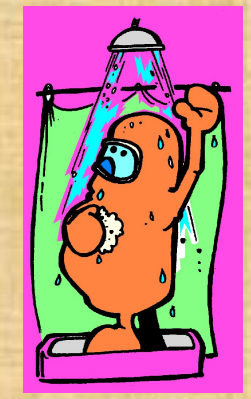
II. INTERNATIONAL CBRN CONGRESS 2019-ANKARA



Chemical Defense session

Recent decontamination technologies for chemical warfare agents

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ALPES MARITIMES

No conflict of interest to report
Opinions are those of the author only

Recent decontamination technologies for CWA

- **Contamination & decontamination**

  What, when & how, where & who

- **Technologies for emergency decontamination of CWA**
  - ❑ Specifically designed ready-to-use kits
  - ❑ Improvised

- **Thorough decontamination**

Contamination & Decontamination

what are we talking about ?

IAEA, NATO, WHO, EU, national guidelines & glossary, …

Decontamination = Reduction of external contamination

(removal & in-situ neutralization)

- **NATO**:

The process of **making** any person, object, or area **safe** by **destroying, neutralizing, making harmless or removing** absorbing chemical or biological agents, or by removing radiological material **clinging to or around it**.

- **EU**:

The **reduction** of C, B, R&N **contamination** of the **surfaces** of living organisms, soil, water or objects.

- **International Atomic Energy Agency**:

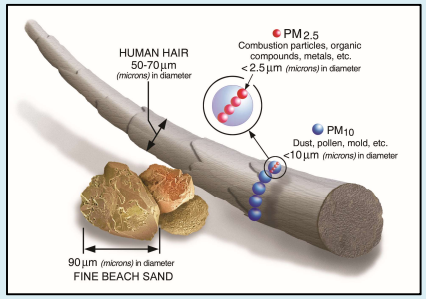
The complete or partial **removal of *contamination*** by a deliberate physical, chemical or biological *process*.

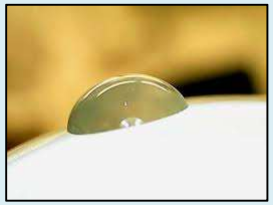
This definition is intended to include a wide range of *processes* for removing *contamination* from people, equipment and buildings, but **to exclude the removal of radionuclides from within the human body** or the removal of radionuclides by natural weathering or *migration processes*, which are not considered to be *decontamination*.

- *Removal of **internal contamination** = **decorporation** (RN) – **treatment** (BC)*

External contamination

What does it look like?





Not always visible …

- **Solid**
- **Liquid**
- **Aerosol**

Environmental conditions (temperature, humidity, wind) can affect the persistence & physical state of agents.

Becoming (externally) contaminated: *how does it happen ?*

- **Direct** contact with CBR agents (more or less perceptible);

- **Indirect** contact with a contaminated surface;

Transfer of contamination


American Journal of Infection Control 41 (2013) S6-S11

Contents lists available at ScienceDirect

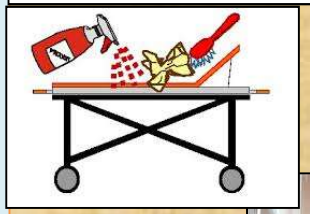
American Journal of Infection Control

journal homepage: www.ajicjournal.org

Original research article

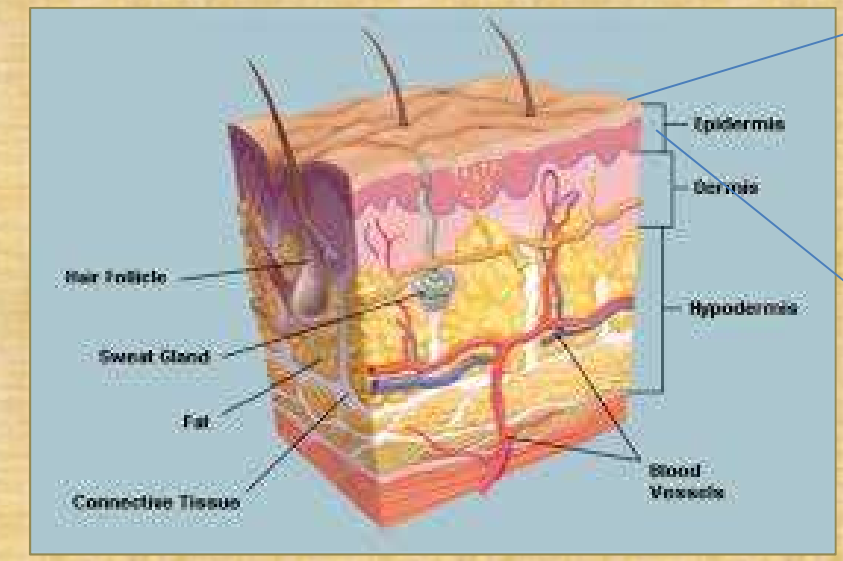
Evidence that contaminated surfaces contribute to the transmission of hospital pathogens and an overview of strategies to address contaminated surfaces in hospital settings

Jonathan A. Otter PhD[a,b,*], Saber Yezli PhD[b], James A.G. Salkeld BSc[b], Gary L. French MD, FRCPath[a]

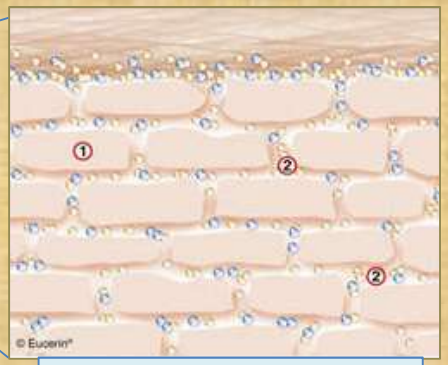


External Contamination

skin as the main target but not only !



Skin



Stratum corneum

eyes

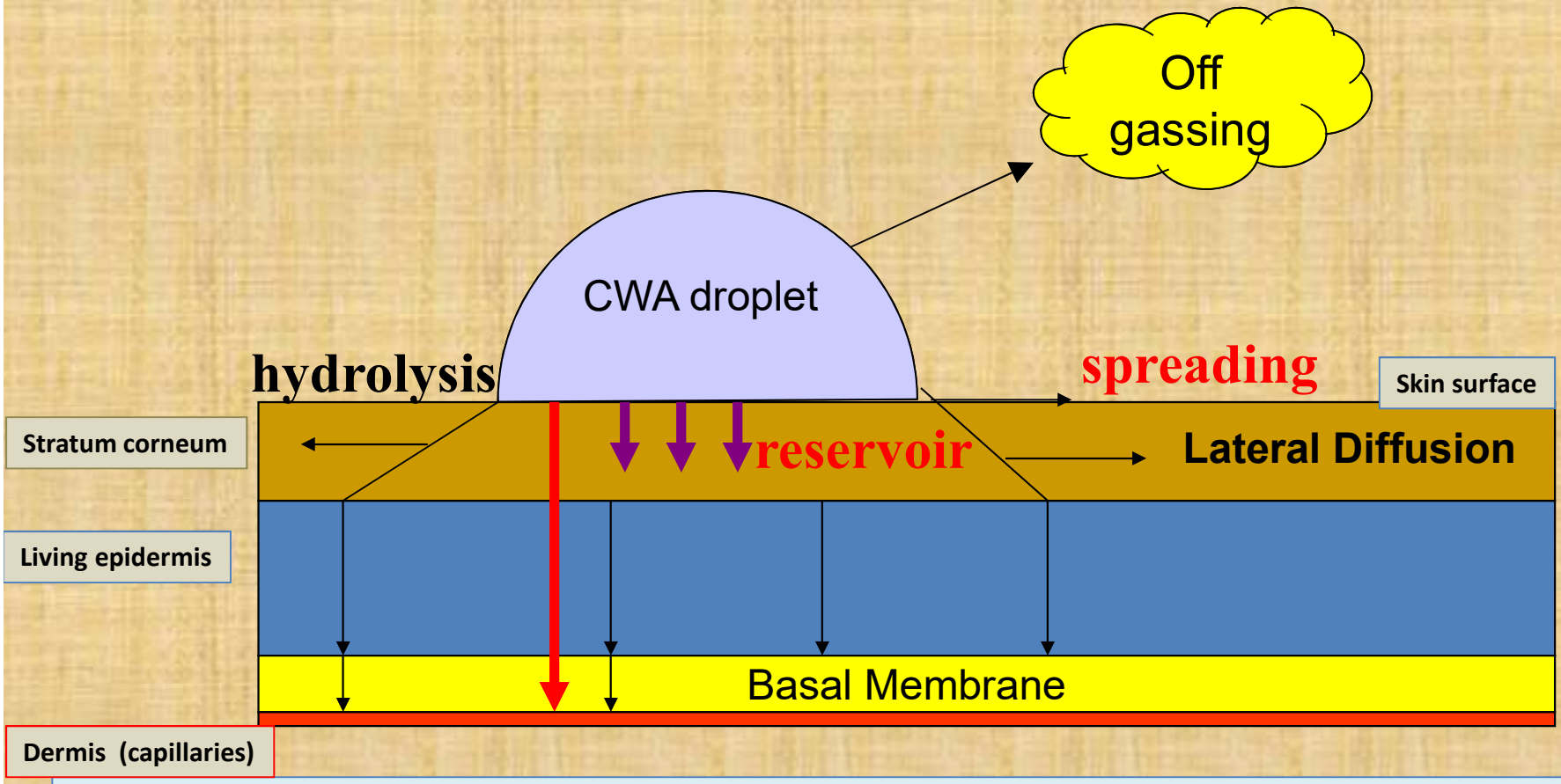
Hair

Clothes & belongings

Undressing is part of the decontamination procedure !

Skin contamination

Becoming of CWA ?



Decontamination products are aimed at acting on the skin surface

and whether feasible in the stratum corneum

Decontamination: when & how ?

Concept of immediate or emergency decontamination

ASAP following exposure to potentially hazardous materials

fast and simple to implement

Spot decontamination

Self or buddy decontamination

« Remove, remove, remove »

- **Immediate or emergency decontamination**

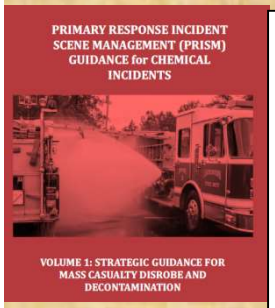
partial undressing (external layer of clothes)

and use of any available absorbent/adsorbent

- **Thorough decontamination**

full undressing then shower with water + soap, rinse & dry

Emergency decontamination can contribute to up to 99% of the decontamination effectiveness.



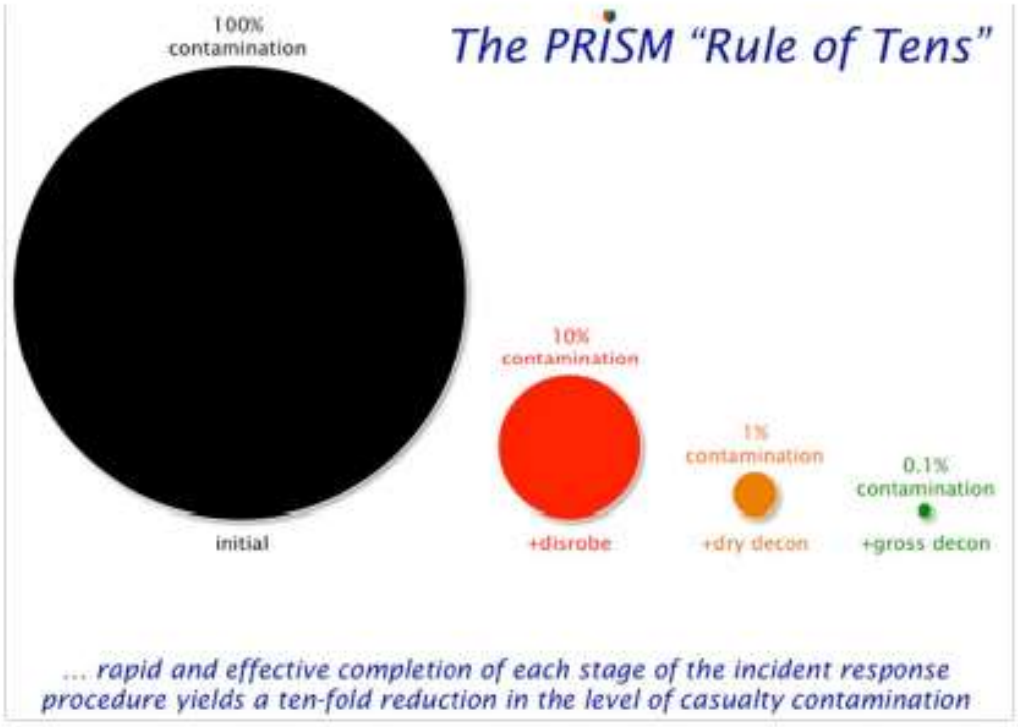


Figure 9: PRISM "rule of tens" for estimating the contribution of each stage of the incident response procedure. This diagram is for guidance only – the actual percentage removal of contaminant will be dependent on the prevailing conditions, the speed of the initial response, the initial dose (contamination density) and nature of the contaminant.

Do not wait for showers before starting decontamination!

Emergency decontamination

Main objective

- **Life (and tissue) saving** decontamination *(ideally, associated with **emergency treatment**, if available)*

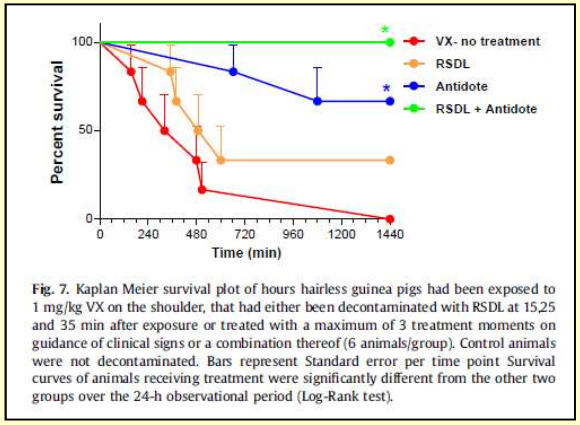


Fig. 7. Kaplan Meier survival plot of hours hairless guinea pigs had been exposed to 1 mg/kg VX on the shoulder, that had either been decontaminated with RSDL at 15,25 and 35 min after exposure or treated with a maximum of 3 treatment moments on guidance of clinical signs or a combination thereof (6 animals/group). Control animals were not decontaminated. Bars represent Standard error per time point Survival curves of animals receiving treatment were significantly different from the other two groups over the 24-h observational period (Log-Rank test).

RSDL decon + treatment

M.J.A. Joosen*, R.M. van den Berg, A.L. de Jong, M.J. van der Schans, D. Noort, J.P. Langenberg, The impact of skin decontamination on the time window for effective treatment of percutaneous VX exposure; Chemico-Biological Interactions 267 (2017) 48-56.

Emergency Decontamination
Where & Who ?

- **Where?**

ideally, immediately after exposure **in the hot zone** (military, industrial workers), or, after extraction from the hot zone, **in the warm zone** (civilians);

- **Who?**

All the potentially contaminated victims;

Priority to **casualties (ambulant and non-ambulant)**;

Possibly the worried well

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- **Thorough decontamination**

« French powdering glove » (NBC–sys)
Fuller's earth

Adsorbing powder delivered on contaminated skin then removed

Composition of the powder :
$Si\ O^2$: 60%
$Al^2\ O^3$: 9%
$Fe^2\ O^3$: 4,5%
Mg O : 10%
Ca O : 2,5%
$Na^2O + K^2\ O$: 1,2%
Loss of ignition : 11,1% on dry product

Effective (skin) but has a few limitations:

- Chemicals not neutralized
- Dispersion of contamination
- Difficult to remove from the skin
- Cannot be used on solid particles

Reactive Skin Decontamination Lotion (RSDL®)

(Emergent BioSolutions)

« Medical device » (FDA approval 2003)

2,3-butanedione K monooximate (1,25M)
Diacetylmonooxime (6%)
MPEG (550 Da)
water (10%)
pH 10.6

Effective (skin)

lipophilic compounds including organophosporus compounds & sulfur mustard

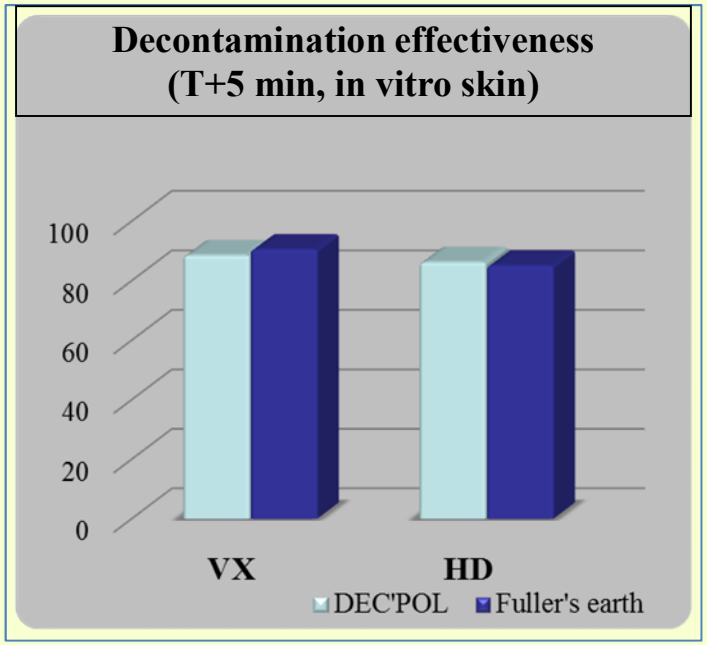
Stability for at least **5 yrs** when stored at **15-30°C**

DECPOL® glove & wipe (Ouvry)

- Absorb & neutralize **hazardous liquids** (hydrophilic & lipophilic BC agents);
- Effectiveness similar to that of FE on VX, HD, paraoxon

glove

wipe



Recent decontamination technologies for CWA

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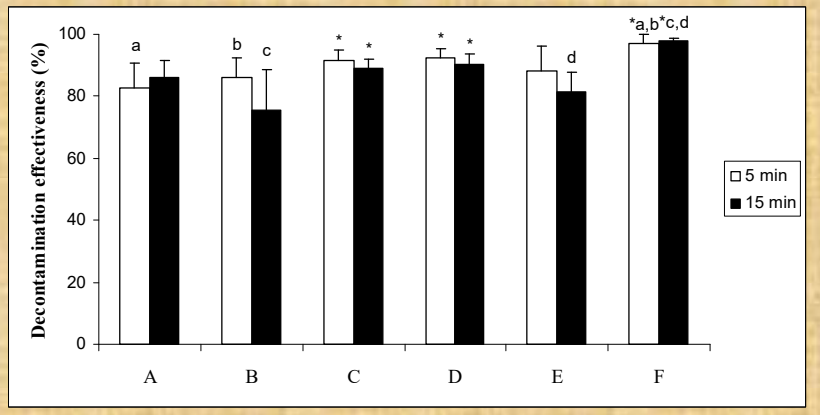
Improvised decontamination *effectiveness of absorbing tissues ?*

IN VITRO SKIN DECONTAMINATION EFFICACY OF VX BY USING ABSORBENTS

- ***Josse D**, G. Barrier, R. Bifarella, C. Cruz, In vitro skin decontamination effectiveness of VX by using absorbents in Advances in Dermatological Sciences **2014**, Ed: R. Chilcott, K.R. Brain, 410-416.*
- ***Josse D**, Barrier G, Emergency decontamination in low-resource settings, in Disaster management: medical preparedness, response and homeland security, Ed. R. Arora, P. Arora, **2013**, chapter 18, p 325.*

Our results from in vitro skin decontamination studies showed that the effectiveness of emergency decontamination performed **15 min post-exposure to VX** with absorbing pads such as a **cotton towel** or a **paper tissue** was similar to that of the « French powder glove ».



*Capital letters stand for: paper tissue (**A**), non woven absorbent tissue (**B**), cotton towel (**C**), Polyvalent absorbent (**D**), standard T-shirt (80% polyamide, 20% elastane) (**E**) and Fuller's earth + cotton tissue (**F**).*

UK-USA (2017): Evaluation of dry decontamination effectiveness in comparison with humid decontamination (shower) in vitro & in vivo (T+15min)

RESEARCH ARTICLE

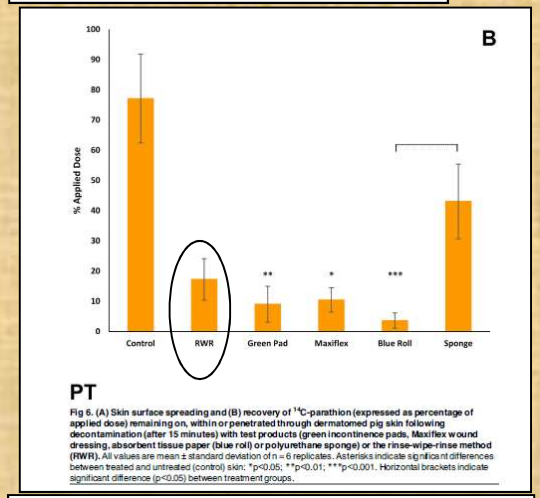
Evaluation of absorbent materials for use as *ad hoc* dry decontaminants during mass casualty incidents as part of the UK's Initial Operational Response (IOR)

Nick Kassout[1], Sara Syed[1], Joanne Larner[1], Richard Amlôt[2], Robert P. Chilcott[1]*

1 Research Centre for Topical Drug Delivery and Toxicology, School of Pharmacy, University of Hertfordshire, Hatfield, United Kingdom, 2 Microbial Risk Assessment and Behavioural Science, Public Health England, Emergency Response Department, Health Protection Directorate, Porton Down, Salisbury, Wiltshire, United Kingdom

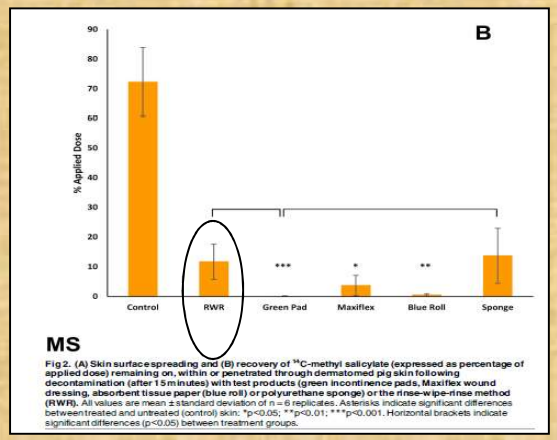
PLOS ONE | DOI:10.1371/journal.pone.0170966 February 2, 2017

In most cases (lipophilic liquids), dry decontamination (5 sec) of skin was more effective than showering (1.5 min) (Amlot et al, 2017).



PT

Fig 6. (A) Skin surface spreading and (B) recovery of ^{14}C-parathion (expressed as percentage of applied dose) remaining on, within or penetrated through dermatomed pig skin following decontamination (after 15 minutes) with test products (green incontinence pads, Maxiflex wound dressing, absorbent tissue paper (blue roll) or polyurethane sponge) or the rinse-wipe-rinse method (RWR). All values are mean ± standard deviation of n = 6 replicates. Asterisks indicate significant differences between treated and untreated (control) skin: *p<0.05; **p<0.01; ***p<0.001. Horizontal brackets indicate significant difference (p<0.05) between treatment groups.



MS

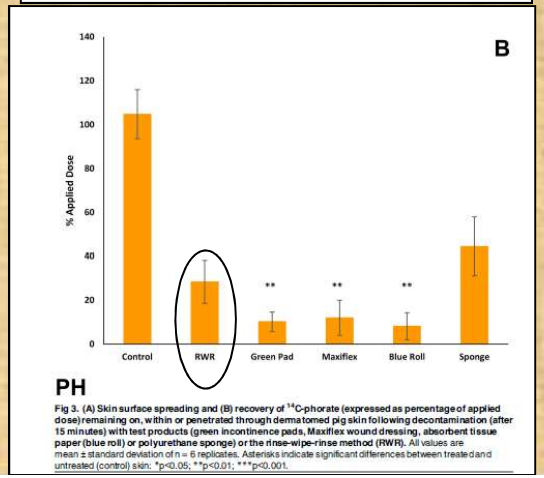
Fig 2. (A) Skin surface spreading and (B) recovery of ^{14}C-methyl salicylate (expressed as percentage of applied dose) remaining on, within or penetrated through dermatomed pig skin following decontamination (after 15 minutes) with test products (green incontinence pads, Maxiflex wound dressing, absorbent tissue paper (blue roll) or polyurethane sponge) or the rinse-wipe-rinse method (RWR). All values are mean ± standard deviation of n = 6 replicates. Asterisks indicate significant differences between treated and untreated (control) skin: *p<0.05; **p<0.01; ***p<0.001. Horizontal brackets indicate significant differences (p<0.05) between treatment groups.

Volunteer trials of a novel improvised dry decontamination protocol for use during mass casualty incidents as part of the UK'S Initial Operational Response (IOR)

Richard Amlôt[1☯*], Holly Carter[1☯], Lorna Riddle[1], Joanne Larner[2], Robert P. Chilcott[2]

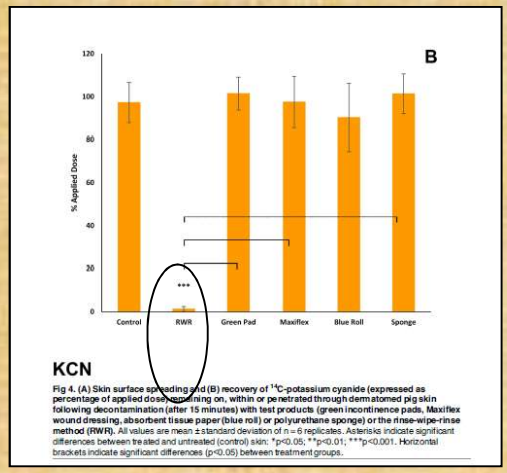
1 Emergency Response Department Science & Technology, Public Health England, Porton Down, Salisbury, Wiltshire, United Kingdom, 2 Research Centre for Topical Drug Delivery and Toxicology, School of Pharmacy, University of Hertfordshire, Hatfield, United Kingdom

☯ These authors contributed equally to this work.
* richard.amlot@phe.gov.uk



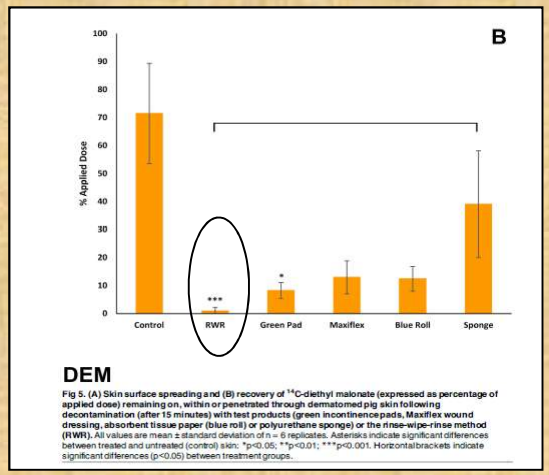
PH

Fig 3. (A) Skin surface spreading and (B) recovery of ^{14}C-phorate (expressed as percentage of applied dose) remaining on, within or penetrated through dermatomed pig skin following decontamination (after 15 minutes) with test products (green incontinence pads, Maxiflex wound dressing, absorbent tissue paper (blue roll) or polyurethane sponge) or the rinse-wipe-rinse method (RWR). All values are mean ± standard deviation of n = 6 replicates. Asterisks indicate significant differences between treated and untreated (control) skin: *p<0.05; **p<0.01; ***p<0.001.



KCN

Fig 4. (A) Skin surface spreading and (B) recovery of ^{14}C-potassium cyanide (expressed as percentage of applied dose) remaining on, within or penetrated through dermatomed pig skin following decontamination (after 15 minutes) with test products (green incontinence pads, Maxiflex wound dressing, absorbent tissue paper (blue roll) or polyurethane sponge) or the rinse-wipe-rinse method (RWR). All values are mean ± standard deviation of n = 6 replicates. Asterisks indicate significant differences between treated and untreated (control) skin: *p<0.05; **p<0.01; ***p<0.001. Horizontal brackets indicate significant differences (p<0.05) between treatment groups.



DEM

Fig 5. (A) Skin surface spreading and (B) recovery of ^{14}C-diethyl malonate (expressed as percentage of applied dose) remaining on, within or penetrated through dermatomed pig skin following decontamination (after 15 minutes) with test products (green incontinence pads, Maxiflex wound dressing, absorbent tissue paper (blue roll) or polyurethane sponge) or the rinse-wipe-rinse method (RWR). All values are mean ± standard deviation of n = 6 replicates. Asterisks indicate significant differences between treated and untreated (control) skin: *p<0.05; **p<0.01; ***p<0.001. Horizontal brackets indicate significant differences (p<0.05) between treatment groups.

Emergency Decontamination
limitations of « dry decontamination » (1/4)

- **<u>Irritants & corrosives</u>**: water flushing of the exposed sites

- **<u>RBC powder</u>**: wash with water* (relatively low flow rate)

* With the exceptions of water-reactive chemicals (eg Na); oxygen-reactive (eg white phosphorus)

Emergency Decontamination
limitations of « dry decontamination » (2/4)

EYES DECONTAMINATION

- **water flushing with a large volume of clean water**
- Commercial eyes decontaminants such as Diphoterine® or Hexafluorine® have been found to be effective against caustic chemicals (Hall *et al*., 2002; Horton *et al*., 2002; Soderberg *et al*., 2004; Carron *et al*., 2009). However, the added value of these decontaminants relative to water is not clearly demonstrated.

Emergency Decontamination
limitations of « dry decontamination » (3/4)

WOUND DECONTAMINATION

- Removal of any potentially contaminated **foreign bodies**;
- Ideally, this should be followed by **saline or water flushing**, gentle scrubbing with a **surgical sponge and disinfection**;
- Alternatively, absorption of contaminants by using a **clean dressing.**

Emergency Decontamination
limitations of « dry decontamination » (4/4)

- **Relatively selective**

e.g. FE not recommended for B & R agents; …

- **Risks of secondary contamination to be evaluated**
- **Logistic & economic**
- **Education is key**

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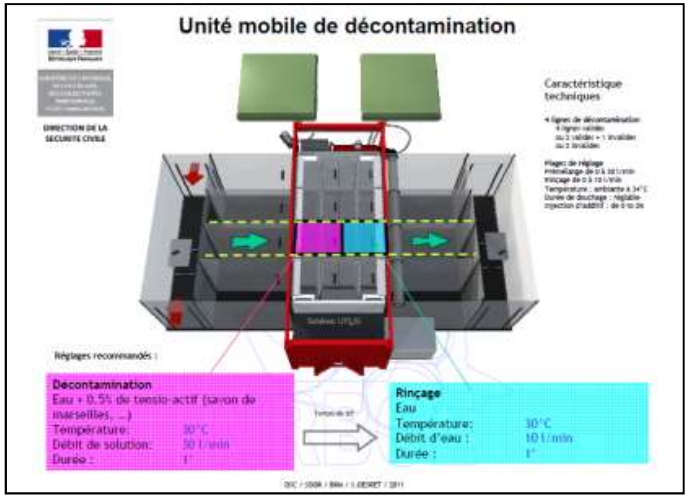
  - ❑ Improvised

- **Thorough decontamination**

Thorough decontamination

- Full undressing, then showering (+ sponge) with detergent & water, then rinse & dry



Parameter	Optimal Condition
Shower water temperature	35°C
Shower duration	60 – 90 seconds
Detergent	0.5% (v/v) Argos™ or FloraFree™
Washing aid	Cotton washcloth.

Table 3: Summary of conditions for optimization of aqueous (shower based) technical decontamination according to the "ORCHIDS Protocol" [26].

optimized showering protocol for skin decontamination of ambulant victims
EU-funded « Orchids project » (2009-2011)

Hair decontamination

Chemico-Biological Interactions 232 (2015) 94–100

Contents lists available at ScienceDirect

Chemico-Biological Interactions

journal homepage: www.elsevier.com/locate/chembioint

Showering effectiveness for human hair decontamination of the nerve agent VX

Denis Josse [a,b,c], Julien Wartelle [a], Catherine Cruz [a]

[a] Institut de Recherche Biomédicale des Armées, Département de Toxicologie et Risques Chimiques, BP73, 91223 Brétigny-sur-Orge, France
[b] Service de Santé et de Secours Médical du Service Départemental d'Incendie et de Secours des Alpes-Maritimes, 140 avenue Maréchal de Lattre de Tassigny, BP90, 06271 Villeneuve-Loubet Cedex, France

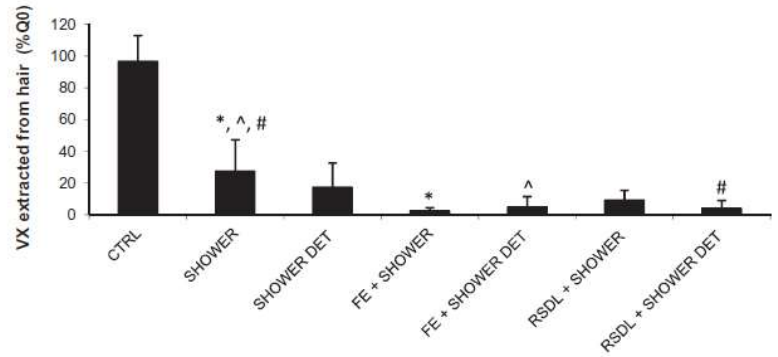


Fig. 1. Amount of VX extracted from non-decontaminated or decontaminated hair 1 h after exposure. Values are means ± SD and are expressed as% of initial dose Q0. Superscript symbols indicate significant differences between same labeled parameters among the decontamination procedures. See Section 2.5.2 for the meaning of abbreviations.

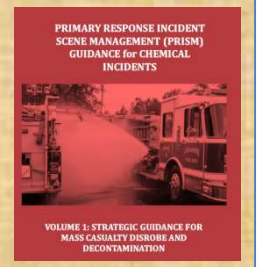
- Hair decontamination is the most effective when **RSDL or Fuller's earth** are used **prior to showering**;
- After showering, **hair drying** with a clean towel removed up to **3%** of the initial contamination

Conclusions (1/2)

1/ Importance of integrating ED in mass decon procedure

French guidelines (2008): emergency decon & undress (external layer) then shower decon

UK-US guidelines



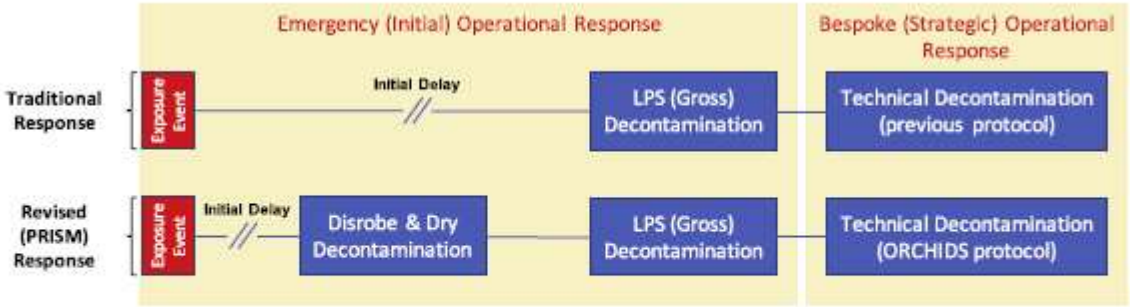


Figure 1. Traditional and revised (PRISM) chemical incident response models. After a contamination event, there was a delay between exposure and functional deployment of LPS decontamination during the initial operational response phase. The revised version reduces the delay by the introduction of a disrobe and DD step. *DD*, Dry decontamination; *LPS*, ladder pipe system of decontamination.

Chilcott et al, 2018

2/ **Choice of ED products and procedures** mostly depends on the **agents** (physicochemistry & toxicity), on the **context** (industrial, terrorist, war) and on the potential **number of victims**

Conclusions (2/2)

3/ <u>For civilians</u>,

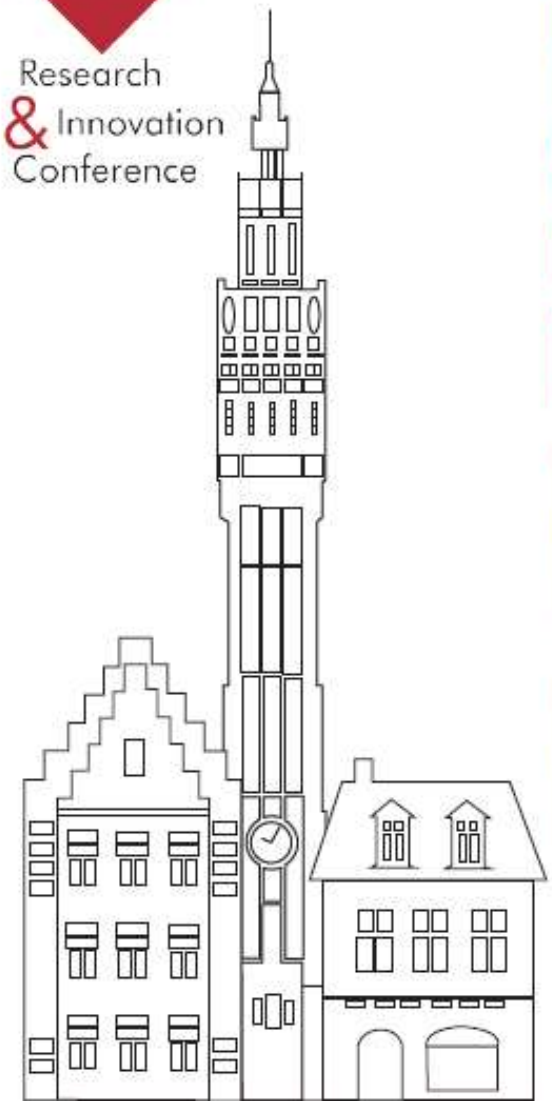
✓**Consider at-risks populations** (« vulnerables ») (elderly, physically or cognitively impaired, pregnant women, low language proficiency…);

✓ **Information & education of the population** (kids at school !): ED should be viewed as a reflex action.

✓ **communication** is crucial for the public compliancy and cooperation.

SAVE THE DATE !

CBRNE
Research & Innovation Conference



LILLE FRANCE May 17th - 20th 2021

www.cbrneconference.fr

Opening of registrations : 1st of September 2020
Deadline abstract submission : 10th of February 2021

DETECTION – IDENTIFICATION
Home-made explosives (HME)
Improvised Explosive Device (IED)
Field sampling & analysis
Bioindicators & sensors

MEDICAL COUNTERMEASURES
Epidemiology - Health surveillance
Drug development
Comprehensive approaches
Diagnosis

PROTECTION – DECONTAMINATION
Human & environmental
Infrastructure
Smart surface & textiles
Skin, wounds, hair & eyes

RISKS & CRISIS MANAGEMENT
Preparedness
Threat and risk assessment
Crisis communication
Transboarder cooperation

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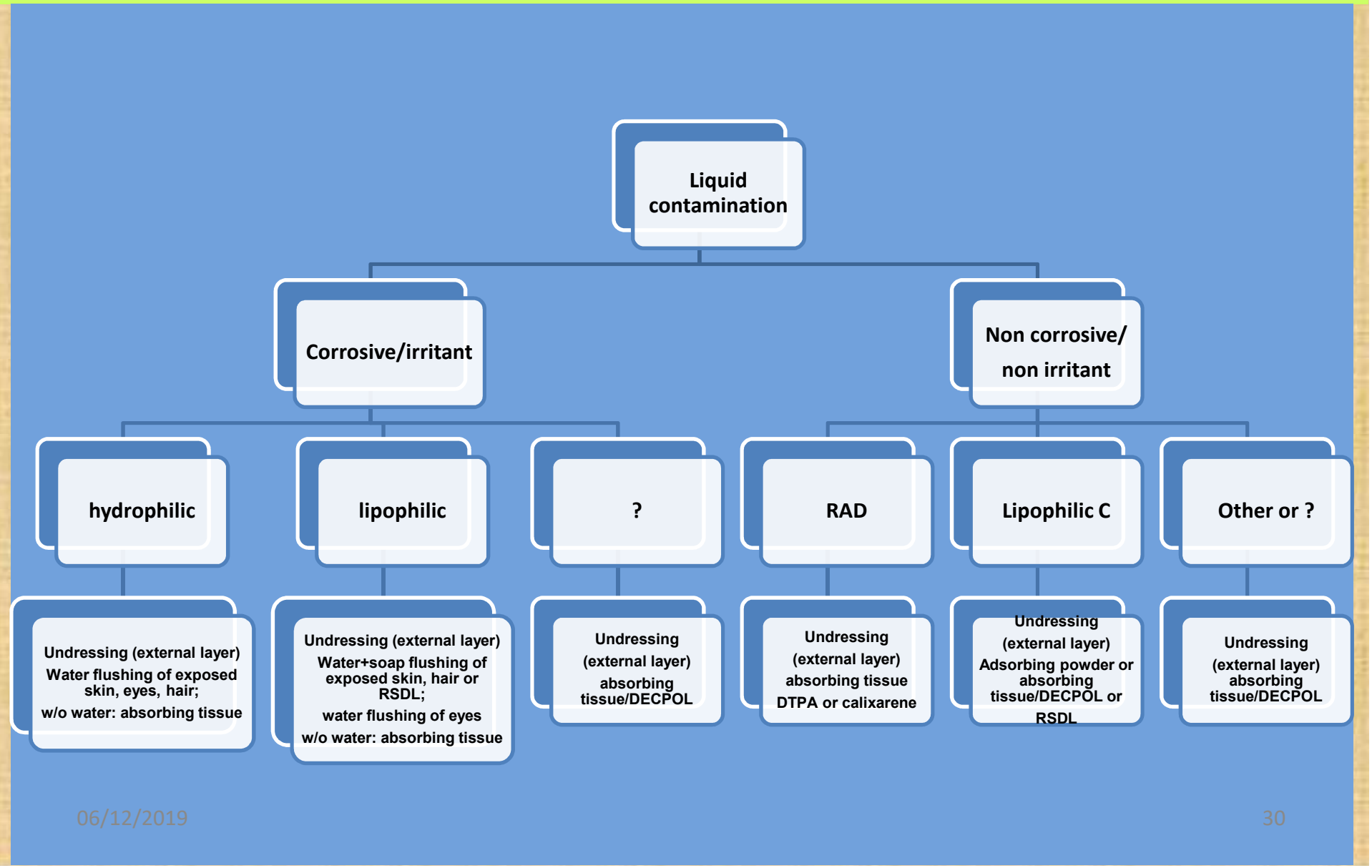
Emergency Decontamination choice of technologies



Solid particle contamination*

CBR or ?

undressing (external layer)

Water+soap flushing (low flow rate)

of exposed skin and hair

Water rinsing (+ eyes cleaning)