FACULTY OF MEDICINE AND HEALTH SCIENCES

DEPARTMENT OF EMERGENCY MEDICINE

CHEMICAL TERRORISM:

THREAT ASSESSMENT, GENERAL MANAGEMENT & SCENARIOS

UPDATE “ACUTE INTOXICATIES”, 4DE LAGE LANDEN SYMPOSIUM INTOXICATIES

Peter De Paepe, Head of the Emergency Department, Ghent University Hospital

9th June 2017

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kritieke diensten

Universitair Ziekenhuis Gent

DISCLOSURE STATEMENT

I do not have a financial interest/arrangement or affiliation with one or more organizations that could be perceived as a real or apparent conflict of interest in the context of the subject of this presentation.

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CHEMICAL TERRORISM

1. CHEMICAL WARFARE AGENTS (CWAs)
2. TOXIC INDUSTRIAL CHEMICALS (TICs)
3. THREAT ASSESSMENT
4. GENERAL MANAGEMENT
5. SCENARIOS
6. CONCLUSIONS

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CHEMICAL TERRORISM: WARFARE AGENTS

- Any toxic chemical or its precursor developed to be used as weapon to kill, injure or temporarily incapacitate
- Listed in the Chemical Weapons Convention (CWC)
- Produced and stockpiled in amounts exceeding requirements for industrial use
- Production/dispersion needs specialized multidisciplinary teams
- Nerve agents and vesicants are the two main groups

CHEMICAL WARFARE POSSESSION

Nation	CW Possession	Signed CWC	Ratified CWC
Albania	Known	January 14, 1993[1]	May 11, 1994[1]
Burma (Myanmar)	Possible	January 14, 1993[2]	July 8, 2015[3]
China	Probable	January 13, 1993	April 4, 1997
Egypt	Probable	No	No
India	Known	January 14, 1993	September 3, 1996
Iran	Known	January 13, 1993	November 3, 1997
Israel	Probable	January 13, 1993[2]	No
Japan	Probable	January 13, 1993	September 15, 1995
Libya	Known	No	January 6, 2004 (acceded)
North Korea	Known	No	No

Nation	CW Possession	Signed CWC	Ratified CWC
Pakistan	Probable	January 13, 1993	October 28, 1997
Russia	Known	January 13, 1993	November 5, 1997
Serbia and Montenegro	Probable	No	April 20, 2000 (acceded)
Sudan	Possible	No	May 24, 1999 (acceded)
Syria	Known	No	September 14, 2013 (acceded)
Taiwan	Possible	n/a	n/a
United States	Known	January 13, 1993	April 25, 1997
Vietnam	Probable	January 13, 1993	September 30, 1998

OPCW, 2013

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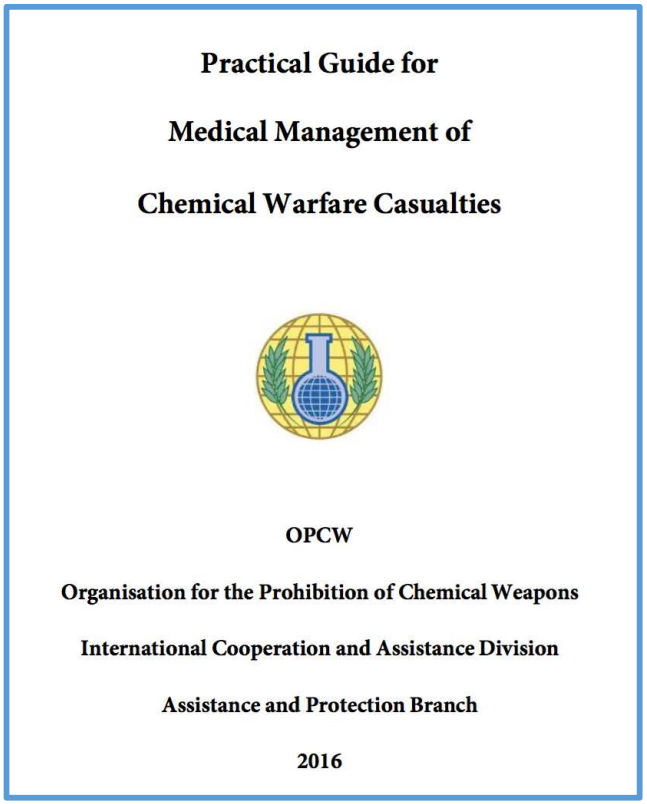
CHEMICAL WARFARE AGENTS

- Nerve agents
- Vesicants (blister agents)
- Lung damaging (choking) agents
- Blood agents
- *Incapacitants*
- *Riot control agents*



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CHEMICAL WARFARE AGENTS: NERVE AGENTS

Nerve agents	Tabun (GA), Sarin (GB), Soman (GD), Cyclosarin (GF), VX
Mechanism of action	Inactivation of acetylcholinesterase resulting in accumulation of acetylcholine at nerve terminals
Route of exposure	Skin, inhalation
Symptoms	Cholinergic toxidrome
Medical management	Personal protective equipment Decontamination Supportive care Specific therapy • Atropine • Oximes • Benzodiazepines

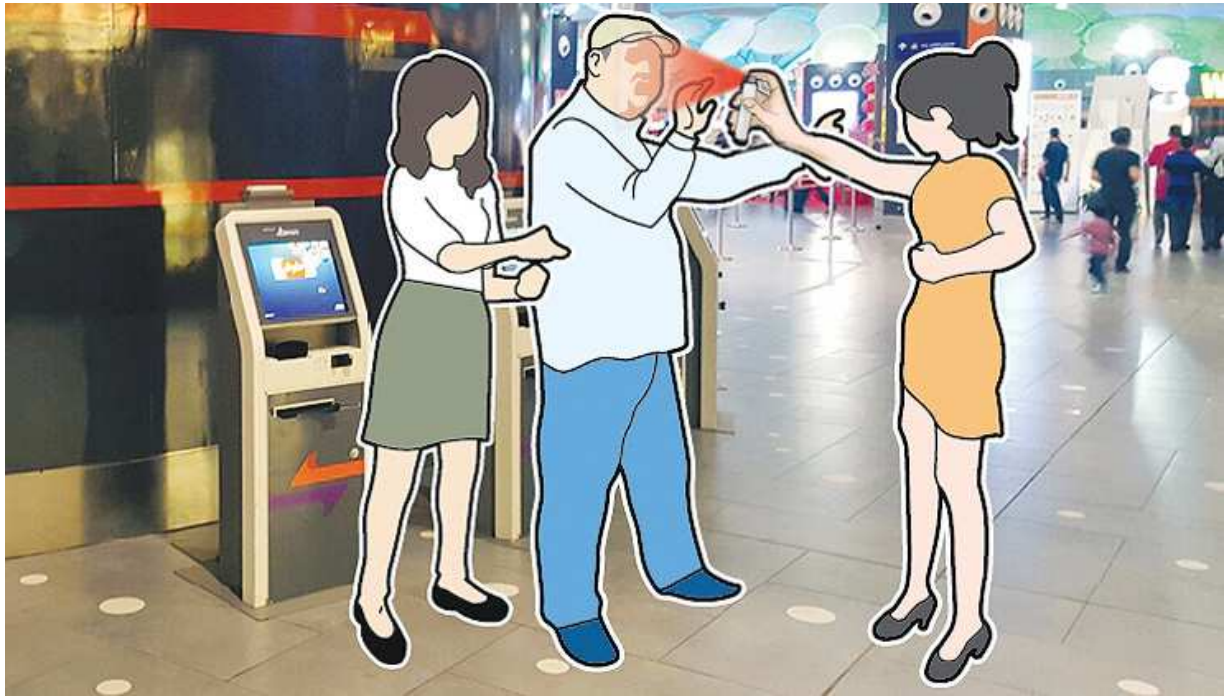
Over 5000 Kurds massacred in Halabja chemical bomb attack
16 March 1988

The New York Times

ASIA PACIFIC

Kim Jong-nam Was Killed by VX Nerve Agent, Malaysians Say

By RICHARD C. PADDOCK and CHOE SANG-HUN FEB. 23, 2017



Sarin attack against Syrian civilians, 4 April 2017

CHEMICAL WARFARE AGENTS: VESICANTS

Vesicants	Sulfur mustard, Nitrogen mustard, Lewisite, Phosgene oxime
Mechanism of action	Alkylating agents + Arsenic absorption for Lewisite
Route of exposure	Skin, inhalation, ingestion
Symptoms	Vesicant (cause blisters) and irritant with main effects on skin, eyes and respiratory system; Lewisite can cause systemic effects of arsenic poisoning
Medical management	Personal protective equipment Decontamination Supportive care Specific therapy for Lewisite: BAL or DMPS

Clinical management of mustard gas casualties

Jan L. Willems, M.D. Ph.D.

Heymans Institute of Pharmacology
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and

Royal School of the Medical Services
Leopoldskazerne
B-9000 Ghent, Belgium

Iranian casualties from the Iran-Iraq conflict, 1984-1986

Annales Medicinae Militaris Belgicae 1989; 3:1–61

CHEMICAL WARFARE AGENTS: CHOKING AGENTS

Choking agents	Chlorine, Phosgene, Diphosgene, Chloropicrin
Mechanism of action	Irritant and corrosive to skin, eyes, respiratory system
Route of exposure	Inhalation, skin
Symptoms	**Inhalation**: cough, wheeze, dyspnoe, pneumonitis, non-cardiogenic pulmonary oedema (ARDS), hypoxia, cardiac arrest **Eyes**: stinging, blepharospasm **Skin**: irritation, erythema, burns
Medical management	Personal protective equipment Decontamination Supportive care

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The use of chlorine gas during World War I

Chemical attack in Syria

A suspected Syrian government chemical attack killed scores of people, including children, in the northwestern province of Idlib.

● Suspected recent attack

Location	*Date*	*Chemical*	*Actor*
Khan Sheikhoun	April 04, 2017	Unconfirmed	Syrian Army (suspected)

ATTACKS PREVIOUSLY INVESTIGATED*

● Where findings on attacks were conclusive

Location	*Date*	*Chemical*	*Actor*
Marea	Aug. 21, 2015	Sulfur mustard	Islamic State
Sarmin	March 16, 2015	Chlorine gas	Syrian Army
Talmenes	April 21, 2014	Chlorine gas	Syrian Army

● Where findings on attacks were inconclusive

Location	*Date*	*Chemical*	*Actor*
Binnish	March 24, 2015	Chlorine gas	Inconclusive
Qmenas	March 16, 2015	Undetermined	Syrian Army
Al-Tamanah	May 25-26, 2014	Undetermined	Inconclusive
Al-Tamanah	April 29-30, 2014	Chlorine gas	Inconclusive
Kafr Zita	April 18, 2014	Chlorine gas	Inconclusive
Kafr Zita	April 11, 2014	Chlorine gas	Inconclusive

*The year-long U.N. and Organization for the Prohibition of Chemical Weapons (OPCW) inquiry — unanimously authorized by the U.N. Security Council — focused on nine attacks in seven areas of Syria, where a separate OPCW fact-finding investigation had already determined that chemical weapons had likely been used.

Source: OPCW-UN Joint Investigative Mechanism; Reuters

Staff, 05/04/2017

REUTERS

CHEMICAL WARFARE AGENTS: BLOOD AGENTS

Blood agents	Hydrogen cyanide, Cyanogen chloride
Mechanism of action	Cytochrome oxidase inhibition preventing cells from using oxygen
Route of exposure	Inhalation, skin, ingestion
Symptoms	Very rapid effects on CNS, death from respiratory or cardiac arrest
Medical management	Personal protective equipment Decontamination if liquid contamination Supportive care Specific therapy: hydroxocobalamin

CHEMICAL WARFARE AGENTS: INCAPACITANTS

Incapacitants	Ultrapotent opioids, 3-quinuclidinyl benzilate (BZ), (LSD)
Route of exposure	Inhalation
Symptoms	Thought disorders or altered state of consciousness
Medical management	Personal protective equipment Decontamination Supportive care Specific therapy: naloxone for opioids

Fentanyl derivative used against terrorists holding hostages in a Moscow theater, 26 October 2002
130 hostages died

CHEMICAL WARFARE AGENTS: RIOT CONTROL AGENTS

Riot control agents	Chemical mace (CN), Tear gas (CS), Adamsite (DM), Capsaicin pepper spray (OC)
Route of exposure	Skin, inhalation
Symptoms	Immediate and short acting irritant effects on eyes, respiratory system (and sometimes skin) Fatalities uncommon
Medical management	Personal protective equipment Decontamination Supportive care


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CHEMICAL WARFARE AGENTS: TOXICITY

Agent	LCt_{50} mg.min/m^3	LD_{50} percutaneously (mg per 70 kg man)
VX	10-30 (aerosolised)	5-10
Soman	50-70	350
Sarin	100	1700
Tabun	135-400	1000
Lewisite	1200-1500	~3500
Sulfur mustard	1500 (>> Effective Dose)	4500 (>> Effective Dose)
Phosgene	3000	N/A
HCN	5000	N/A

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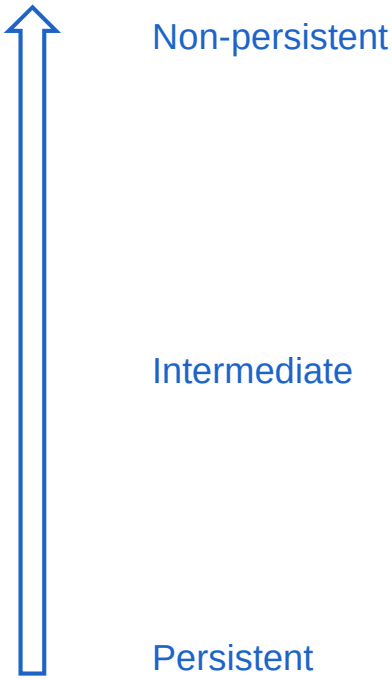
The toxic hazard will depend on the volatility (for inhalation) and persistency (for skin) of the agent

VOLATILITY OF CHEMICAL WARFARE AGENTS

Agent	Boiling point (°C)	Volatility at 25°C (mg per m^3)
Phosgene	8	>1,000,000
Water (reference)	100	~150,000
Sarin (GB)	158	22,000
Lewisite	196	3,900
Soman (GD)	198	3,900
Sulfur mustard	217	910
Cyclosarin (GF)	239	680
Tabun (GA)	247	490
Nitrogen mustard	257	110
VX	300	9



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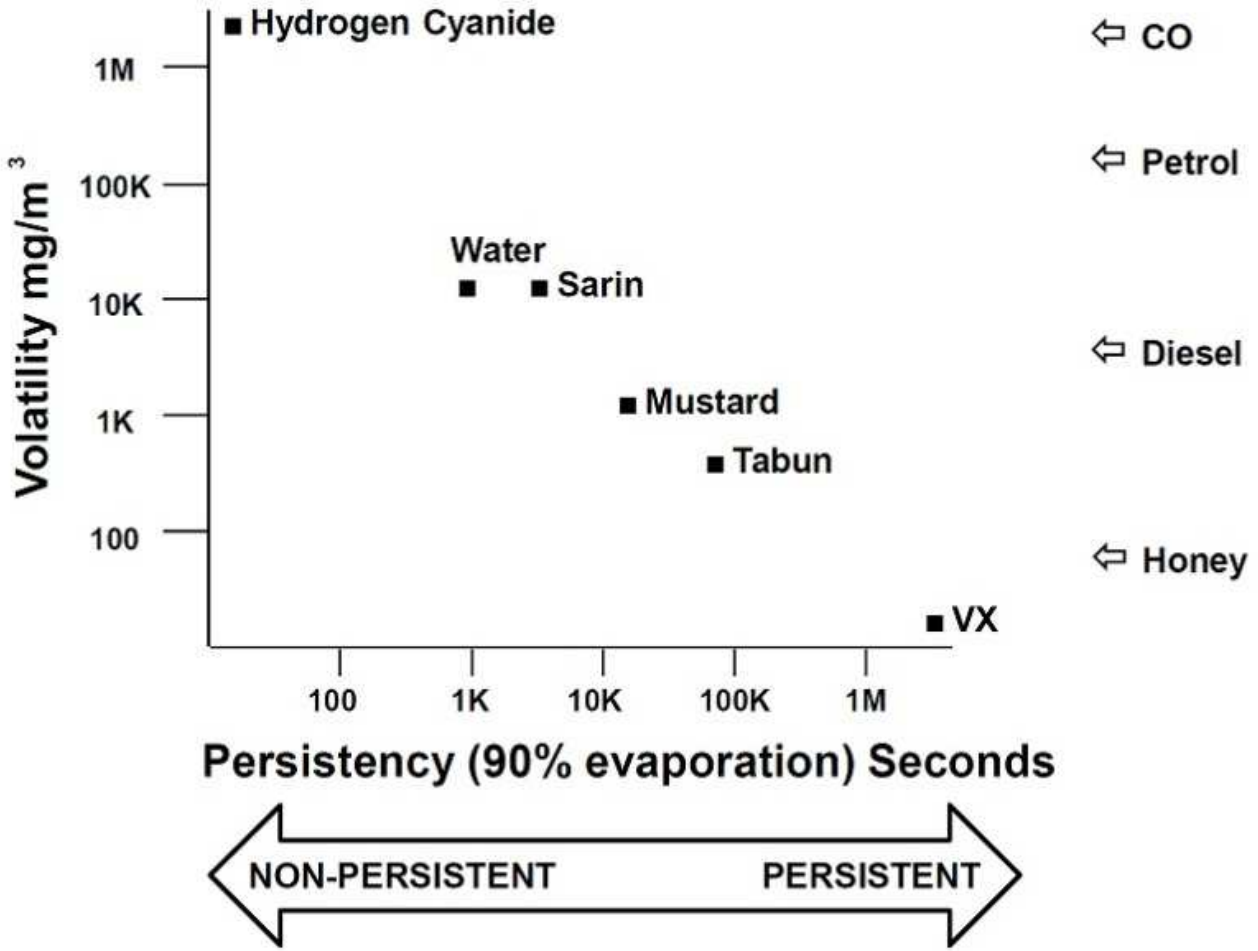

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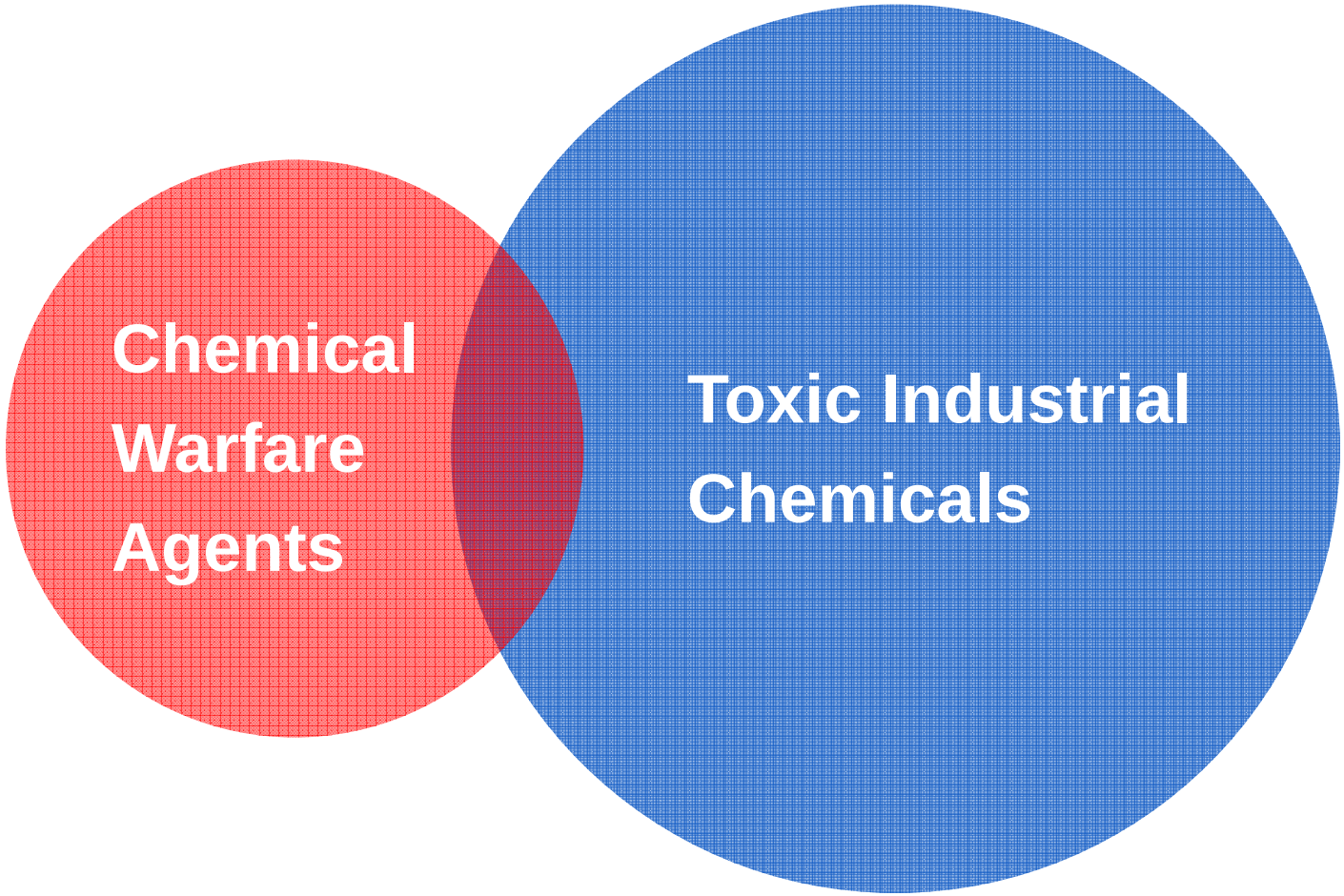

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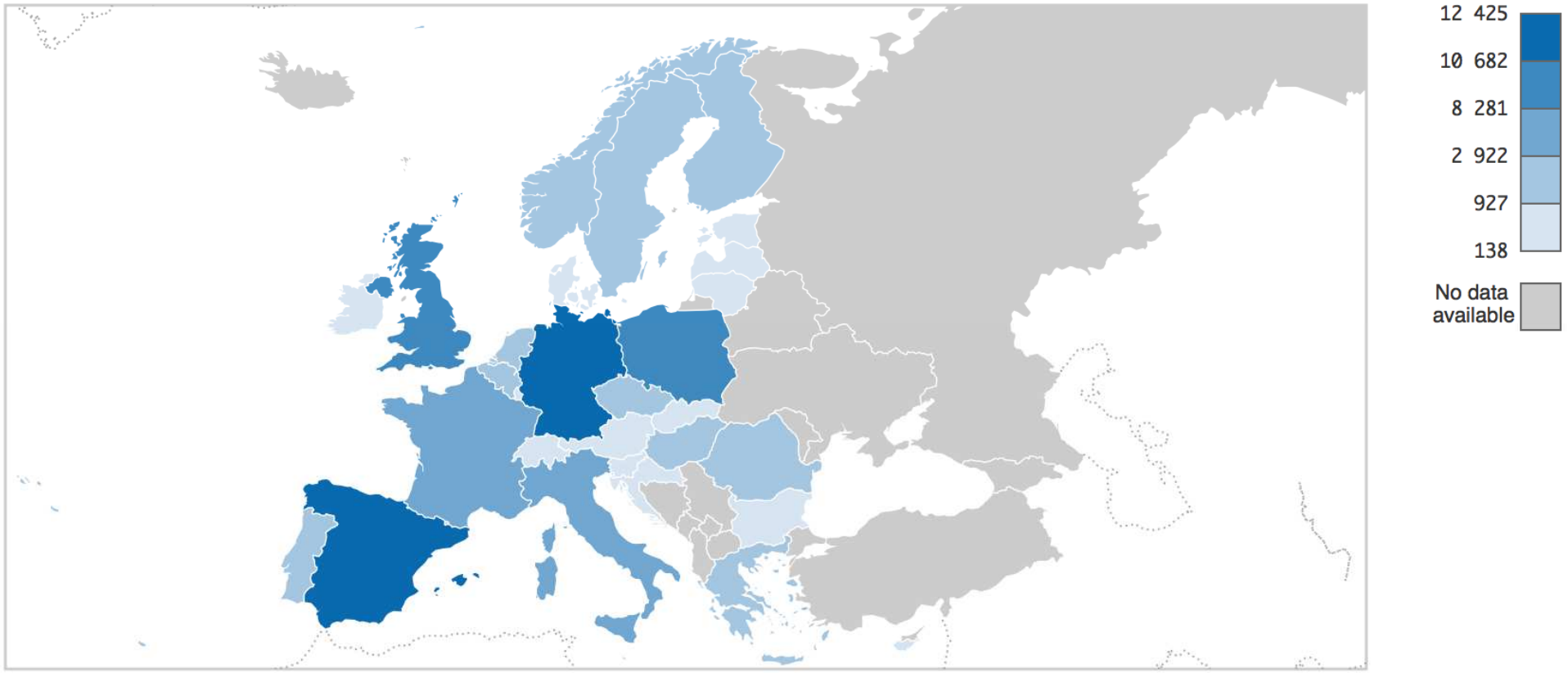
EXAMPLES OF HIGH-HAZARD TICs

Ammonia	Arsine	Boron trichloride
Boron trifluoride	Carbon disulphide	Chlorine
Diborane	Ethylene oxide	Fluorine
Formaldehyde	Hydrogen bromide	Hydrogen chloride
Hydrogen cyanide	Hydrogen fluoride	Hydrogen sulphide
Fuming nitric acid	Phosgene	Phosphorus trichloride
Sulphur dioxide	Sulphuric acid	Tungsten hexafluoride


The Wetteren acrylonitrile disaster
May 4th 2013
➢ >2,000 residents evacuated
➢ 438 ED admissions
➢ 8 severely poisoned
➢ 1 person died

Annual road freight transport of dangerous goods, by type of dangerous goods and broken down by activity

Dangerous goods: 10. Total all dangerous goods groups **Transport coverage:** Total transport **Unit of measure:** Million tonne-kilometre (TKM) **Year:** 2015



eurostat

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RISK OF A CHEMICAL ATTACK

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RISK OF A CHEMICAL ATTACK

- Most chemical agents are difficult to acquire, handle and transport
- Sophisticated expertise and technology may be necessary to produce the agents
- Chemical properties may make it difficult to disperse a sufficient quantity to produce toxicity
- Enormous quantities are necessary to contaminate a water supply or poison people at a civic gathering reducing their potential for use as a terrorist weapon

RISK OF A CHEMICAL ATTACK: HURDLES FOR "SUCCESS"

- Attacks in Matsumoto (1994) and the Tokyo subway (1995) by the Aum Shinrikyo group
- Sarin was used in both attacks

Tu et al. Toxin Reviews. 2007; 26:231-274

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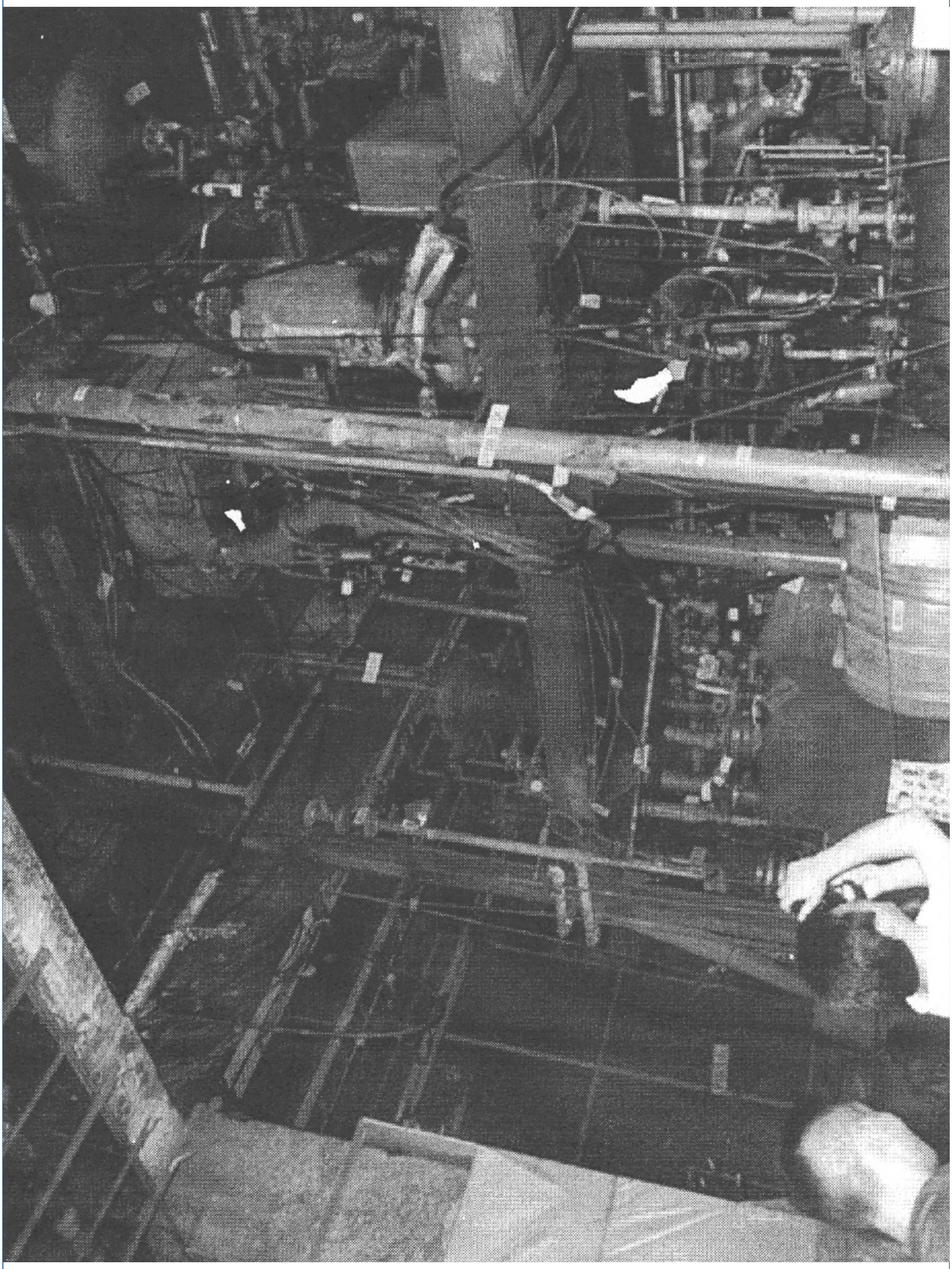
ATTACK IN MATSUMOTO, 1994

- Truck with 20-30kg of pure Sarin parked near the target
- Computer-controlled system to release a cloud of Sarin when heated
- A light breeze pushed it towards a cluster of private houses during 10-20 min releasing ~3L Sarin (23:00h)
- Second hit when sun rose, and Sarin was heated and volatilized
- 8 people killed, 274 others seeking treatment


3 of 15 inhabitants died
3 of 10 inhabitants died
1 died and 5 affected
1 of 8 inhabitants died
Judges' residence



TOKYO SUBWAY ATTACK, 1995

- Sarin attack was launched on the subway system in the early morning rush hour, targeting a number of different rail routes
- Liquid sarin (30% purity) transported in sachets, which the offenders pierced with sharpened umbrella tips on the floor of the train carriage
- Sarin leaked out and began to evaporate quickly, with rapid effects
- 12 recorded deaths, 54 seriously injured, 980 affected, over 5,000 presented themselves to hospitals

RISK OF A CHEMICAL ATTACK: HURDLES FOR "SUCCESS"

- Effective delivery devices
- Achievement of lethal toxicity threshold across a large, public, open area or network
- Enormous quantities are required to reach lethal dose thresholds over large areas

⇒ more effective in creating panic and confusion than in causing actual mass casualties

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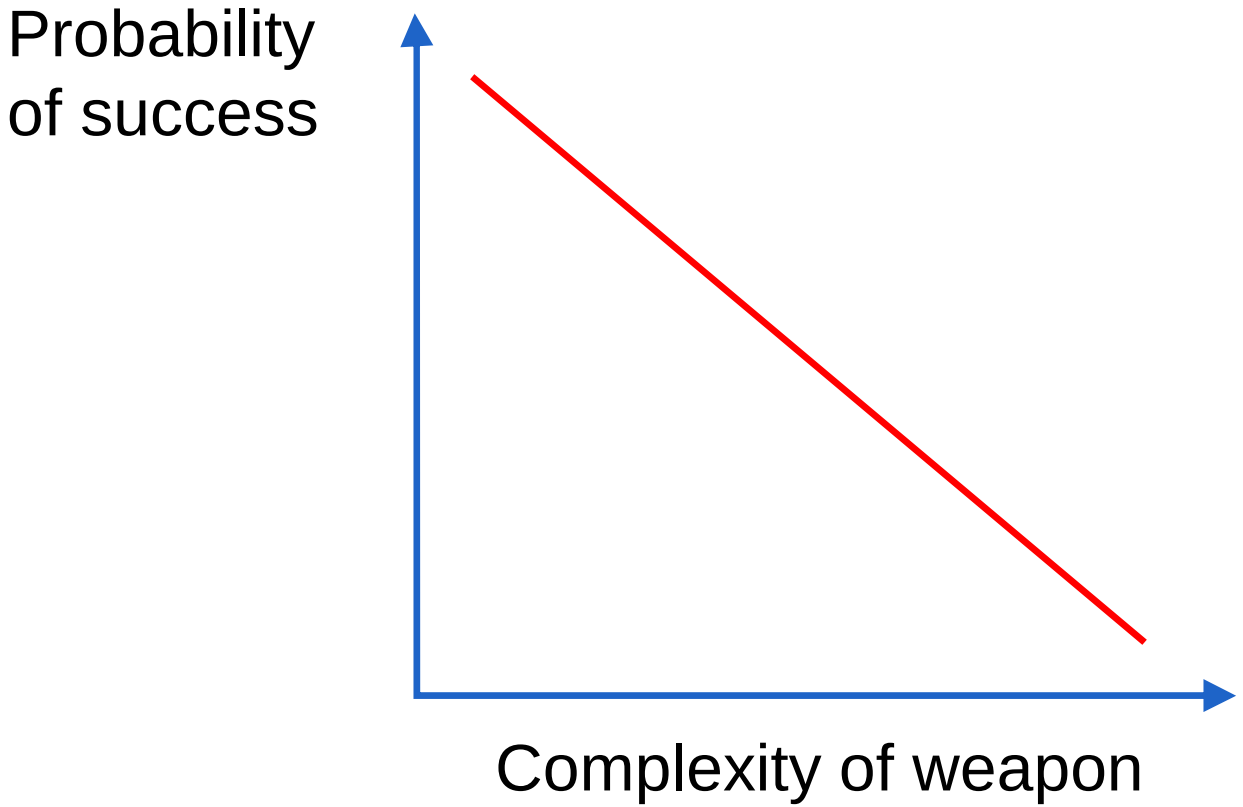
RISK OF A CHEMICAL ATTACK: HURDLES FOR “SUCCESS”



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LONDON BRIDGE ATTACK, JUNE 3, 2017

7 people killed

48 injured

BOSTON MARATHON BOMBING, APRIL 15, 2013

3 people killed

264 injured

BRUSSELS ATTACKS, MARCH 22, 2016

Note: Local time shown

35 people killed

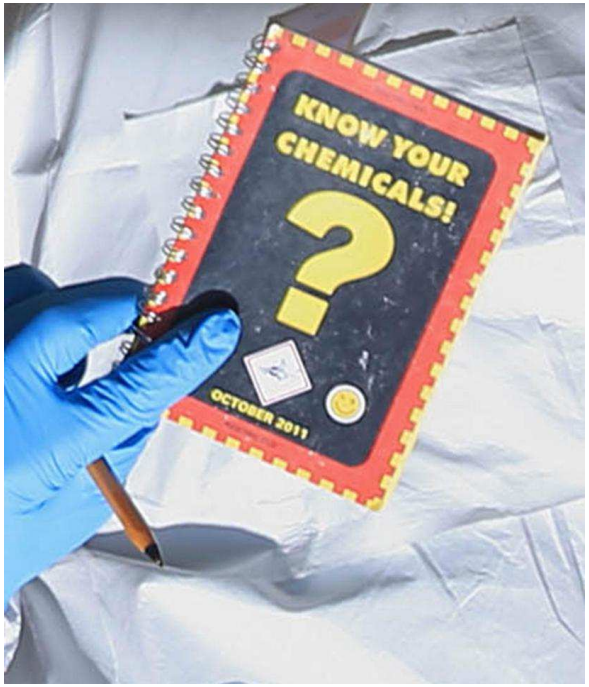
300 injured

(62 critically)

MANCHESTER ATTACK, MAY 24, 2017

22 people killed

> 60 injured



Briefing

December 2015

European Parliament

ISIL/Da'esh and 'non-conventional' weapons of terror

The European Union and its Member States must prepare for the possibility of a chemical or biological attack on their territory by the self-styled 'Islamic State' in Iraq and the Levant (known variously as IS, ISIS or ISIL, and by the Arabic acronym 'Da'esh').

Several experts[1] have warned that there is a genuine risk of ISIL/Da'esh using chemical, biological, radiological or even nuclear materials in the context of future attacks on European targets. It has been suggested that the group's next weapon of choice could, for example, be an improvised explosive device containing chemical or radioactive materials.

First on CNN: ISIS creating chemical weapons cell in new de facto capital, US official says


By Ryan Browne and Barbara Starr, CNN

Updated 2020 GMT (0420 HKT) May 17, 2017

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CHEMICAL INCIDENTS: MANAGEMENT
LESSONS LEARNED FROM SARIN ATTACK IN TOKYO SUBWAY

- Preparedness to manage CBRN incidents
- Highly trained and experienced clinical personnel with profound knowledge of toxidromes
- Detailed mass decontamination plan
- Crowd control to hospitals
- Personal protective equipment for fire fighters and health care workers; 10% of immediate responders and 23% of hospital staff experienced secondary exposure
- Immediately available stockpiles of antidotes

Tu et al. Toxin Reviews. 2007; 26:231-274


Teusler Memorial Hall


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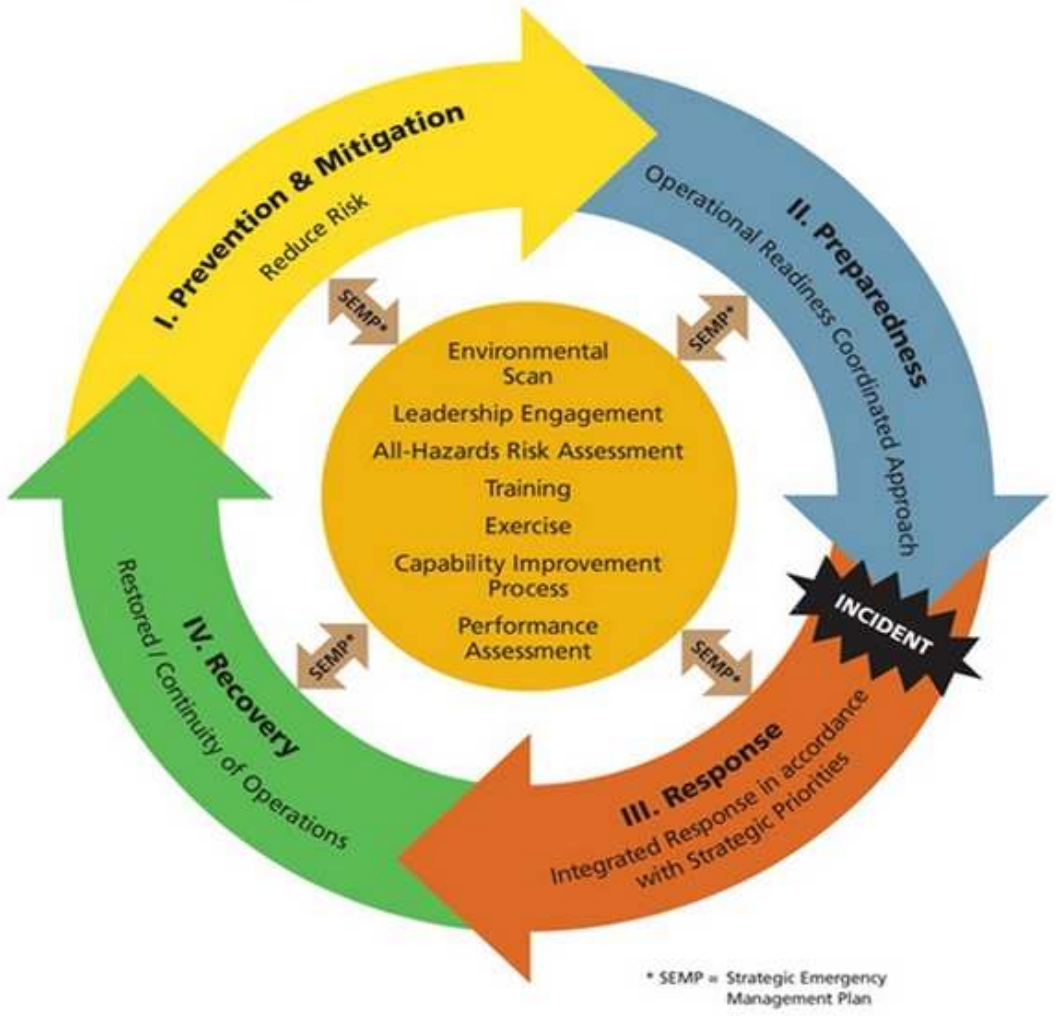
CHEMICAL INCIDENTS: MANAGEMENT



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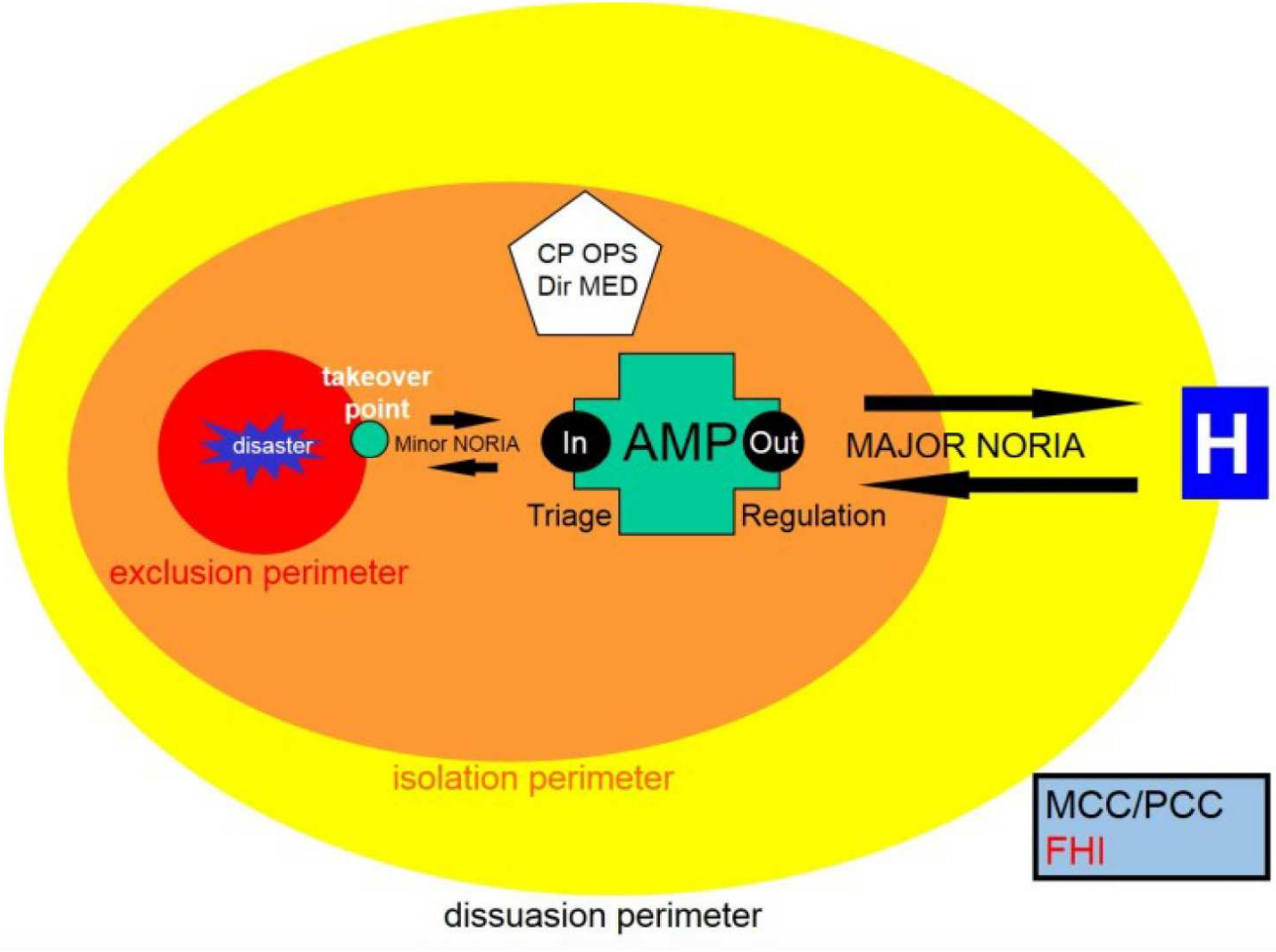
CHEMICAL INCIDENTS: MANAGEMENT



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CHEMICAL INCIDENTS: MANAGEMENT

- Ensure either that you are wearing ‘chemical’ personal protective equipment **or** that patient has been decontaminated
- Decontaminate patient (outside the department) if this has not already been done
- Stabilise airway (oxygen by mask, intubate and ventilate if needed), control any haemorrhage, set up IV access if needed
- Assess cause, give antidotes if appropriate, reassess and seek expert advice

Health Protection Agency, 2008

CHEMICAL INCIDENTS: MANAGEMENT

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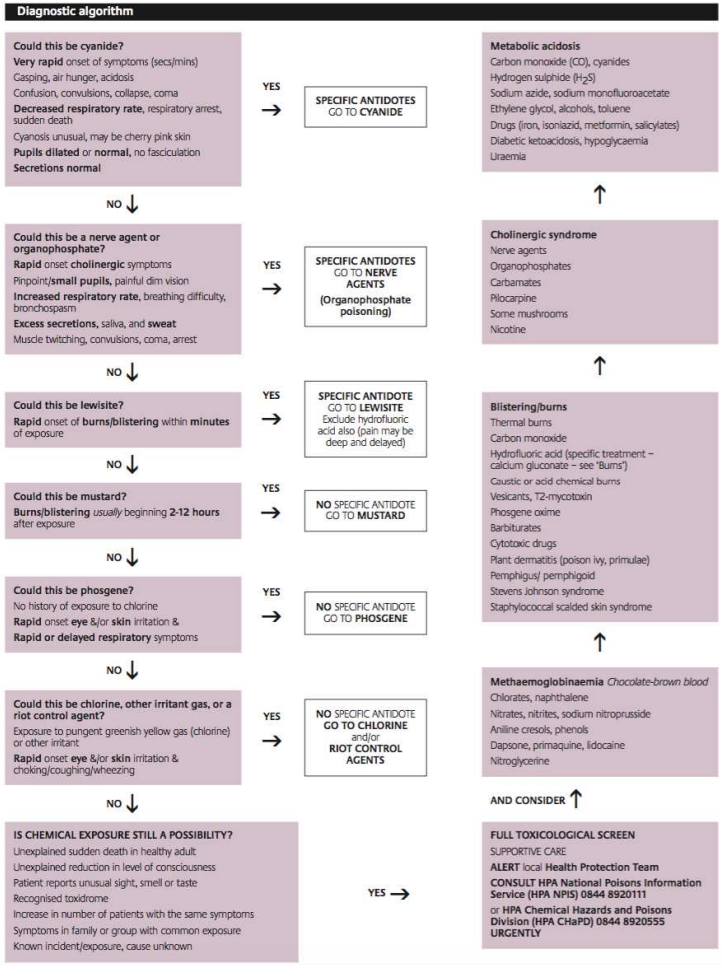
CHEMICAL INCIDENTS: MANAGEMENT



Health Protection Agency, 2008

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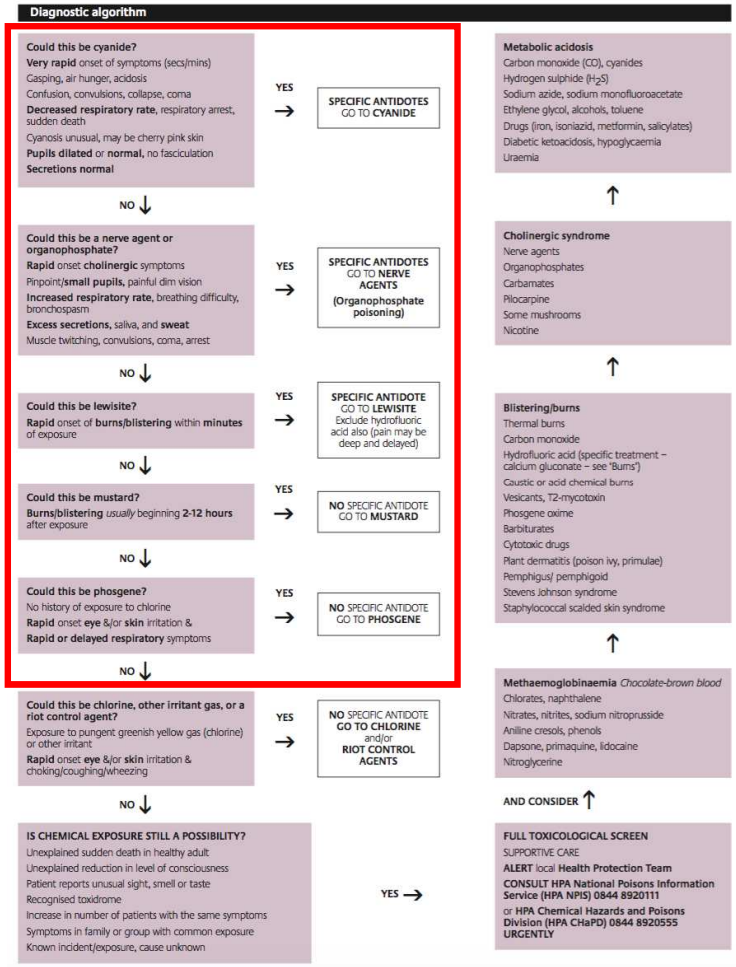
CHEMICAL INCIDENTS: MANAGEMENT



Health Protection Agency, 2008

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CHEMICAL INCIDENTS: MANAGEMENT

Could this be cyanide?

Very rapid onset of symptoms (secs/mins)

Gasping, air hunger, acidosis

Confusion, convulsions, collapse, coma

Decreased respiratory rate, respiratory arrest, sudden death

Cyanosis unusual, may be cherry pink skin

Pupils dilated or **normal,** no fasciculation

Secretions normal

YES →

SPECIFIC ANTIDOTES GO TO **CYANIDE**

NO ↓

Could this be a nerve agent or organophosphate?

Rapid onset **cholinergic** symptoms

Pinpoint/**small pupils,** painful dim vision

Increased respiratory rate, breathing difficulty, bronchospasm

Excess secretions, saliva, and **sweat**

Muscle twitching, convulsions, coma, arrest

YES →

SPECIFIC ANTIDOTES GO TO **NERVE AGENTS**

(Organophosphate poisoning)

Health Protection Agency, 2008

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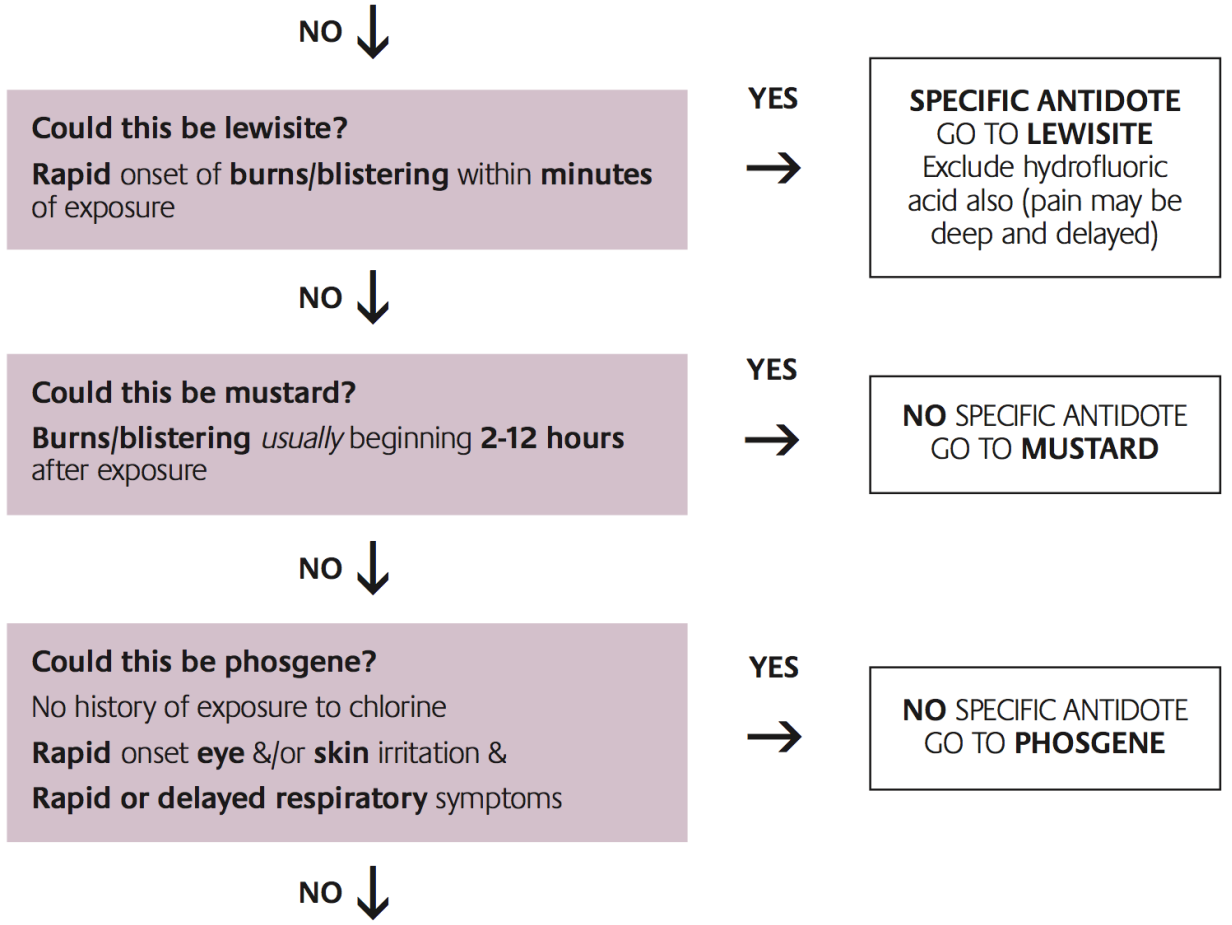
CHEMICAL INCIDENTS: MANAGEMENT



Health Protection Agency, 2008

CHEMICAL INCIDENTS: ANTIDOTES

Advice to Superior Health Council of Belgium

Agent	Antidote	Urgency of antidote availability	Cost (€) per 100 patients*
Nerve agent	Atropine	+++	8,000
	Midazolam	+++	200
	Pralidoxime	++	800,000
Cyanide	Hydroxocobalamin	+++	130,000
	Sodium thiosulfate	+	9,500
Lewisite	DMPS	+	45,000
Hydrofluoric acid	Calcium gluconate	+	
Opioids	Naloxone	+++	3,500

* Based on worst case scenario

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CHEMICAL INCIDENTS: ANTIDOTES

- Route of administration: i.m. preferred over i.v. for mass casualties
- Ready-to-use formulations (auto-injectors)
- Central stockpile versus disseminated antidote strategy
- Capacity and control of stockpiles
- Which oxime(s)
- Feasibility of prehospital oxime treatment in a civilian setting
- Benefit of oximes in rapidly aging nerve agents

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CHEMICAL ATTACK – BLISTER AGENT

Light aircraft sprays chemical agent yellow (sulfur mustard and lewisite) into a packed football stadium	
Casualties	150 fatalities; 70,000 hospitalized
Evacuations	More than 100,000 evacuated; 15,000 seek shelter in immediate area (decontamination required)
Economic impact	$500 million
Recovery timeline	Weeks; many long-term health effects

National planning scenarios. US Department of Homeland Security, 2006

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CHEMICAL ATTACK – TICs

Terrorists launch rocket-propelled grenades over a petroleum refinery resulting in major fires. Metals are released in plumes from burning cargoes of nearby ships. Multiple cargo containers with isocyanates, nitriles and epoxy resins explode.	
Casualties	350 fatalities; 1,000 hospitalized
Evacuations	10,000 evacuated, 1,000 seek shelter in safe areas, 25,000 instructed to temporarily shelter-in-place
Economic impact	Billions of dollars
Recovery timeline	Months

National planning scenarios. US Department of Homeland Security, 2006

CHEMICAL ATTACK – NERVE AGENT

Eight dispersion devices release Sarin vapor into the ventilation systems of three large commercial office buildings in a metropolitan area	
Casualties	5,700 fatalities (95% of building occupants); 300 injuries
Evacuations	Temporary shelter in place for 50,000 people in adjacent buildings
Economic impact	$300 million
Recovery timeline	3 to 4 months

National planning scenarios. US Department of Homeland Security, 2006

CHEMICAL ATTACK – CHLORINE TANK EXPLOSION

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CHEMICAL ATTACK – CHLORINE TANK EXPLOSION

Terrorists infiltrate an industrial facility and rupture a chlorine storage tank using a low-order explosive, releasing a large quantity of chlorine gas downwind	
Casualties	17,500 fatalities; 10,000 severe injuries; 100,000 hospitalizations
Evacuations	100,000 instructed to temporarily shelter-in-place, 50,000 evacuated, 500,000 self-evacuate
Economic impact	Millions of dollars
Recovery timeline	Weeks

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National planning scenarios. US Department of Homeland Security, 2006

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CONCLUSIONS

- Use of chemicals is appealing to terrorist groups because the impact in terms of death, disability, economic losses, and panic remain high
- Although the probability of incidents resulting in widespread public health disasters appears low, the consequences are high, and substantial preparations must be made in advance
- Multidisciplinary emergency plans should include CBRN emergency preparedness
- Emergency medical responders should be familiar with the symptoms and management of chemical exposures
- Early decontamination is often critical for victims exposed to chemical agents
- A global strategy on stockpiling antidotes is crucial

“The purpose of terrorism lies not just in the violent act itself. It is in producing terror. It sets out to inflame, to divide, to produce consequences which they then use to justify further terror.”

Tony Blair
March 18, 2003

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