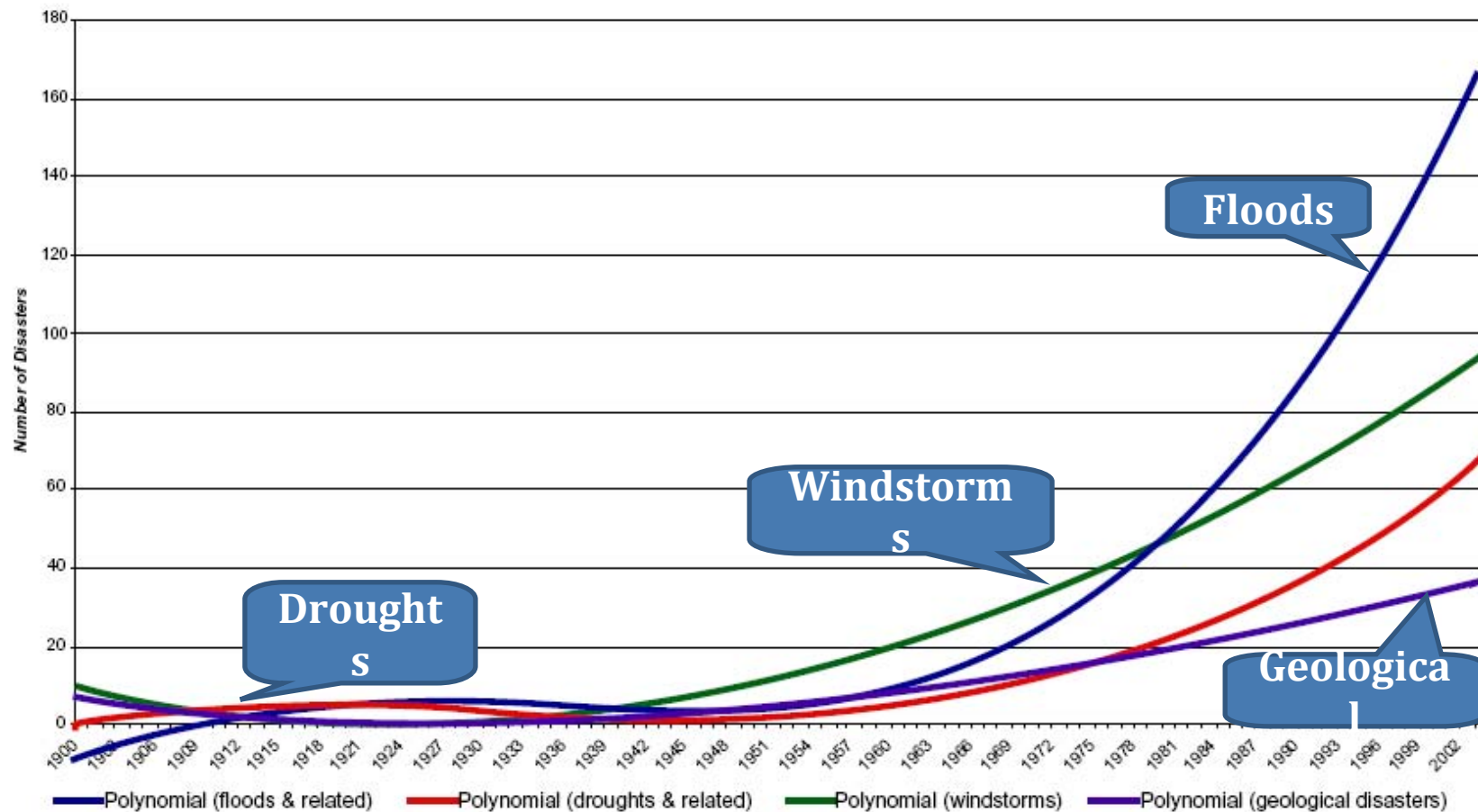


Impact of Secondary Disasters

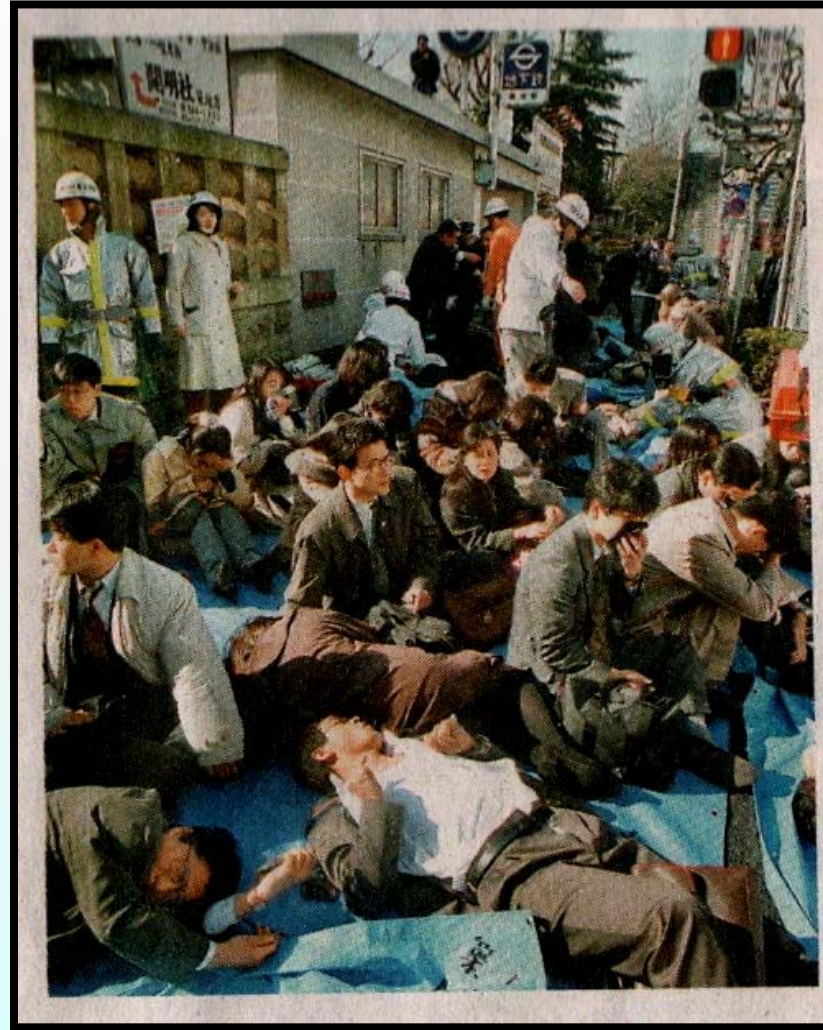


Worldwide Natural Disasters

Worldwide polynomial time trends for the four major types of natural disasters: 1900 - 2003

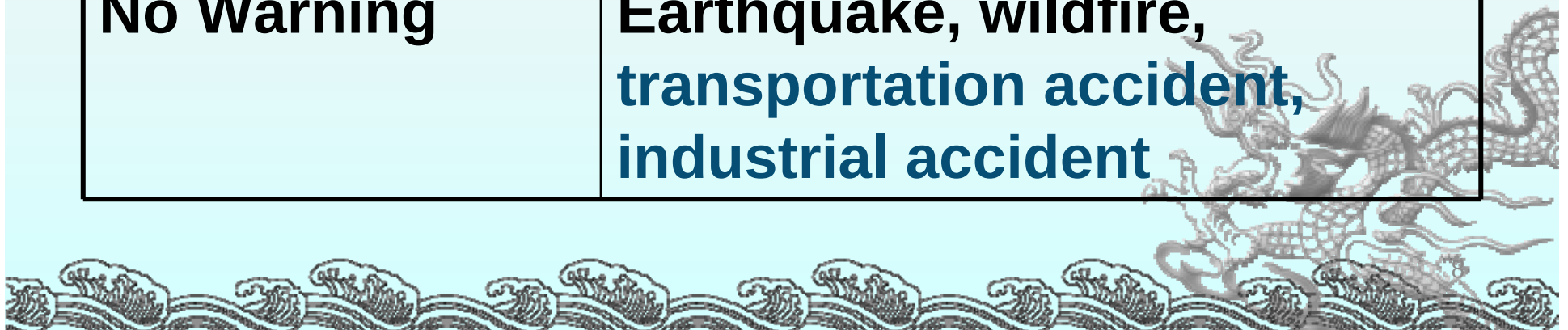


Manmade Disaster



Natural & Man-made Events

	Example
Early Warning	Hurricane/typhoon, flood, volcanic eruption, thunderstorm
Limited Warning	Tornado, structural collapse
No Warning	Earthquake, wildfire, transportation accident, industrial accident



Chemical



Sarin

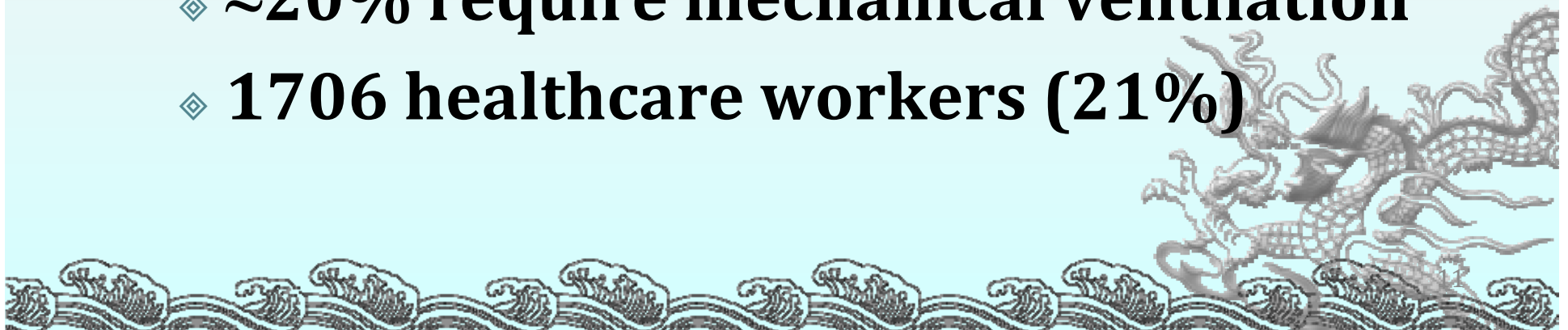
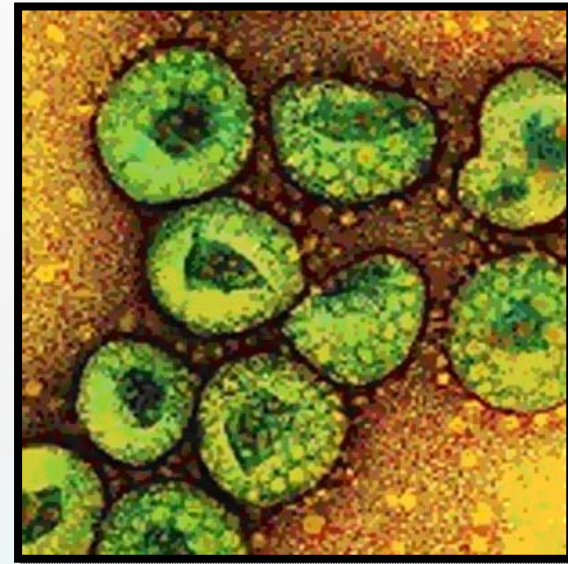
- ◆ 20 March 1995
- ◆ Tokyo subway
- ◆ Aum Shinrikyo Cult
- ◆ 5500 exposed
- ◆ 3227 went to hospitals
- ◆ 550 transported by ambulances (17%)
- ◆ 2 deaths
- ◆ 13 ($\approx 20\%$) A&E personnel affected, 6 ($\approx 9\%$) required treatment



Biological

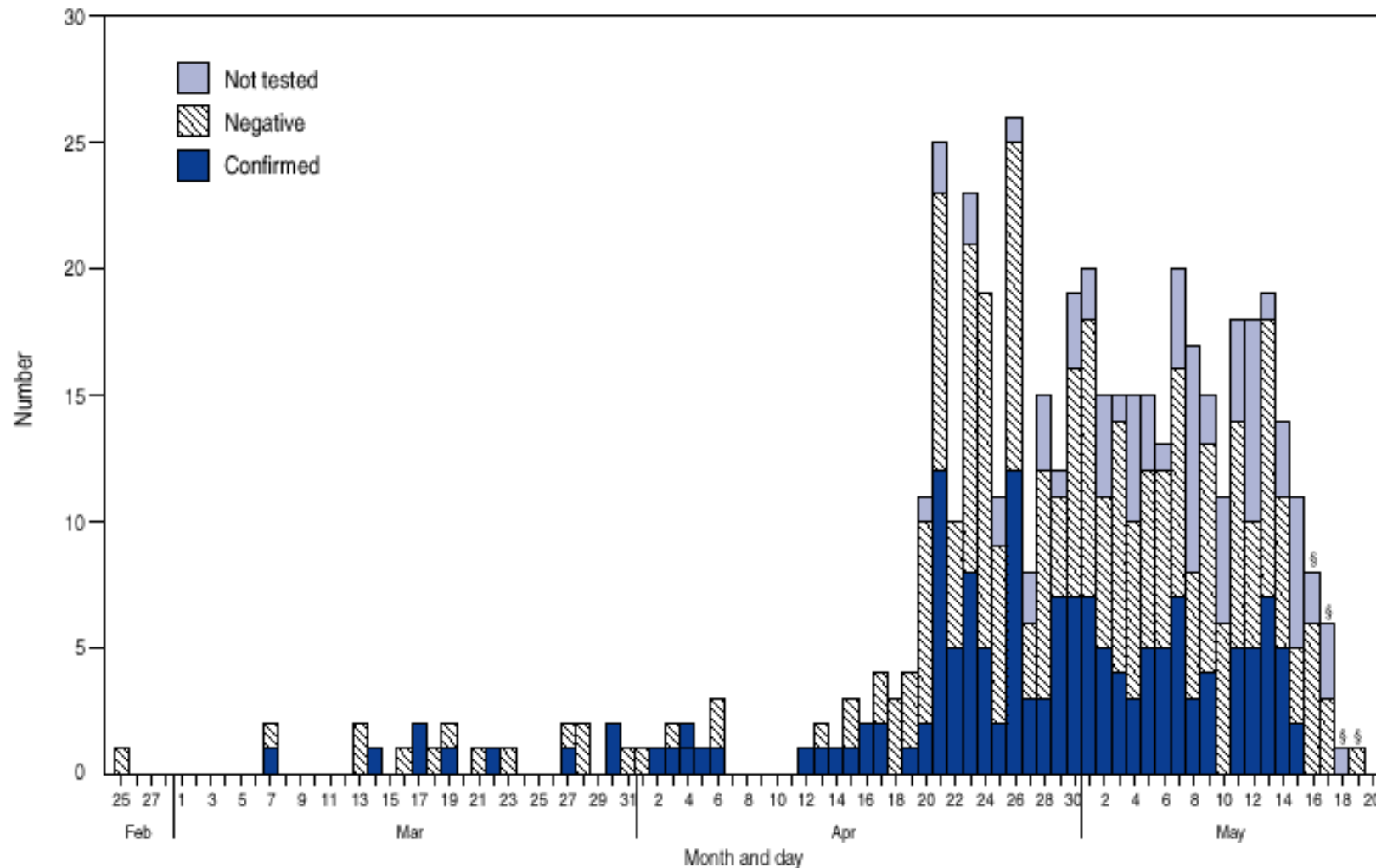
◆ SARS

- ◆ Nov 2002 – Jul 2003
- ◆ 30 countries
- ◆ 8096 cases
- ◆ 774 deaths (10%)
- ◆ ≈20% require mechanical ventilation
- ◆ 1706 healthcare workers (21%)



Taiwan SARS Epicurve

FIGURE 1. Number* of probable cases of severe acute respiratory syndrome, by laboratory status† and date of illness onset — Taiwan, February 25–May 22, 2003



* N = 483.

† Laboratory testing was conducted using polymerase chain reaction.

Radiation

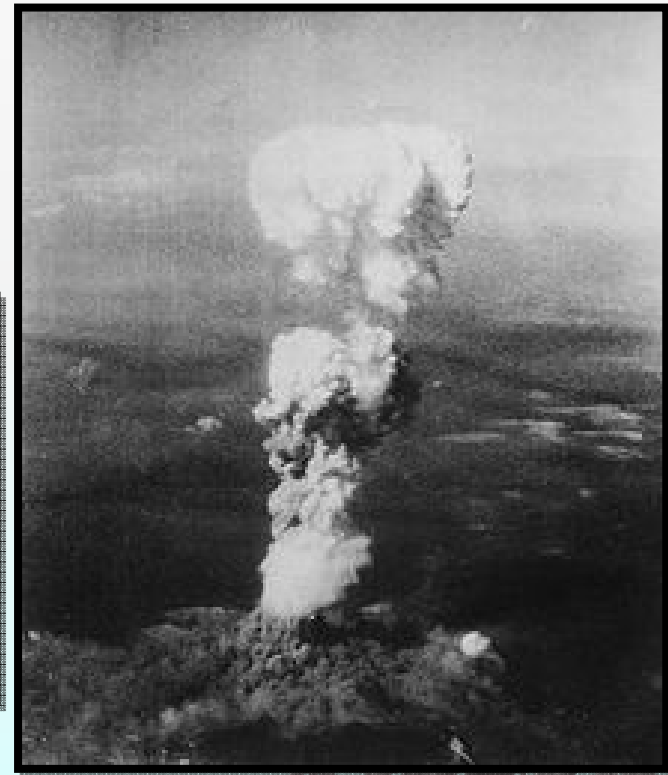
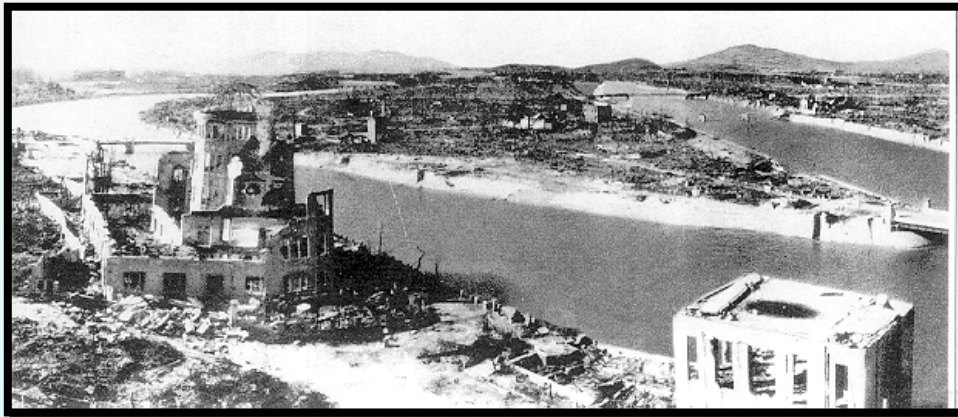
◆ Chernobyl nuclear reactor accident

- ◆ 26 April 1986
- ◆ 237 acute radiation sickness
- ◆ 31 ($\approx 13\%$) died
- ◆ 135,000 evacuated



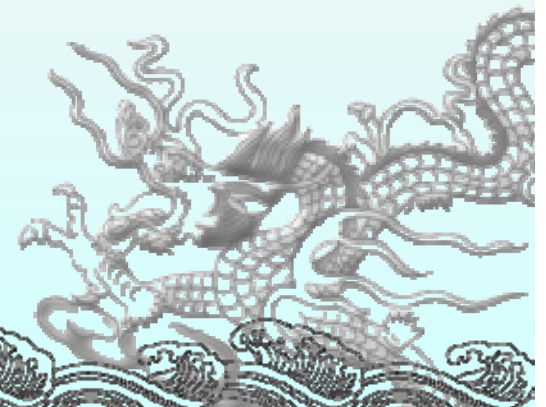
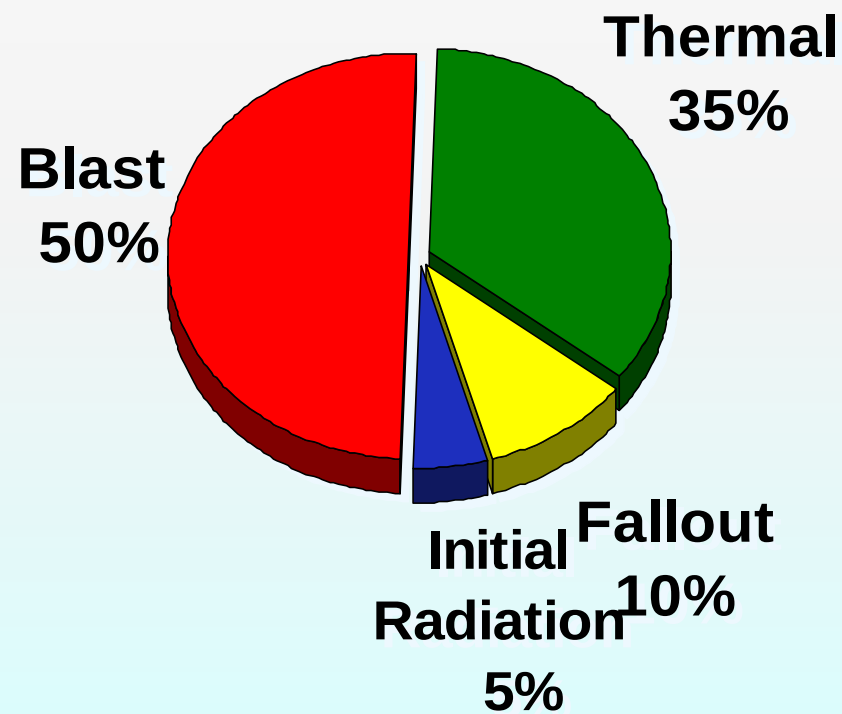
Nuclear

- ◆ **Hiroshima atomic bomb explosion**
 - ◆ **6 August 1945**
 - ◆ **Death: 140,000**



Nuclear Detonation

Standard Fission / Fusion

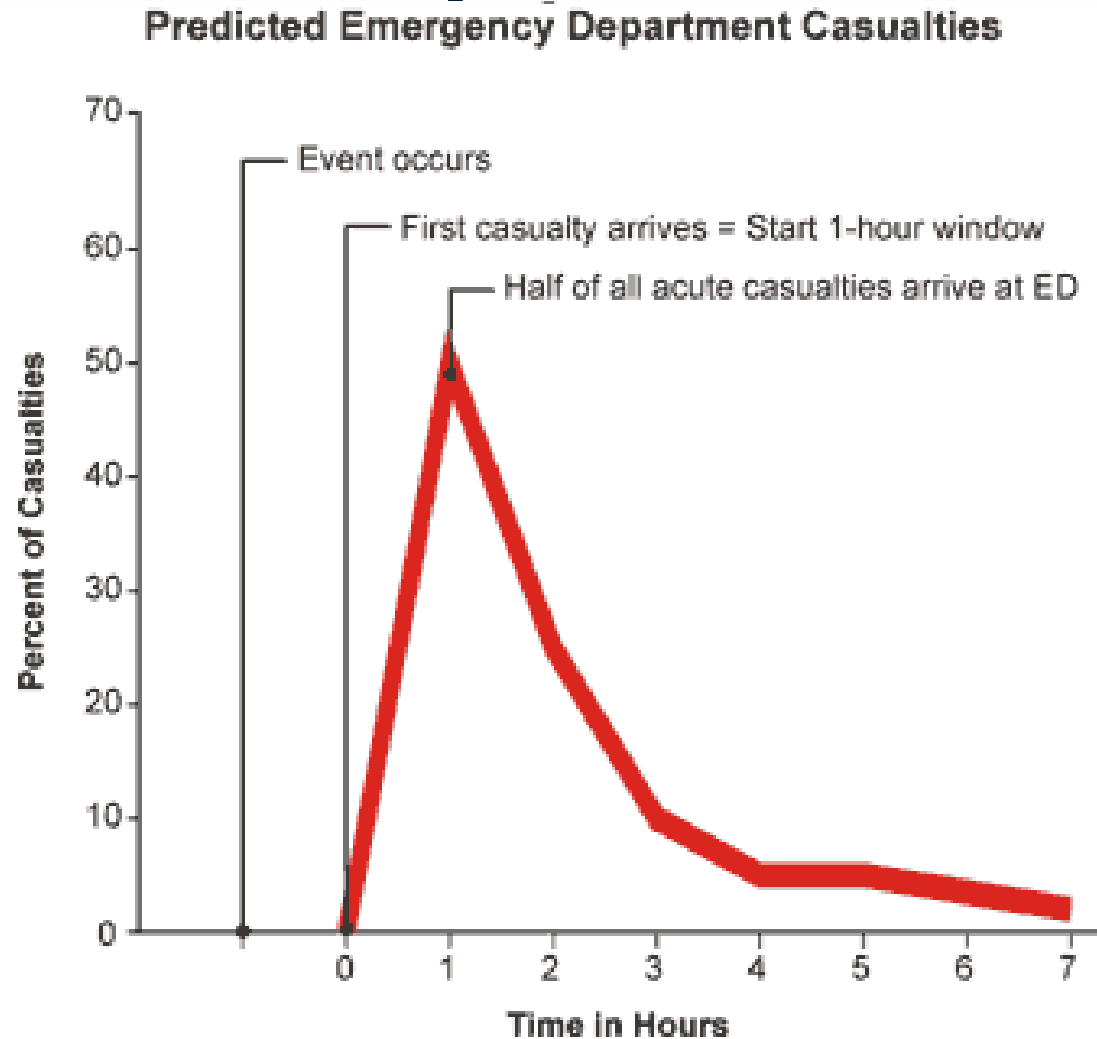


Explosive

- ◆ **World Trade Center , New York**
 - ◆ **11 September 2001**

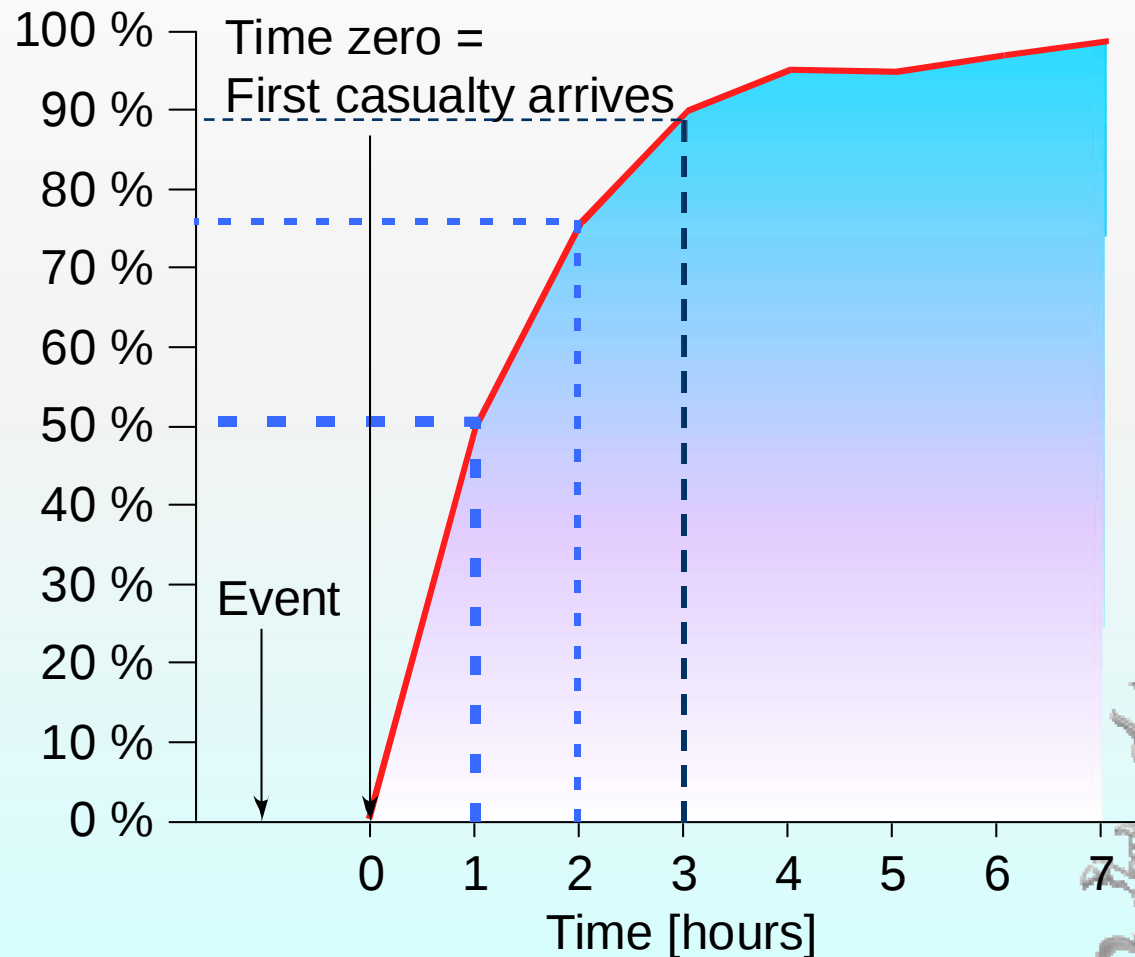


Logistic Issues after an Explosion



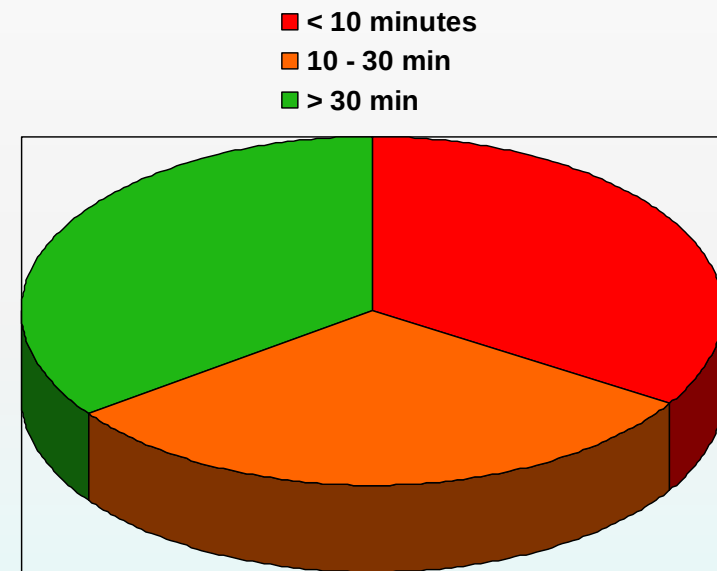
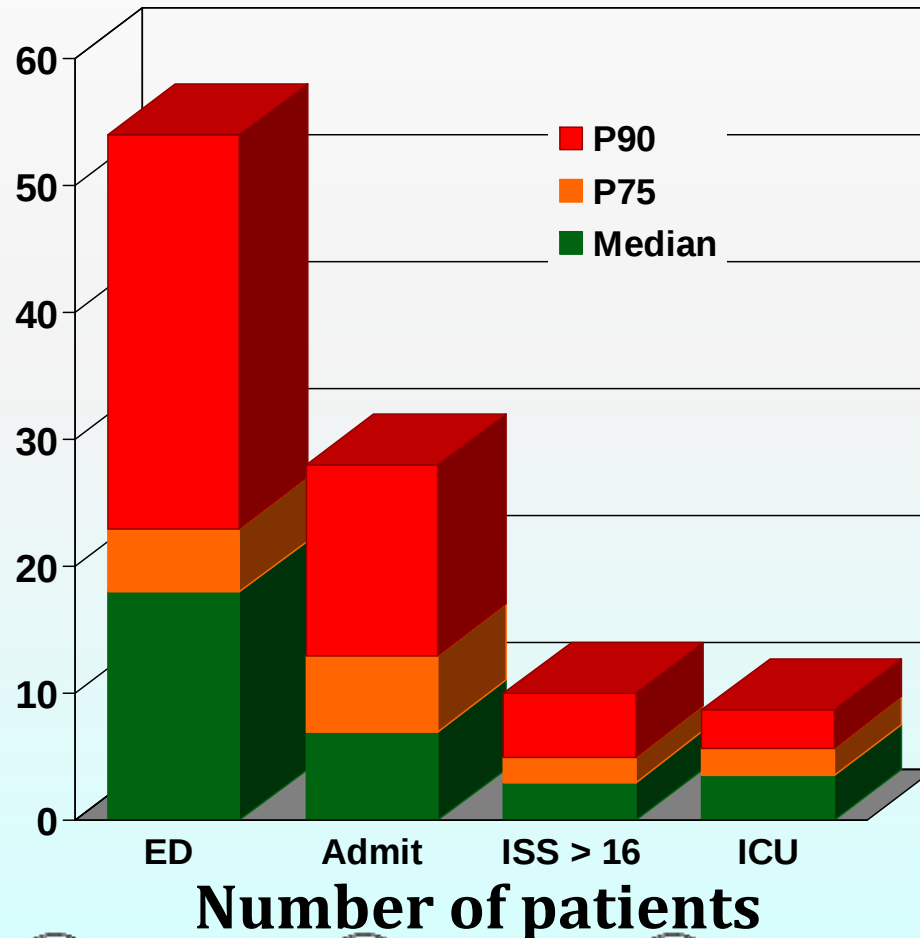
Logistic Issues after an Explosion

Cumulative Predicted Emergency Department Casualties



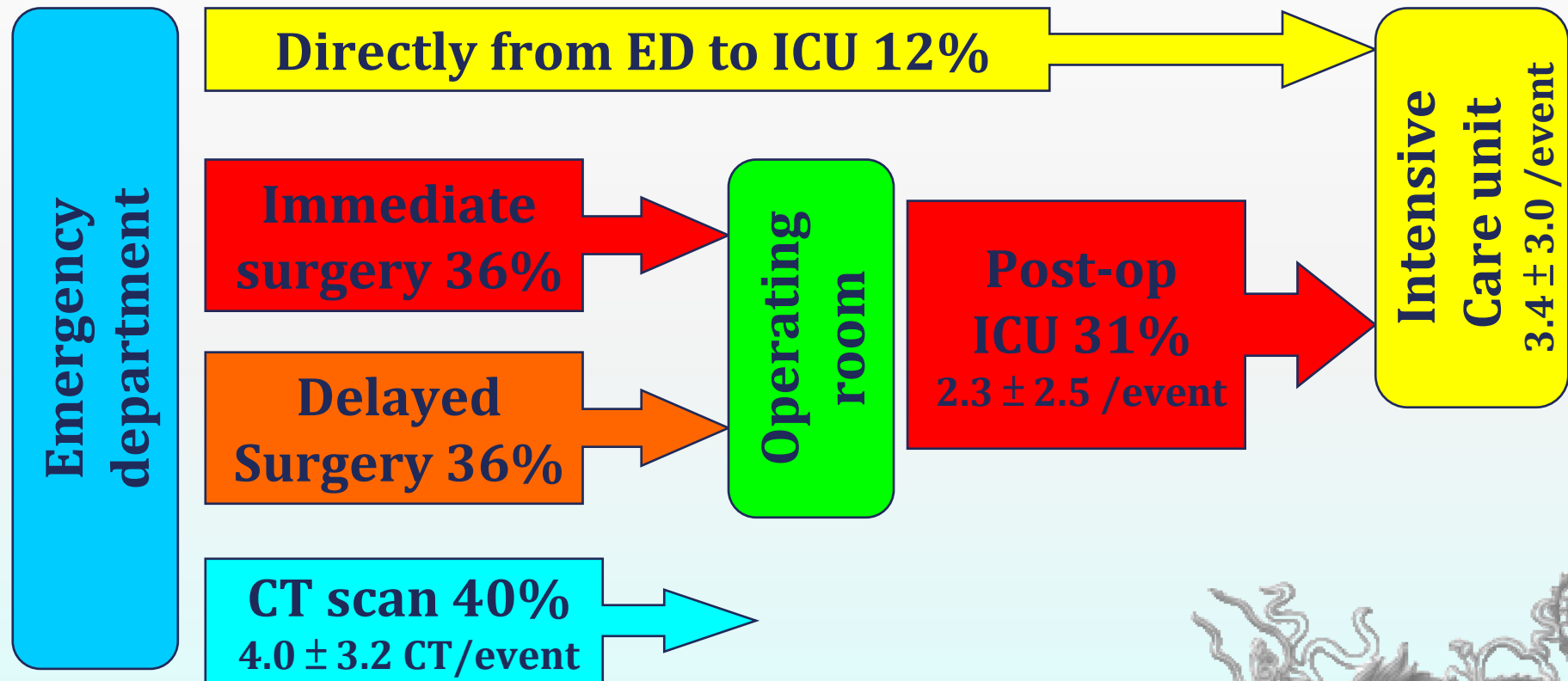
Logistic Issues

- ◆ Terror induced mass casualties
- ◆ Israeli data over 32 events



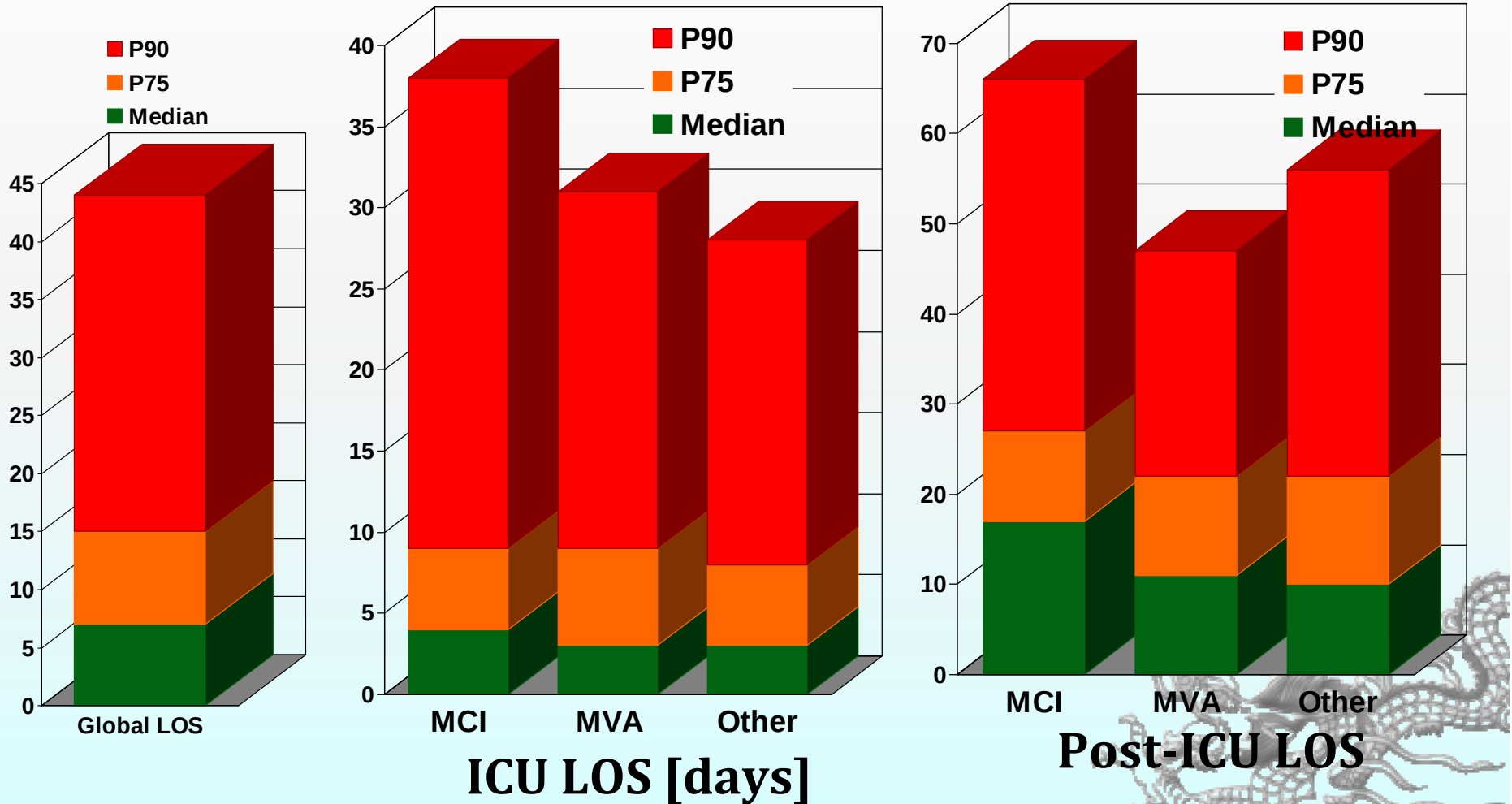
Delay of arrival
(time zero = first patient in ED)

Patient flow after bombing



Logistic Issues

◆ ICU and hospital bed use



Challenges to ICU

- ◆ Primary blast injury
- ◆ Inhalation burn
 - ◆ Thermal
 - ◆ Chemical
- ◆ **Respiratory pathogen**
- ◆ Respiratory toxin



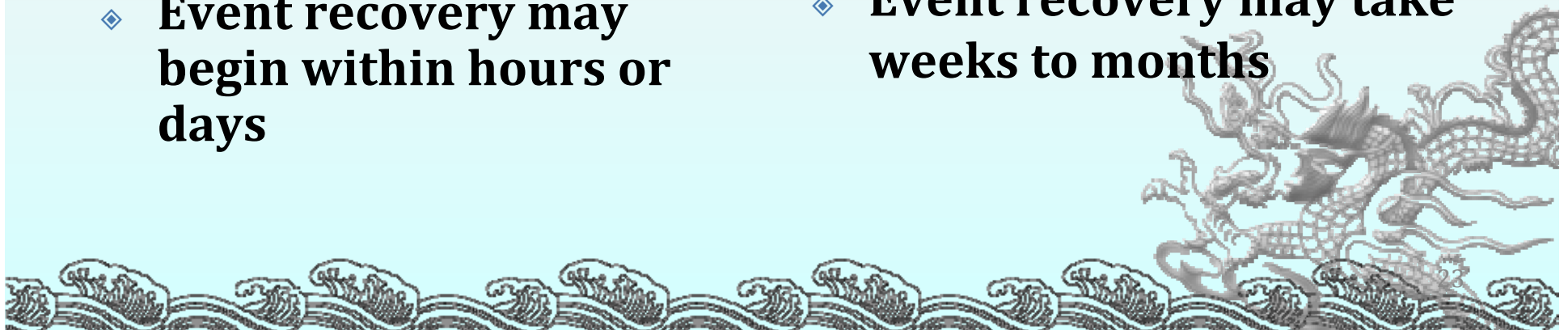
Impact on ICU

Conventional Explosion

- ◆ Casualties in 100s
- ◆ Mostly trauma
- ◆ Most patients present to the nearest hospital
- ◆ Greatest demand on A&E, surgical & mental services
- ◆ Event recovery may begin within hours or days

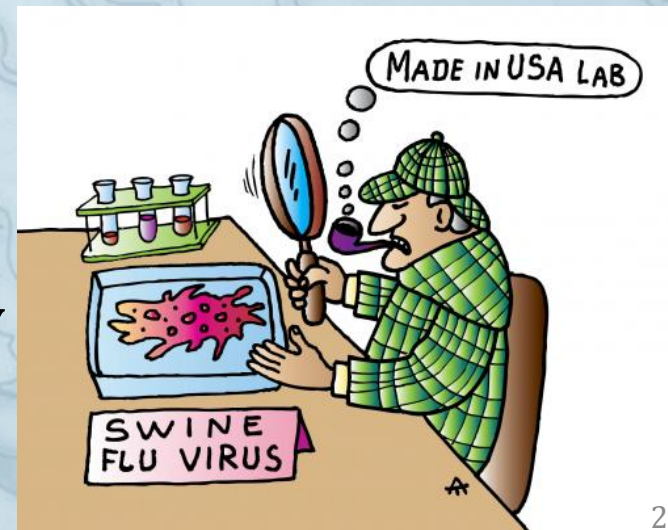
Epidemic or Pandemic

- ◆ Casualties in 1000s
- ◆ Mostly non-trauma
- ◆ Patients present to many hospitals
- ◆ Greatest demand on medical & **ICU** services
- ◆ Event recovery may take weeks to months



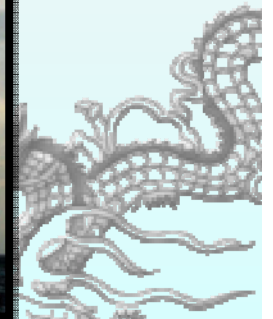
Even though science cannot predict what kind of **epidemic** we will experience and how serious its lethality will be . . . the preparations we do now would apply to other scenarios as well. The time and energies are put to good use.

Janet Napolitano
Secretary of Homeland Security



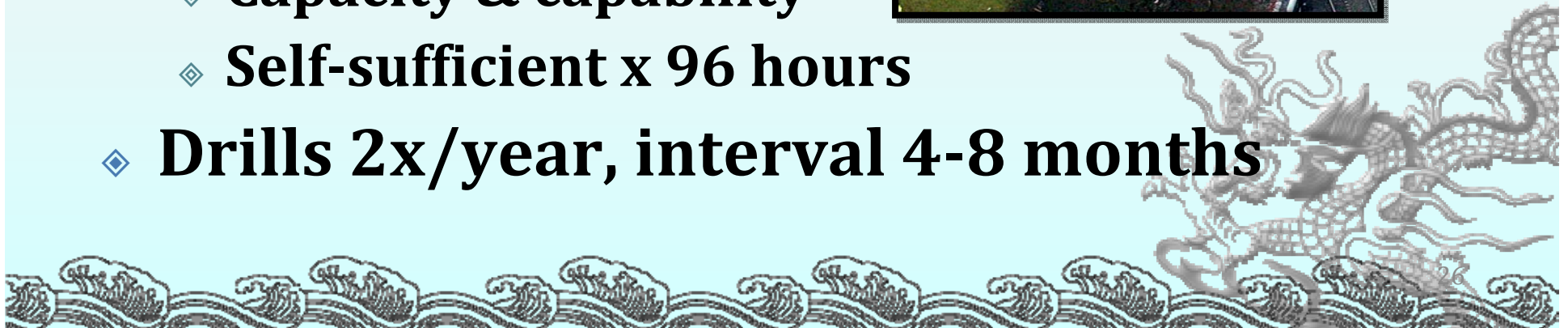
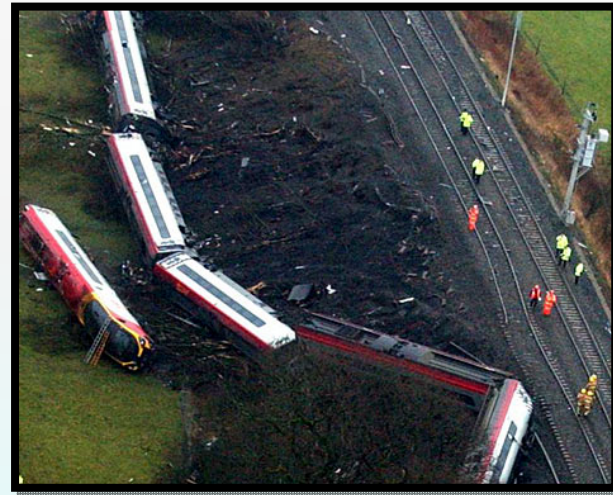
The Solution is Preparation

- ◆ Hazard-vulnerability analysis
- ◆ Planning
- ◆ Incident Command System
- ◆ Training & Drills
- ◆ Equipment & supplies



Hazard Vulnerability Analysis

- ◆ Risk identification & weighting
- ◆ Probability of occurrence
- ◆ Contingency plan
 - ◆ External & internal
 - ◆ Simple & flexible
 - ◆ Applicable to routine
 - ◆ Capacity & capability
 - ◆ Self-sufficient x 96 hours
- ◆ Drills 2x/year, interval 4-8 months



Disaster Planning

- ◆ All hazards approach
- ◆ Daily routine doctrine
- ◆ Minimal acceptable care
- ◆ Internal & external Communications



Evacuation

- ◆ **Partial**

- ◆ **Horizontal**

- ◆ **Vertical**

- ◆ **Full**



- ◆ **Sequence**

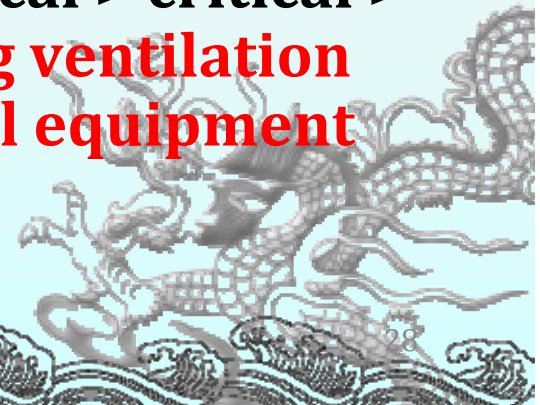
- ◆ **Closest to danger**

- ◆ **Farthest from escape route/ exit**

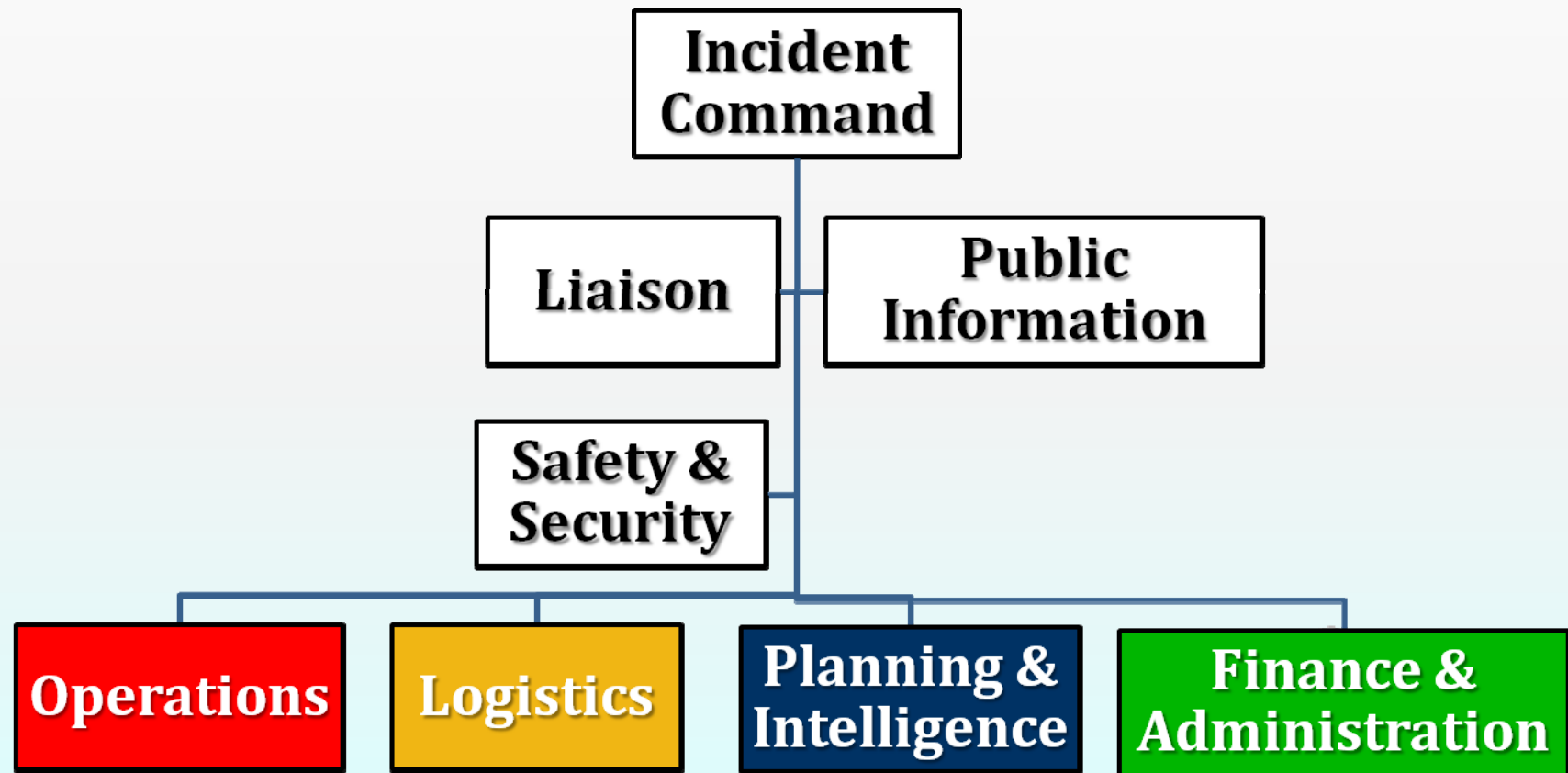
- ◆ **Top down**

- ◆ **Ambulatory > semi-ambulatory > non-ambulatory**

- ◆ **Non-critical > critical > requiring ventilation or special equipment**

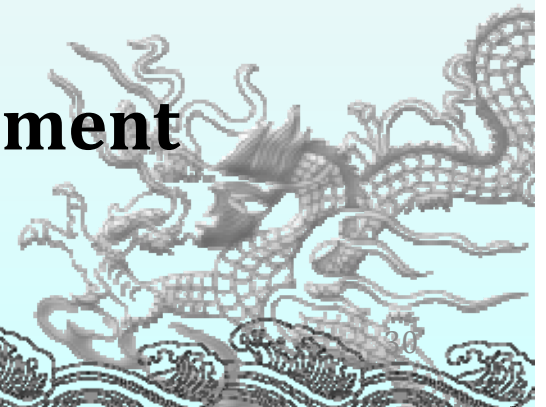


Hospital Incident Command System (ICS) - America



Principles of ICS

1. **Common terminology**
2. **Modular organization**
3. **Integrated communications**
4. **Unified command structure**
5. **Consolidated action plans**
6. **Manageable span-of-control**
7. **Pre-designated incident facilities**
8. **Comprehensive resource management**



Job Action Sheet

- ◆ **What they are going to do?**
- ◆ **When they are going to do it?**
- ◆ **Who they will report to after they have done it?**
- ◆ **Documentation**



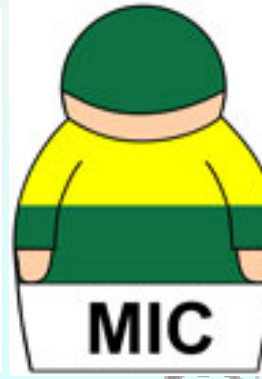
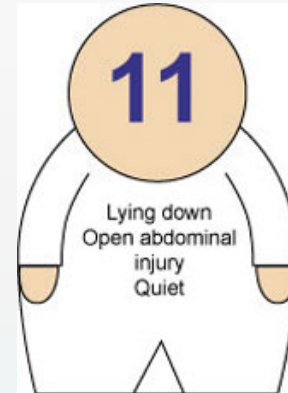
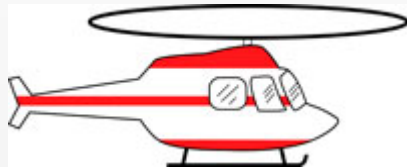
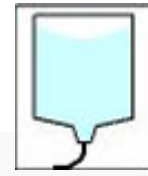
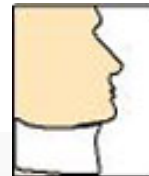
Emergo Train System (ETS) Europe & Australasia

- ◆ **Field**
 - ◆ Ambulance incident command
 - ◆ Medical incident command
- ◆ **Hospital**
 - ◆ Logistics command
 - ◆ Medical command





Emergo Train System





Emergo Train System

TRANSPORTMIDDELEN

AMB/HCP	KOMST	PATIENT	VERTREK	BESTEMMING	AANKOMST OP BESTEMMING	TERUG TER PLEKKE
	15.15	—	—	—	—	—
	15.22		16.00	Smalltown	16.25	16.50
	15.22		16.05	Smalltown	16.27	16.52
	15.22		16.05	Middletown	16.45	17.25
	15.40					
	15.40					
	15.40					
	16.00	   	16.05	North City	16.35	17.10
	16.10	   	16.15	North City	16.40	17.15



The floor plan is divided into several functional areas:

- EMERGENCY DEPARTMENT:**
 - ARRIVING PATIENTS:** Includes 'WHEELCHAIR NURSE' and 'LIFT NURSES'.
 - AVAILABLE STAFF:** Includes 'MD' (Medical Doctor) and 'NURSE'.
 - EMERGENCY TEAM:** A grid showing 'NURSE' and 'DOCTORS' (MD) with 'PATIENT' icons.
- SMALLTOWN:** The central area, likely a corridor or common space.
- SURGERY:**
 - OP THEATRE:** A grid showing 'OP TEAM' (AN, OR, NURSE), 'SURGEONS' (MD), 'PATIENT', and 'THEATRE BLOCKED UNTIL'.
- INTENSIVE CARE:**
 - VENTILATION:** A grid showing 'NURSE' and 'MD' icons.
 - BEDS OTHER:** A grid showing 'NURSE' and 'MD' icons.



Emergo Train System

SMALLTOWN				INTENSIVE CARE			
BEADEMING		ANDERE BEDDEN					
							
1	 	1		7			
2	 	2		8			
3		3					
4		4					
5		5					
6		6					

Challenges

- ◆ **Safety**
- ◆ **Structure**
- ◆ **Space**
- ◆ **Staff**
- ◆ **Stuff (equipment, supplies & drugs)**



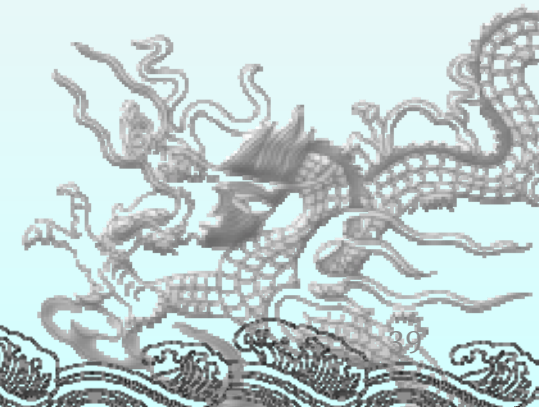
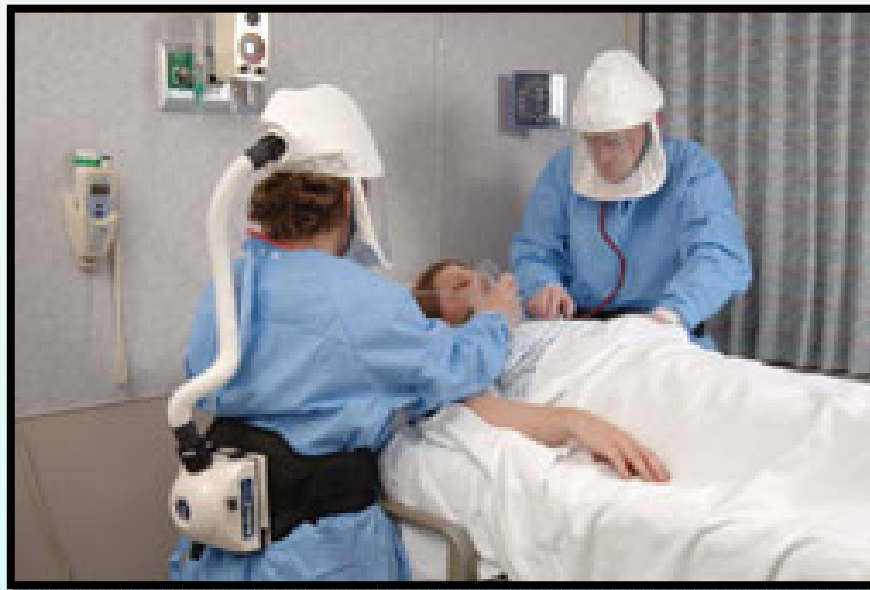
Disaster Principle I

- ◆ **Human life**
 - ◆ **Provider**
 - ◆ **Public**
 - ◆ **Patient**
- ◆ **Environment**
- ◆ **Property**
- ◆ **Function**
- ◆ **Evidence**
- ◆ **Reputation**



Personal Protective Equipment

- ◆ PPE
 - ◆ PAPR
 - ◆ N95



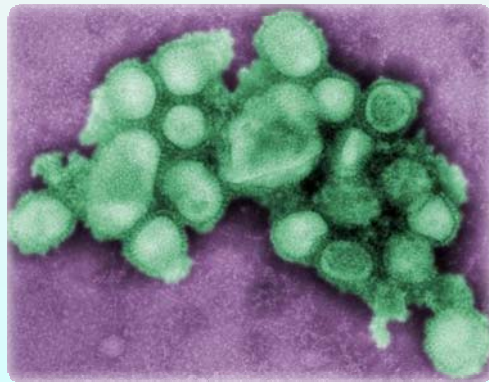
Airborne infections

- ◆ **Obligate airborne**
 - ◆ Tuberculosis, open
- ◆ **Preferential airborne**
 - ◆ Chickenpox & disseminated herpes zoster
 - ◆ Measles
- ◆ **Opportunistic airborne**
 - ◆ Smallpox
 - ◆ SARS
 - ◆ Influenza

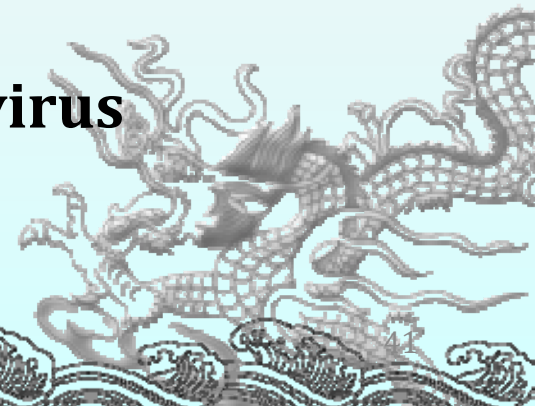


Secondary Contamination

- ◆ Patient
- ◆ Healthcare provider
- ◆ Hospital
 - ◆ Equipment (including transportation)
 - ◆ Environment (including building)



Swine flu virus



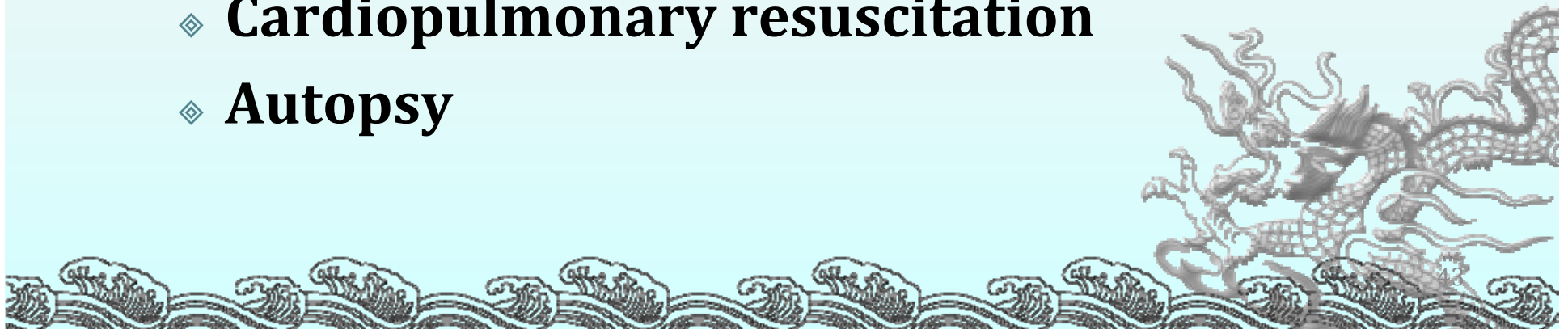
Risk Factors

- ◆ **Infectivity/dissemination of agent**
- ◆ **Immunity of host**
 - ◆ **Vaccination/immunoprophylaxis**
 - ◆ **Chemoprophylaxis**
 - ◆ **PPE**
- ◆ **Dose/concentration of agent**
- ◆ **Intimacy of contact**
- ◆ **Duration of contact**



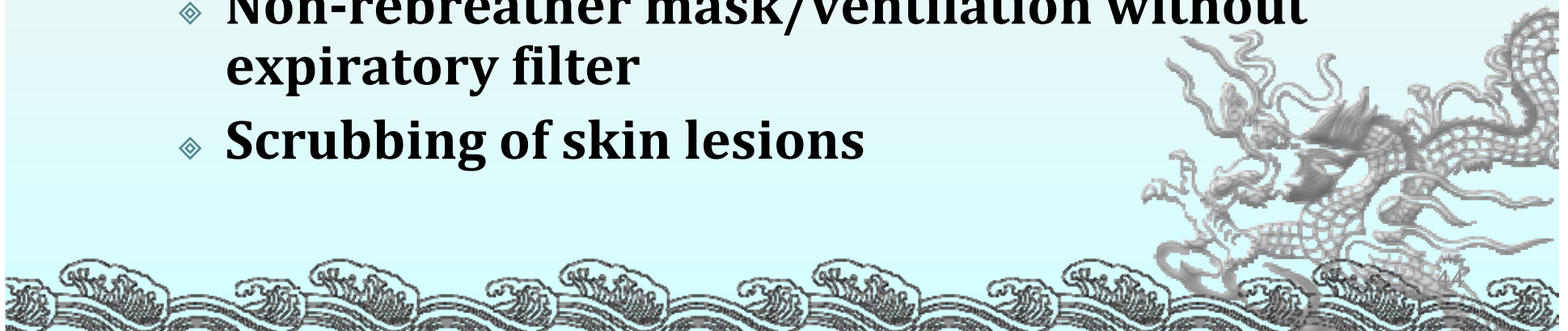
Procedures with Increased Risk of Secondary Transmission

- ◆ **Definitive risk (airborne precaution)**
 - ◆ **Endotracheal intubation**
 - ◆ **Extubation**
 - ◆ **Open-circuit suctioning**
 - ◆ **Bronchoscopy**
 - ◆ **Surgical airways**
 - ◆ **Cardiopulmonary resuscitation**
 - ◆ **Autopsy**



Procedures with Increased Risk of Secondary Transmission

- ◆ **Controversial risk ($\geq$ droplet precaution)**
 - ◆ **Noninvasive positive pressure ventilation**
 - ◆ **Bilevel positive airway pressure**
 - ◆ **High frequency oscillating ventilation**
 - ◆ **Nebulization of medication**
 - ◆ **Humidified oxygen delivery**
 - ◆ **Bag-mask ventilation**
 - ◆ **Non-rebreather mask/ventilation without expiratory filter**
 - ◆ **Scrubbing of skin lesions**

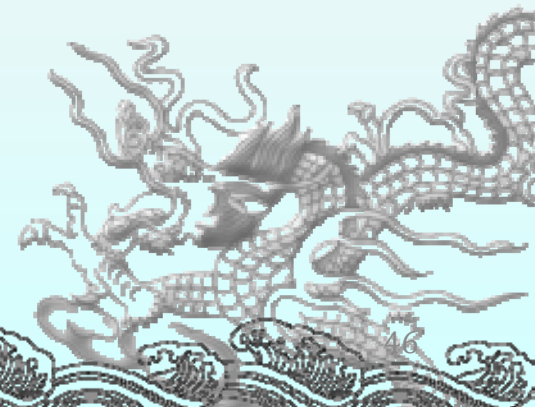


Scenario

- ◆ It is a mid-autumn morning, the A&E department is crowded with patients with flu-like symptoms, overflowing into the hallways. Every inpatient bed is filled.
- ◆ Half of these patients have high fever and respiratory distress; a handful requires mechanical ventilation in the ICU.
- ◆ Some staff are afraid to come to work due to the mysterious infectious outbreak being reported on the local television news.



Scene at the A&E Department



Usual Clinical Practice

- ◆ Do the maximum
- ◆ For a single patient
- ◆ With all resources
- ◆ All the time



Disaster Principle II

- ◆ Do the best
- ◆ For the most
- ◆ With the least
- ◆ In time shortest



Triage

- ◆ **The greater the number of casualties**
 - ◆ **The more difficult the triage process**
 - ◆ **The more time it will take**
 - ◆ **The higher the number of preventable deaths**



Triage Factors

◆ Medical

◆ Criticality

- ◆ Injury Severity
- ◆ Time dependency
- ◆ Life>limb/organ

◆ Co-morbidity

◆ Salvageability

◆ Predicted quality of outcome

◆ Resource consumption

◆ Social

◆ Community leader

◆ Healthcare provider

◆ Media worker

◆ Criminal



Traditional Medical Ethics

- ◆ **Beneficence**
- ◆ **Non-maleficance**
- ◆ **Justice**
- ◆ **Autonomy**



Triage Ethical & Moral Tests

- ◆ Impartiality test 推己及人
- ◆ Universalizability test 人同此心
- ◆ Interpersonal justifiability test (fairness)
公平公正

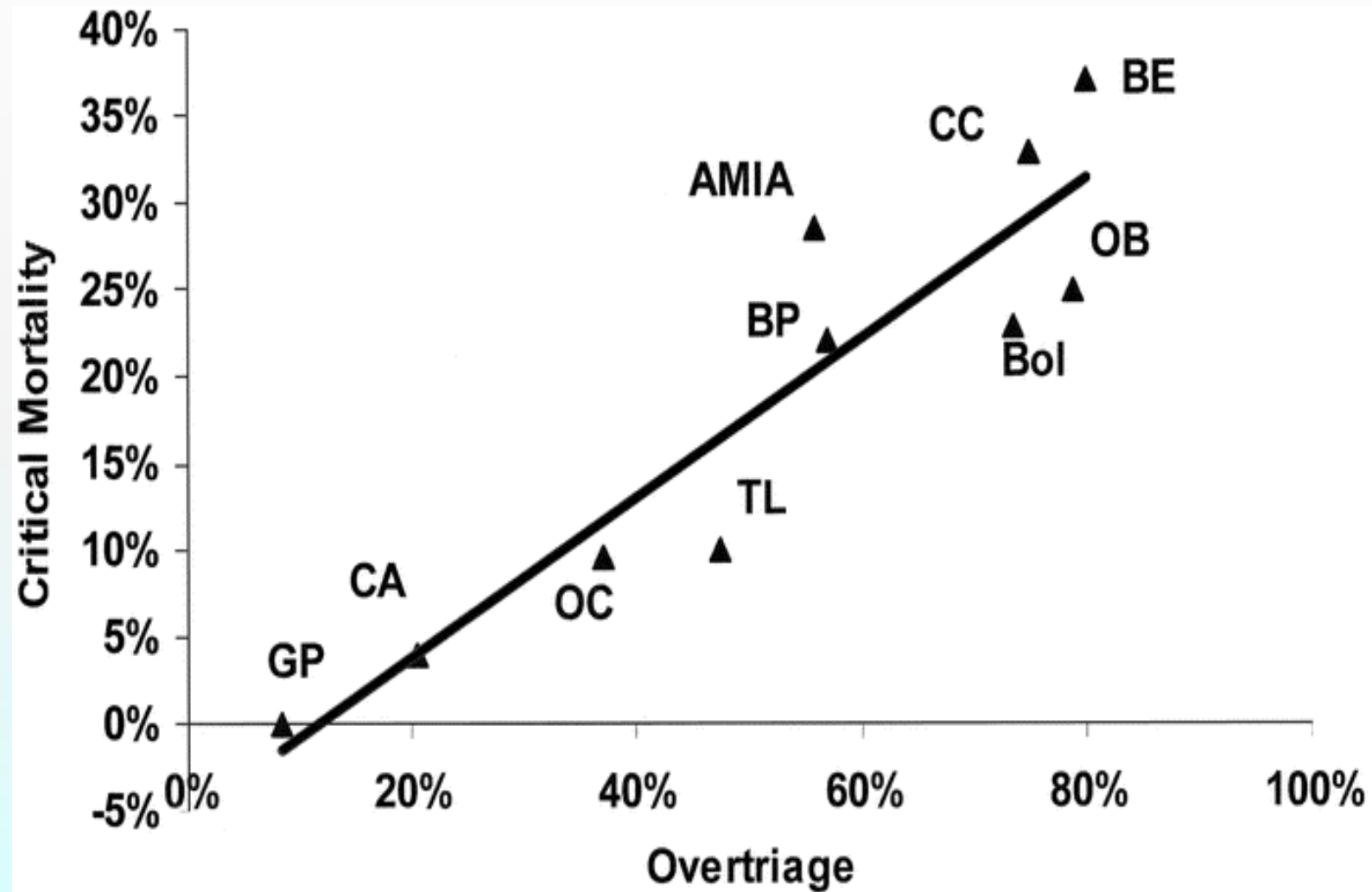


Triage Principles

1. **First Come, First Served: equal chance**
2. **Egalitarianism: those most in need**
3. **Utilitarianism: the greatest good for the greatest number**



Overtriage 8-80%



Triage & Definitive Care Areas



1° or Field Triage



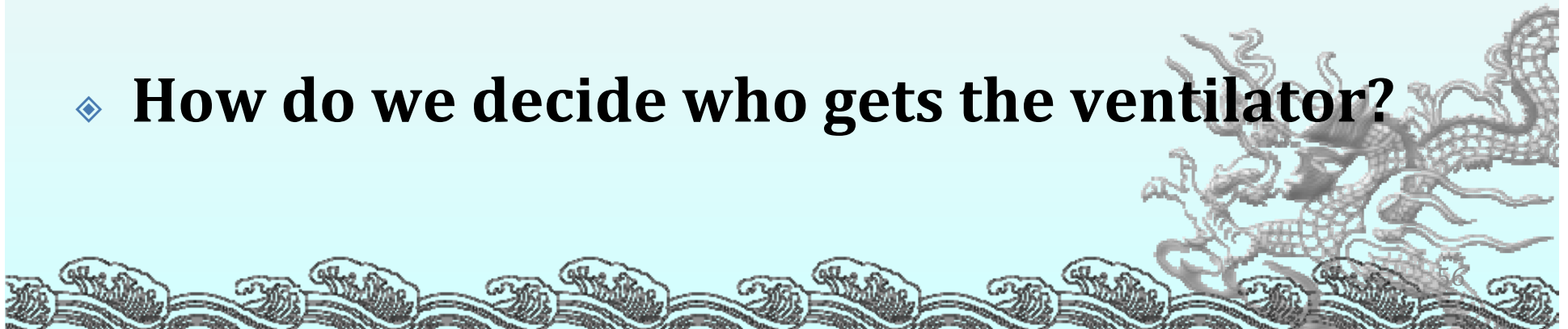
2° or ED Triage

3° or ICU Triage



Resource Problem

- ◆ The city is having Pandemic Flu, your ICU has only 1 ventilator remaining
- ◆ A call from the ED: 4 patients with acute respiratory failure
 - A. F/48, single mother of two
 - B. M/72, hospital's big donor
 - C. M/18, drug abuse history
 - D. F/32, journalist, newly-wed
- ◆ How do we decide who gets the ventilator?



Who gets the ICU bed/ventilator?

	Patient A	Patient B	Patient C	Patient D
Age	48	72	18	32
Gender	Female	Male	Male	Female
Status	Single mother	Hospital donor	Drug user	Journalist
Need for ICU bed ± ventilator	Needs ventilator	Needs ventilator	Septic shock, 3 µg/kg/min dopamine	Needs ventilator
Co-morbidity	None	Severe emphysema	IV drug use	None
Organ failure status	Respiratory failure, septic shock and oliguric renal failure	Respiratory failure only	Septic shock only	Respiratory failure only

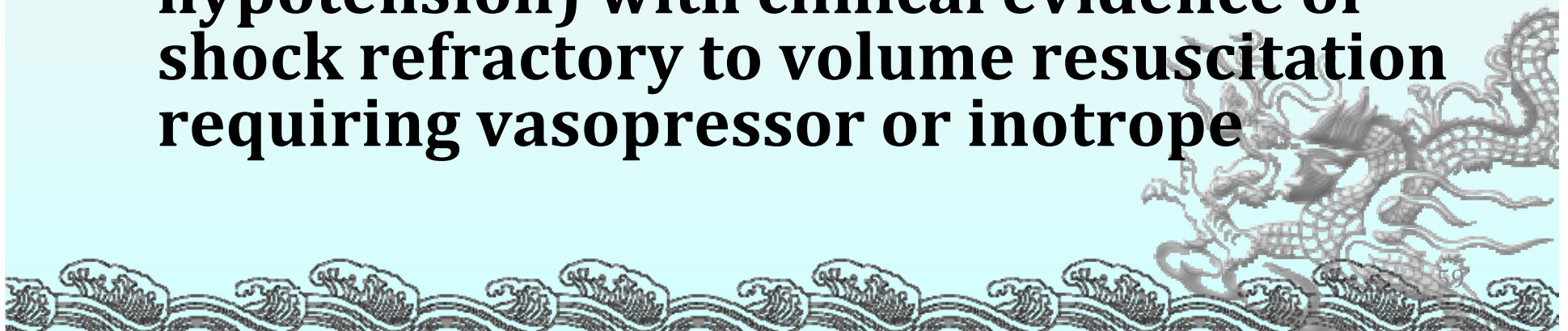
Components of a Triage Protocol

- ◆ Inclusion criteria
- ◆ Exclusion criteria
- ◆ Minimal qualifications for survival
- ◆ Prioritization tool



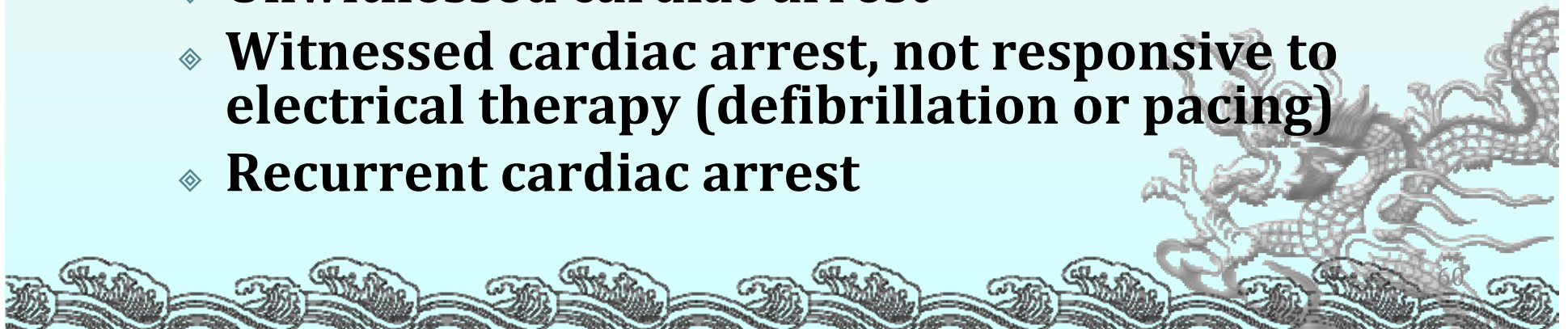
Inclusion Criteria

- ◆ **Requirement for invasive ventilatory support**
 - ◆ Refractory hypoxemia ($\text{SpO}_2 < 90\%$ on non-rebreather mask or $\text{FiO}_2 > 0.85$)
 - ◆ Respiratory acidosis ($\text{pH} < 7.2$)
 - ◆ Clinical evidence of impending respiratory failure
 - ◆ Inability to protect or maintain airway
- ◆ **Hypotension ($\text{SBP} < 90$ mmHg or relative hypotension) with clinical evidence of shock refractory to volume resuscitation requiring vasopressor or inotrope**



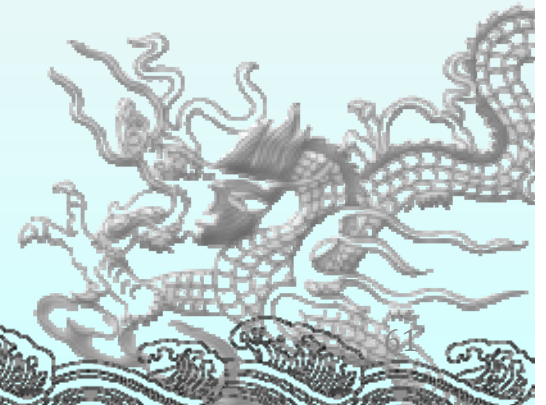
Exclusion Criteria (I)

- ◆ Severe trauma
- ◆ Severe **burns** of patient with any 2 of the following:
 - ◆ Age > 60 yr
 - ◆ > 40% of total body surface area affected
 - ◆ Inhalation injury
- ◆ Cardiac arrest
 - ◆ Unwitnessed cardiac arrest
 - ◆ Witnessed cardiac arrest, not responsive to electrical therapy (defibrillation or pacing)
 - ◆ Recurrent cardiac arrest



Exclusion Criteria (II)

- ◆ **Severe comorbidities**
 - ◆ **Severe baseline cognitive impairment**
 - ◆ **Advanced untreatable neuromuscular disease**
 - ◆ **Metastatic malignant disease**
 - ◆ **Advanced & irreversible immuno-compromise**
 - ◆ **Severe & irreversible neurologic condition**
 - ◆ **Age > 85 yr**
 - ◆ **Elective palliative surgery**



Exclusion Criteria (III)

- ◆ End-stage organ failure meeting the following criteria:

Lungs

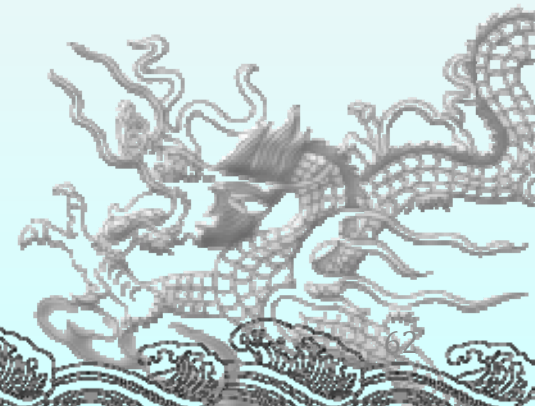
- ◆ Severe COPD
- ◆ Severe primary or secondary pulmonary hypertension
- ◆ Severe cystic or pulmonary fibrosis

Heart

- ◆ NYHA class III or IV heart failure

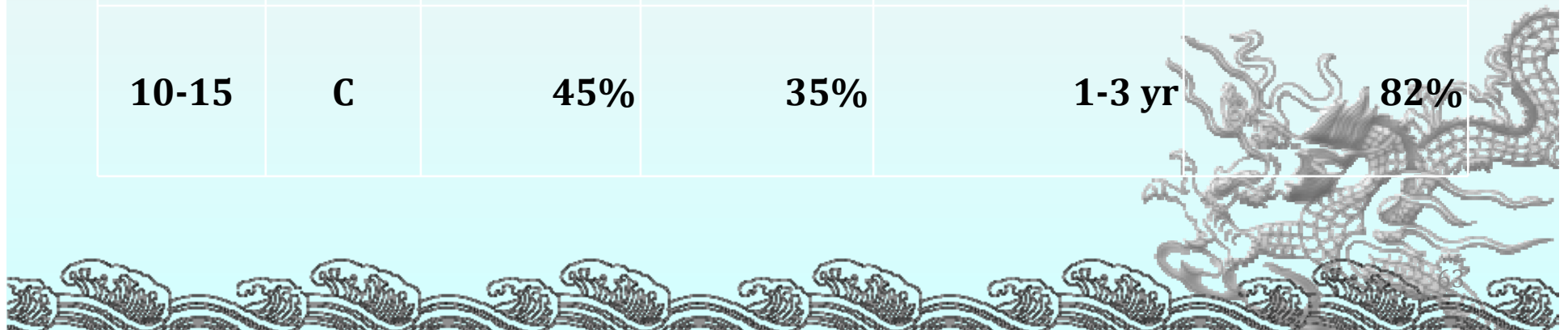
Liver

- ◆ Child-Pugh score ≥ 7



Child-Pugh Classification

Points	Class	One year survival	Two year survival	Life expectancy	Peri-operative mortality
5-6	A	100%	85%	15-20 yr	10%
7-9	B	81%	57%	4-14 yr	30%
10-15	C	45%	35%	1-3 yr	82%



Sequential Organ Failure Assessment (SOFA) Score

Variable	0	1	2	3	4
PaO ₂ /FiO ₂	>400	≤400	≤300	≤200	≤100
Platelets	>150	≤150	≤100	≤50	≤20
Bilirubin	<20	20-32	33-100	101-203	>203
Hypotension (μg/kg/min)	None	MAP <70 mm Hg	Dopamine =5	Dopamine >5 Adrenaline =0.1 Noradrenaline =0.1	Dopamine >15 Adrenaline >0.1 Noradrenaline >0.1
GCS	15	13-14	10-12	6-9	<6
Creatinine	<106	106-168	169-300	301-433	>434

Ontario Triage Prioritization Tool 2006

Color	Initial	48-hour	120-hour	Priority/ Action
Blue	SOFA >11	•SOFA >11 •SOFA stable at 8-11	•SOFA >11 •SOFA stable at 8-11	•Palliative •Discharge from critical care
Red	•SOFA ≤ 7 •Single organ failure	SOFA <11 & decreasing	SOFA <11 & decreasing	Highest
Yellow	SOFA 8-11	SOFA stable at <8	SOFA <8 with <3-point decrease in past 72 hours	Intermediate
Green	No significant organ failure	No longer ventilator dependent	No longer ventilator dependent	•Defer •Discharge from critical care •Reassess as needed

Baseline SOFA >11, mortality >90%: Age is a controversial issue

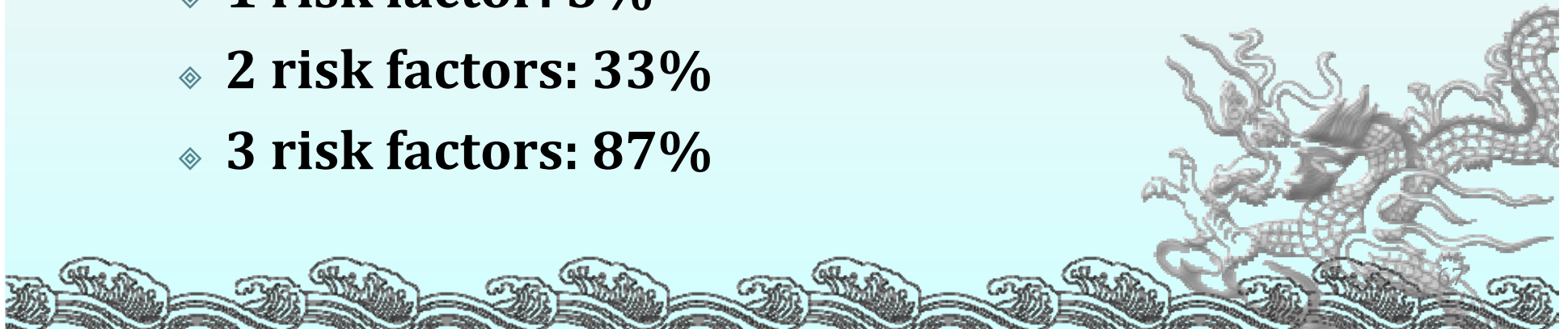
Triage in radiological injuries

- If concurrent traumatic injuries, the trauma should dictate triage and initial treatment priorities
- Concurrent severe trauma reduces fatal dose of radiation and fatal trauma. Adapt triage categories:

Conventional triage, only trauma	Adapted triage category following radiation exposure				
	Unlikely	Probable	Minimum	Moderate	Severe
P1	P1	P1 or P4	P1 or P4	P4	P4
P2	P2	P1	P1	P4	P4
P3	P3	P2	P2	P4	P4
P4	P4	P4	P4	P4	P4

Ryan Burn Prediction Score

- ◆ Risk factors
 - ◆ Burn surface area >40%
 - ◆ Age >60 years
 - ◆ Inhalation injury present
- ◆ Mortality based on number of risk factors
 - ◆ 0 risk factor: 0.3%
 - ◆ 1 risk factor: 3%
 - ◆ 2 risk factors: 33%
 - ◆ 3 risk factors: 87%

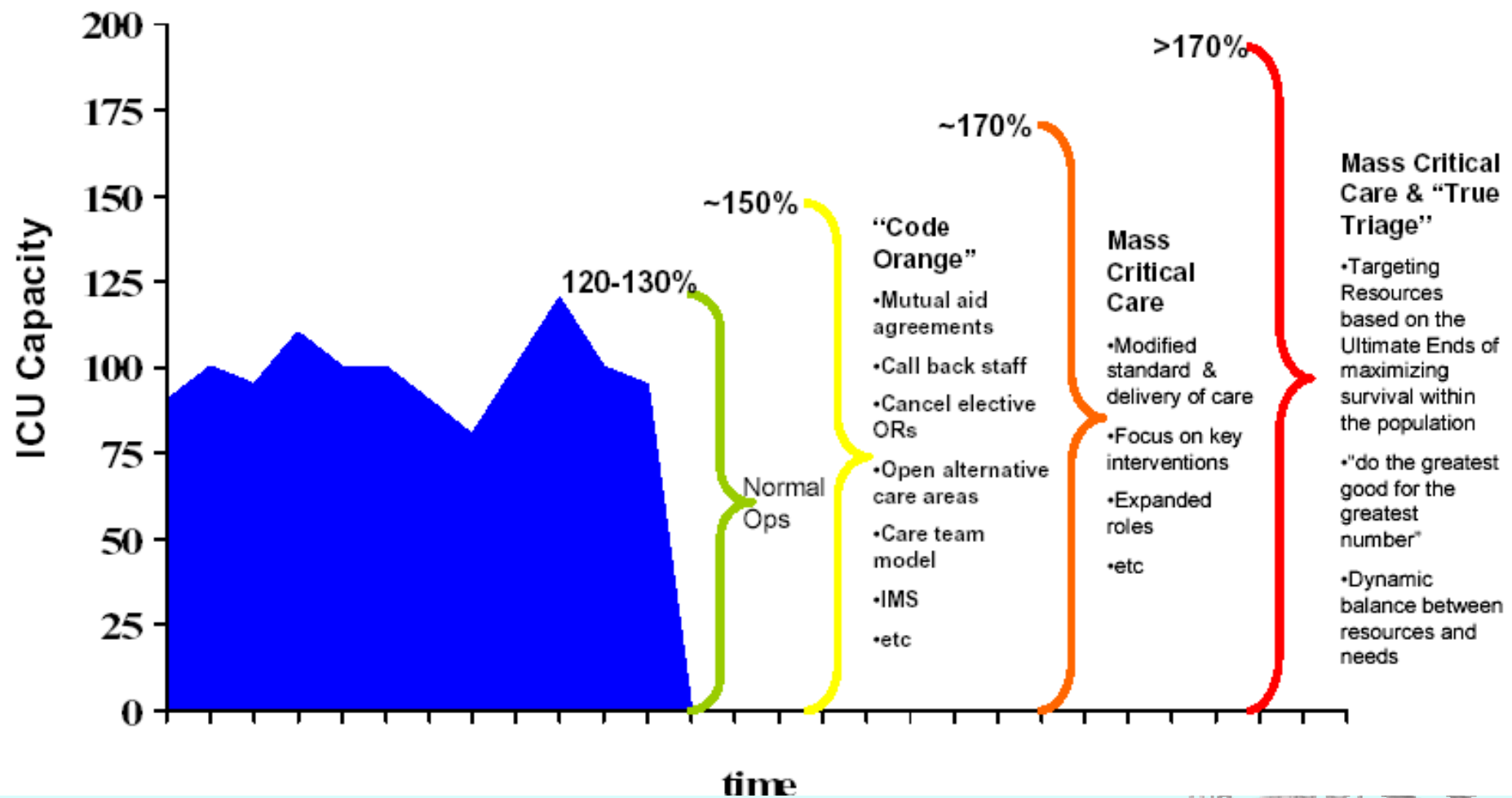


Disaster Survivors

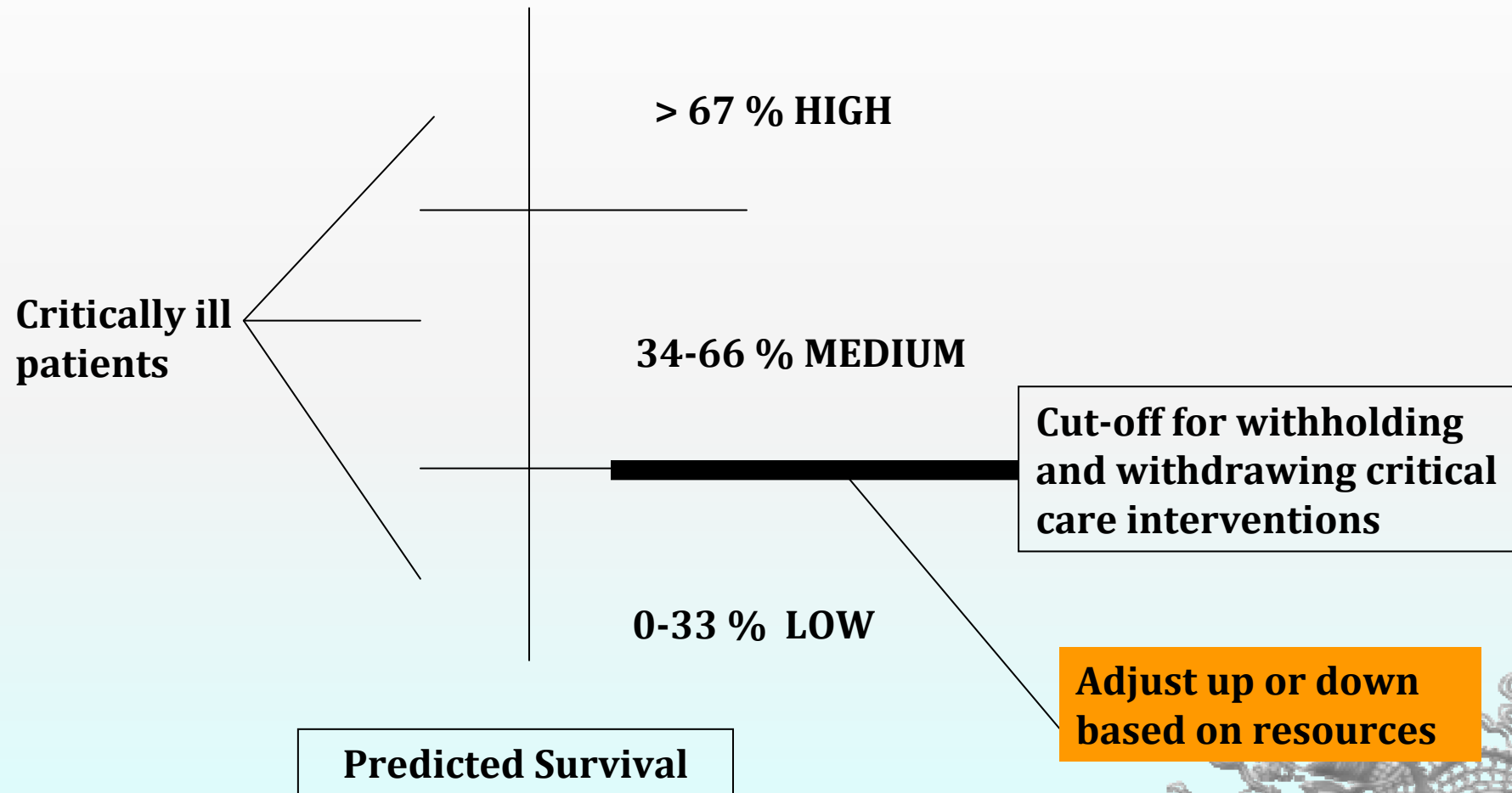
- ◇ 2-6 hours <50%
- ◇ 24 hours <10%



Response Thresholds



Triage Criteria & Allocation Of Critical Care Resources



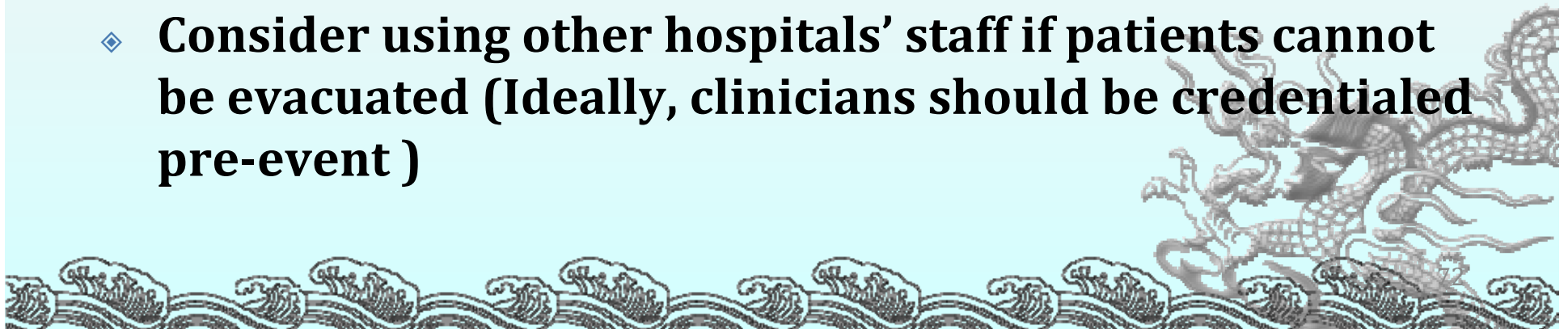
Patient demand, predictive ability, and resource availability are dynamic!

ICUs have Limited Reserve Staff



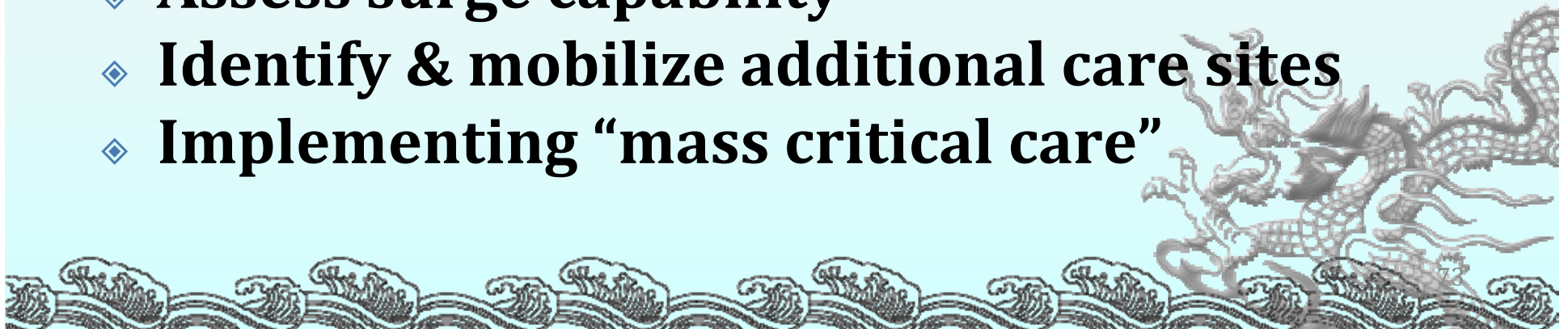
Staff Management

- ◆ Mobilize those on-duty
- ◆ Call back those off-duty
- ◆ Adjust shifts & schedules
- ◆ Provide boarding in hospital
- ◆ Provide support to staff family (Child care & elder care)
- ◆ If sustained event, postpone scheduled vacations
- ◆ Consider short-term staff: patient ratio changes for lower acuity ICU patients
- ◆ Consider using other hospitals' staff if patients cannot be evacuated (Ideally, clinicians should be credentialed pre-event)



Surge Response Strategies

- ◆ **Mobilization**
 - ◆ **Staff, on-duty & off-duty**
 - ◆ **Supplies & equipment**
 - ◆ **Facilities**
- ◆ **Early patient discharge**
- ◆ **Cancellation/withholding elective activities**
- ◆ **Cancellation of outpatient activities**
- ◆ **Assess surge capability**
- ◆ **Identify & mobilize additional care sites**
- ◆ **Implementing “mass critical care”**



Emergency Mass Critical Care Interventions

Mechanical ventilation

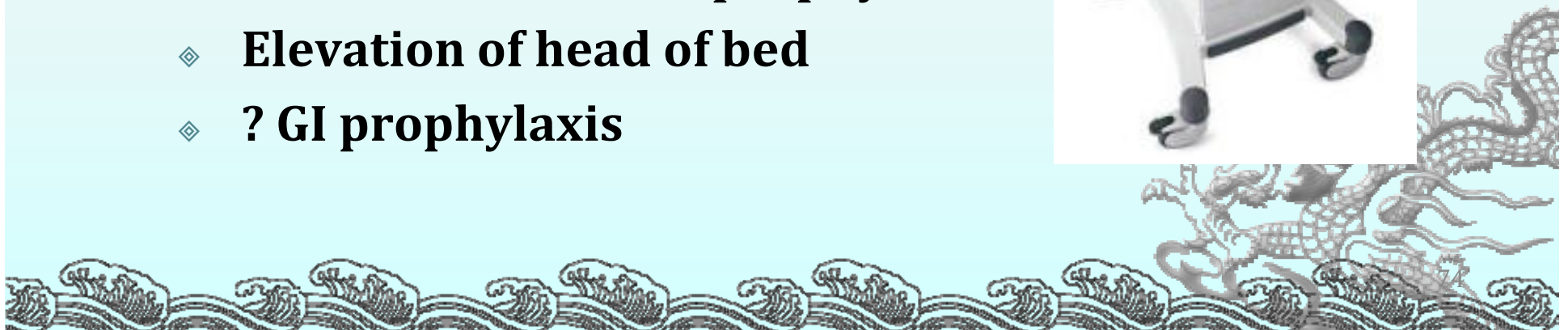
- ◆ Basic mode

Hemodynamic support

- ◆ IV fluid
- ◆ Vasopressor

Prophylactic intervention

- ◆ Thromboembolism prophylaxis
- ◆ Elevation of head of bed
- ◆ ? GI prophylaxis



Tiered staffing

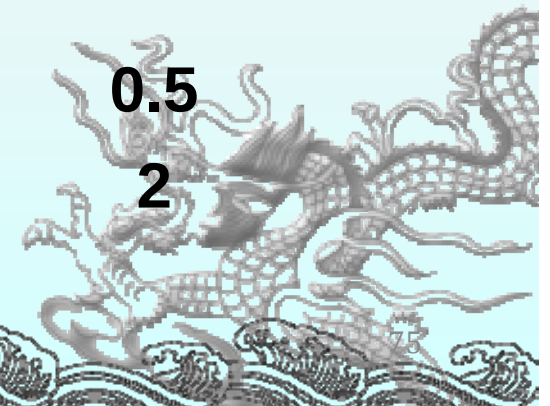
<u>Staff Category</u>	<u>Usual ICU Care</u>	<u>Emergency Mass Critical Care</u>
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Nurses

Critical Care	14	4
Non-CC	0	12

Intensivists

Critical Care	1	0.5
Non-CC	0	2



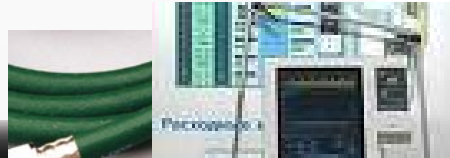
DIVISION OF STRATEGIC NATIONAL STOCKPILE



CENTERS FOR DISEASE CONTROL AND PREVENTION



PPV CATEGORIES



Sophisticatedly ventilators
ENHANCED Ventilators

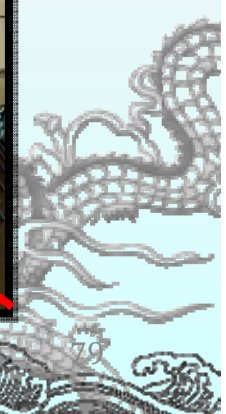


Space

- ◆ **Transfer all non-critically ill and injured patients out of ICU**
- ◆ **Board critically ill and injured patients in Post-Anesthetic Care Unit and A&E Department**
- ◆ **Evacuate patients to other critical care-capable facilities**
- ◆ **Cancel non-emergent surgeries that would require ICU post-op care**



Mass Casualty Respiratory Failure

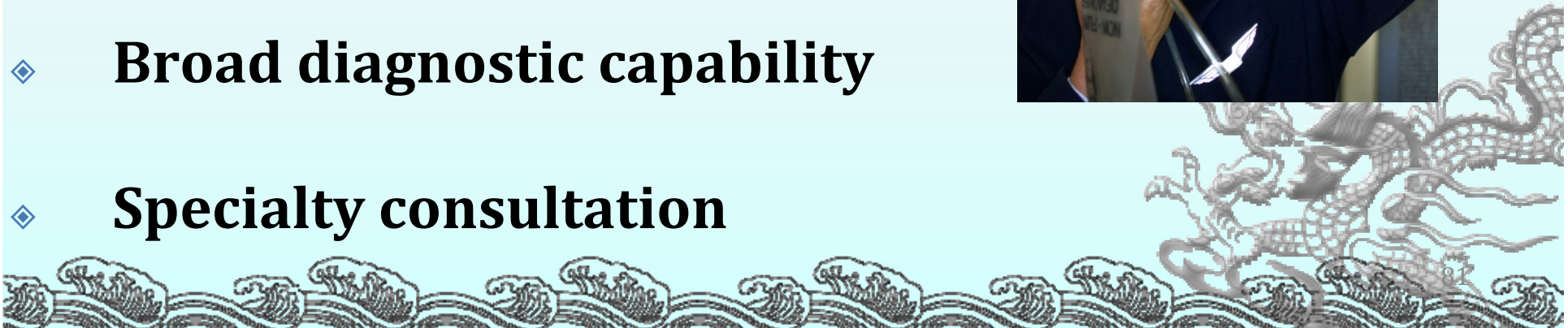


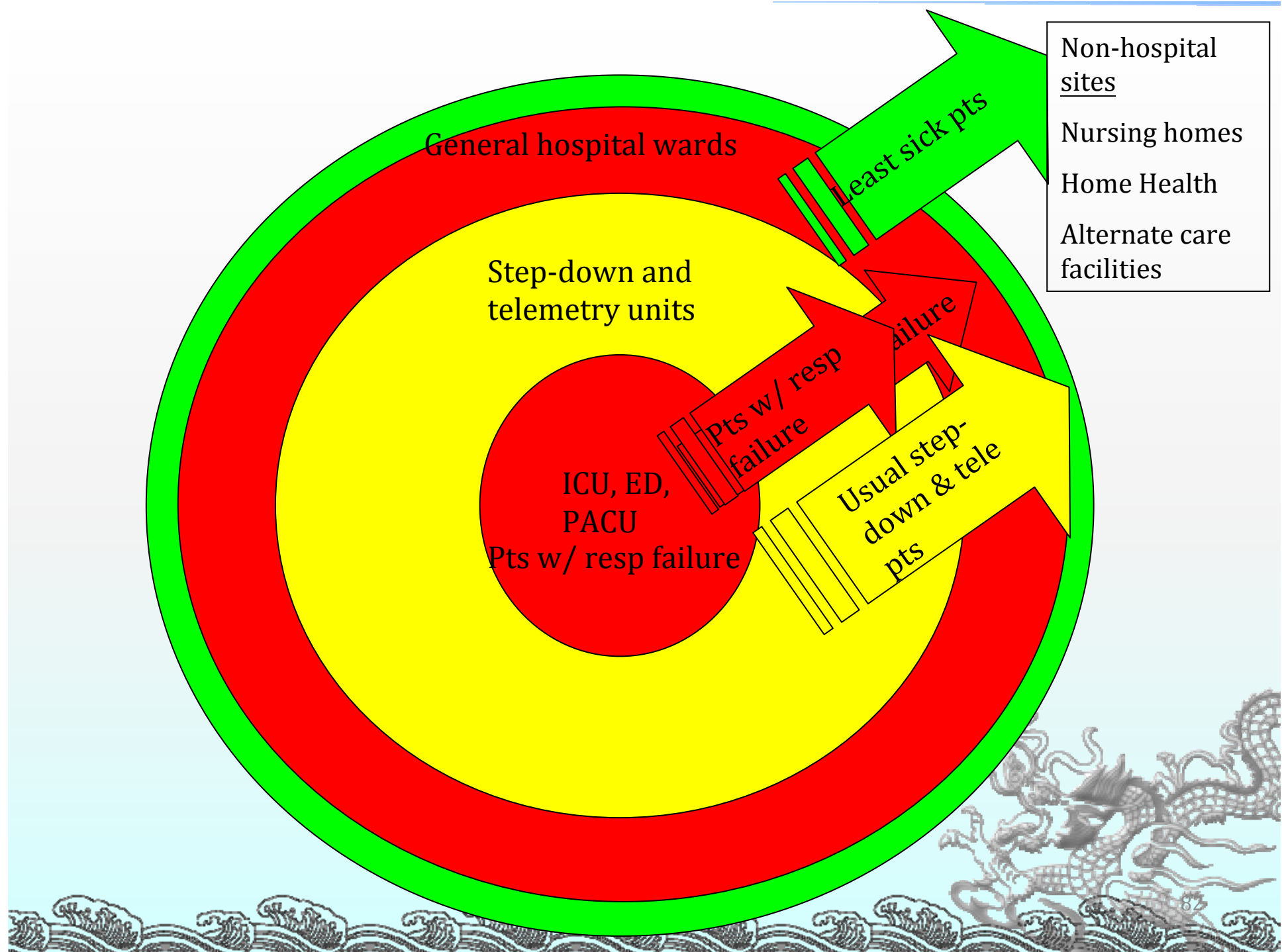
Oxygen



Challenges of Critical Care Outside of Hospitals

- ◆ **Expensive hospital beds**
- ◆ **Oxygen!!**
- ◆ **Suction**
- ◆ **Infection control**
- ◆ **Broad diagnostic capability**
- ◆ **Specialty consultation**





Extended Knowledge Base

- ◆ **Trauma**
 - ◆ Penetrating injury
 - ◆ Blunt/crush injury
- ◆ **Blast injury**
- ◆ **Burns**
- ◆ **Chemical**
- ◆ **Biological**
- ◆ **Radiological**
- ◆ **Nuclear**



Extended Spectrum of Duties

- ◆ Life/limb-saving therapy
- ◆ Organ-support therapy
- ◆ Pain/symptom-relieving therapy
- ◆ Palliative care
- ◆ Bereavement care



Surge Capability – Burn

Burn specialist team
1 surgeon/orthopaedist
1 anaesthesiologist/intensivist
1-2 nurses

Usual ICU team
Physicians
Nurses
Others



Non-burn ICU with burn patients
8-12 severe burn patients

**Converting a multidisciplinary ICU
into a burn ICU**



Surge Capability - Paediatrics

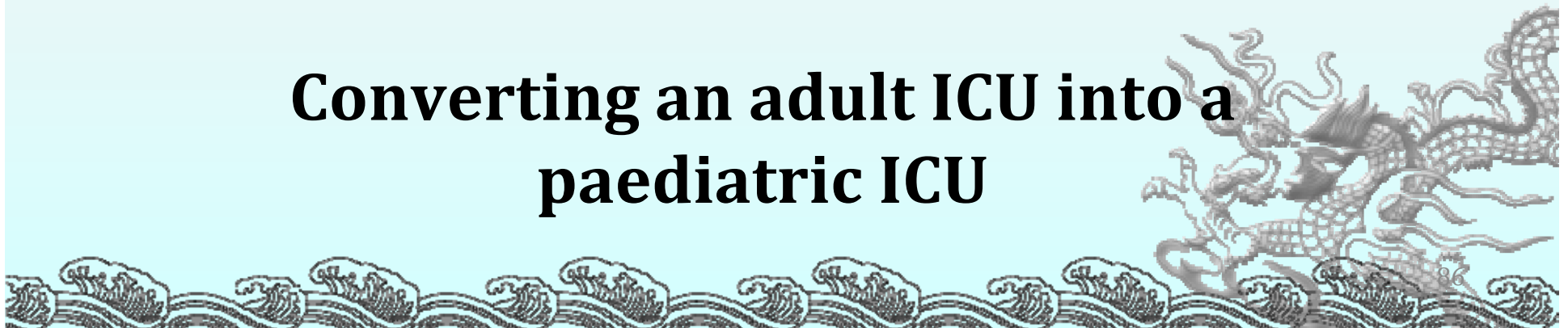
Paediatric specialist team
1 paediatrician
1 anaesthesiologist/intensivist
1-2 nurses

Usual ICU team
Physicians
Nurses
Others



Adult ICU with paediatric patients

**Converting an adult ICU into a
paediatric ICU**



The Vulnerable Population

- ◆ The young
- ◆ The elderly
- ◆ The disabled
 - ◆ Deaf
 - ◆ Blind
 - ◆ Mentally retarded
- ◆ The poor
- ◆ The isolated
- ◆ The equipment-dependent
- ◆ The chronically ill
- ◆ Women
- ◆ Pets



Mental Health of the Provider

◆ Compassion fatigue

- ◆ Feeling overwhelmed
- ◆ Emotional numbness
- ◆ Detached
- ◆ Anxiety
- ◆ Anger
- ◆ Avoidance
- ◆ Re-experiencing
- ◆ Sleep disturbance
- ◆ Intrusive thoughts

◆ Post-traumatic stress disorder

- ◆ Insomnia
- ◆ Nightmares
- ◆ Flashbacks
- ◆ Hypervigilance
- ◆ Emotional numbness
- ◆ Apathy
- ◆ Irritability
- ◆ Avoidance



Thank you

**The best patient outcomes are
produced by the best prepared teams**

*Fundamentals of
Disaster Management*

