

Critical Evaluation of the Wash-in Effect

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Acknowledgments

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- Material presented here has not been reviewed by NIOSH and no endorsement should be inferred.

Background

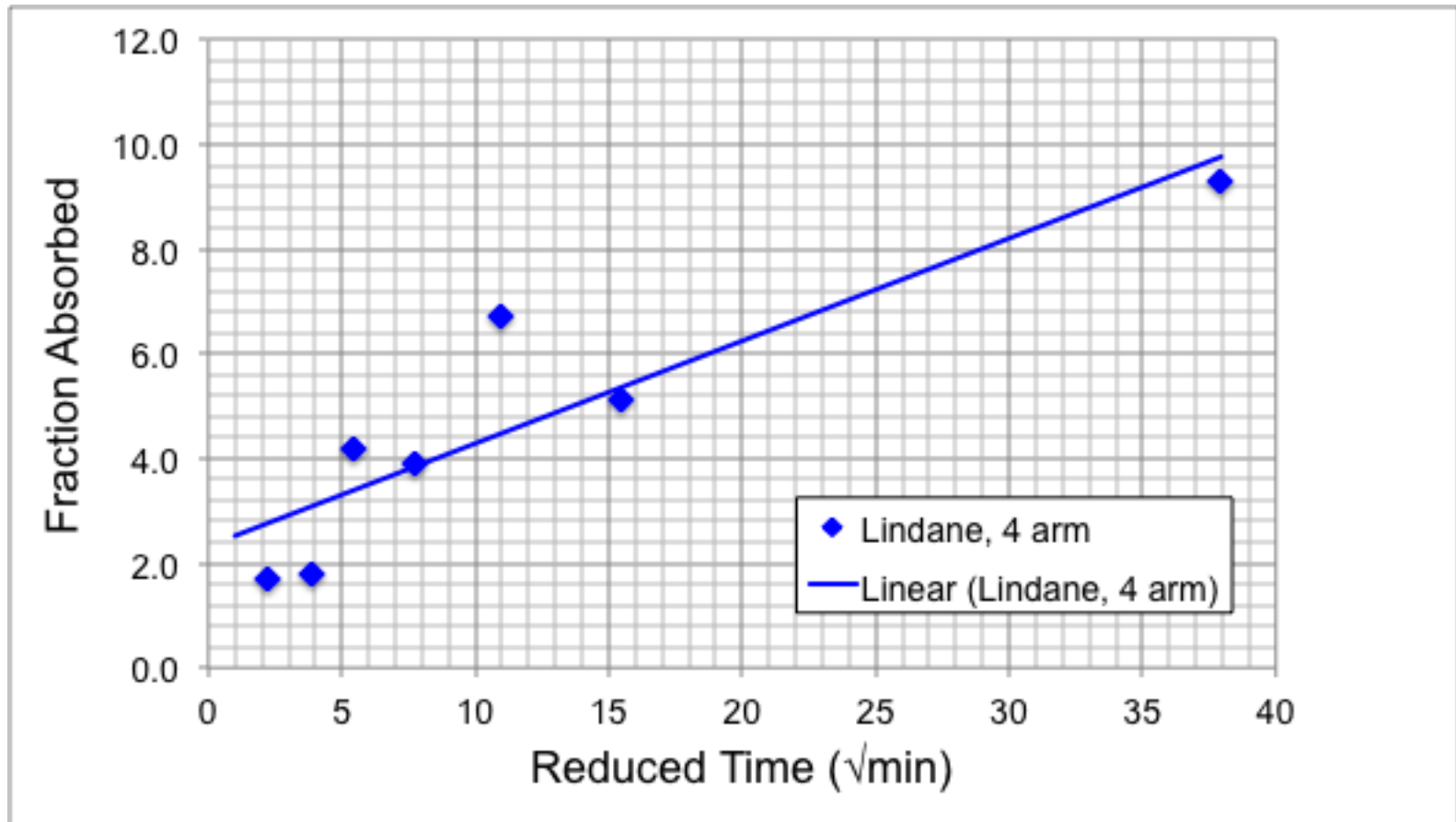
- washing with soap and water is standard practice for both industrial and personal hygiene
- wash-in effect? (Moody & Maibach, 2006)
 - *“... it is recommended that caution be practiced when skin is washed as the W-I effect may increase both local cutaneous and general systemic toxicity.”*
 - *“The potential importance of the W-I cannot be overly stressed.”*

Moody & Maibach, *F&CT* 2006

- Feldman & Maibach, 1974; lindane?
- Wester, 1977; hydrocortisone
- Moody et al., 1995; DEET
- Moody & Nadeau, 1997; 2,4-D
- Loke et al., 1999; diethylmalonate
- Boeniger review “in press”

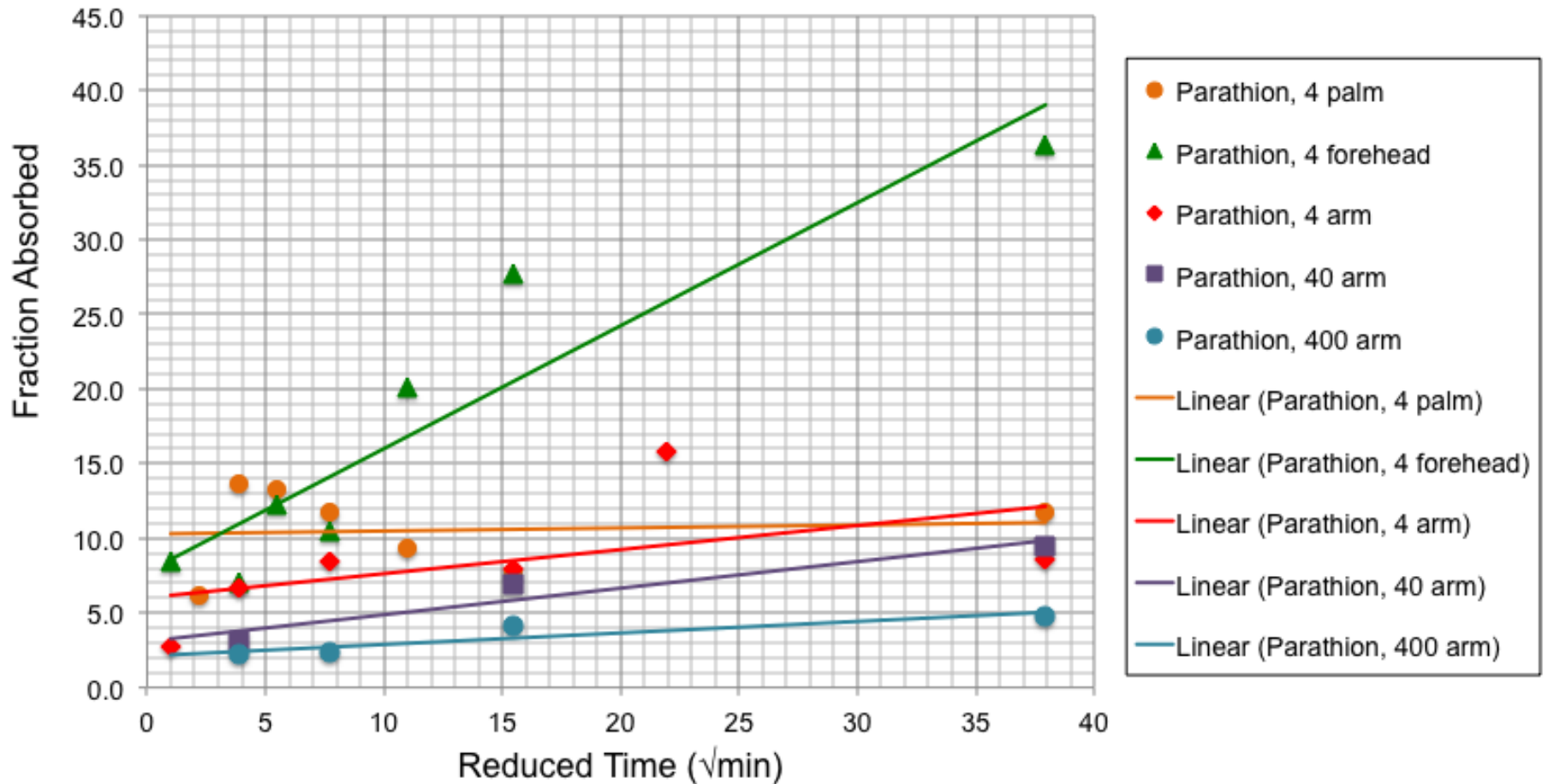
Feldman & Maibach, 1974

Lindane/human in vivo



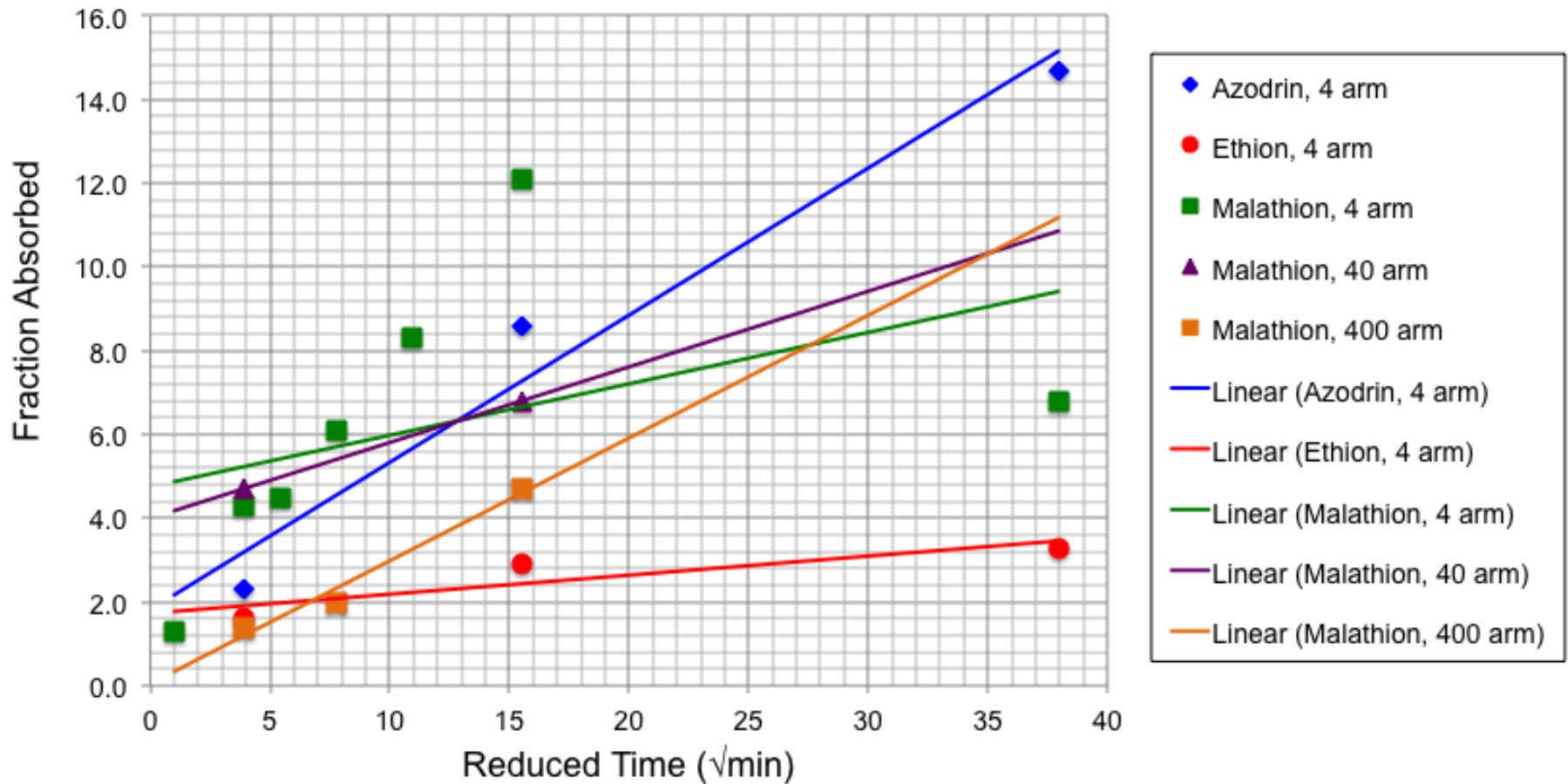
Feldman & Maibach, 1974

Parathion/human in vivo



Feldman & Maibach, 1974

other OPs/human in vivo



Wester & Maibach, 1975, 1977

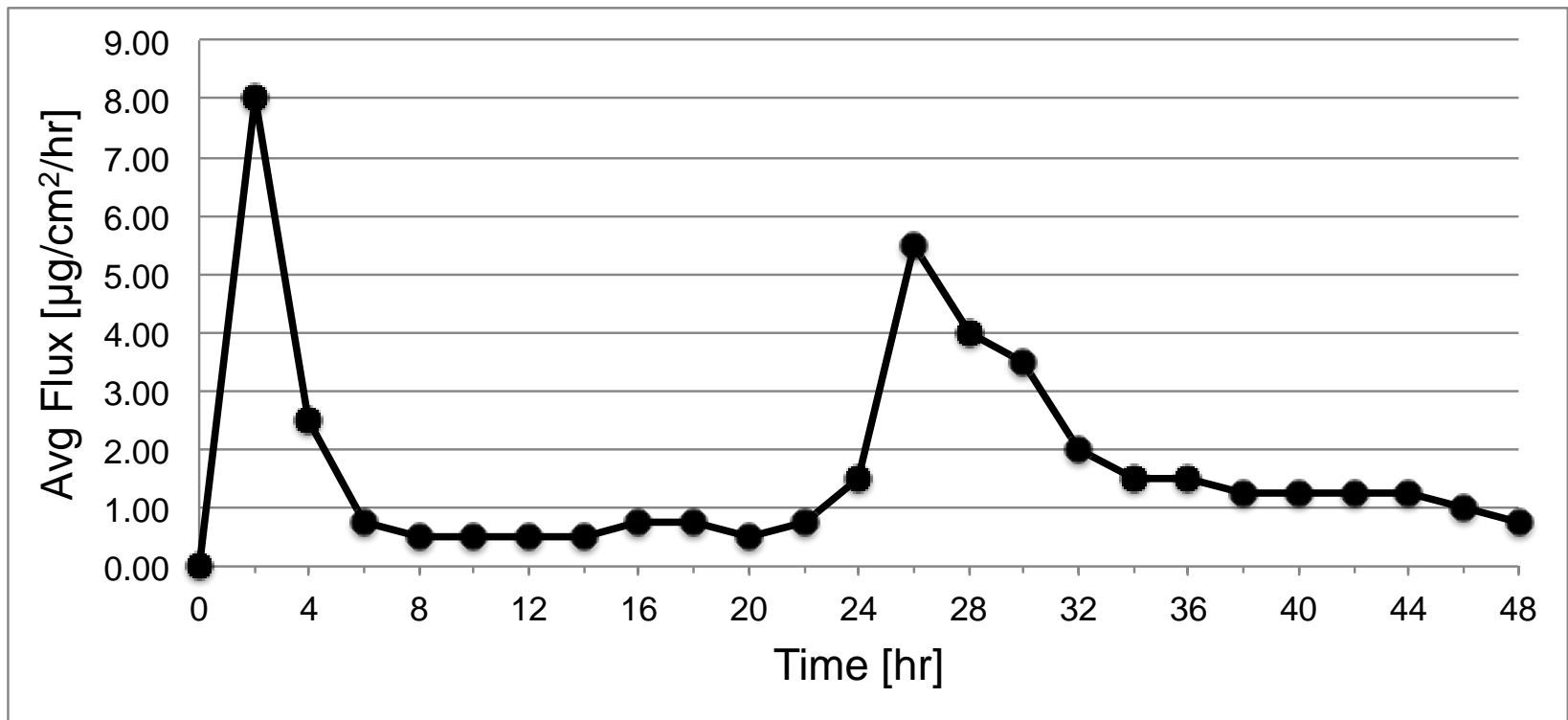
Hydrocortisone/rhesus in vivo

- application at time 0, 24, 48 hrs
- with or without preceding wash
- urine capture for 120 hrs
- finding of greater uptake with washing
- wash-in? (No, bad statistical technique)

Moody 2,4-D amine (human in vitro) Experiments

- c. 750 ug/cm² loads
- c. 70% recovered from skin at 48 hrs

Approximate reconstruction of (human in vitro) 2,4-D amine data (Moody and Nadeau, 1997)



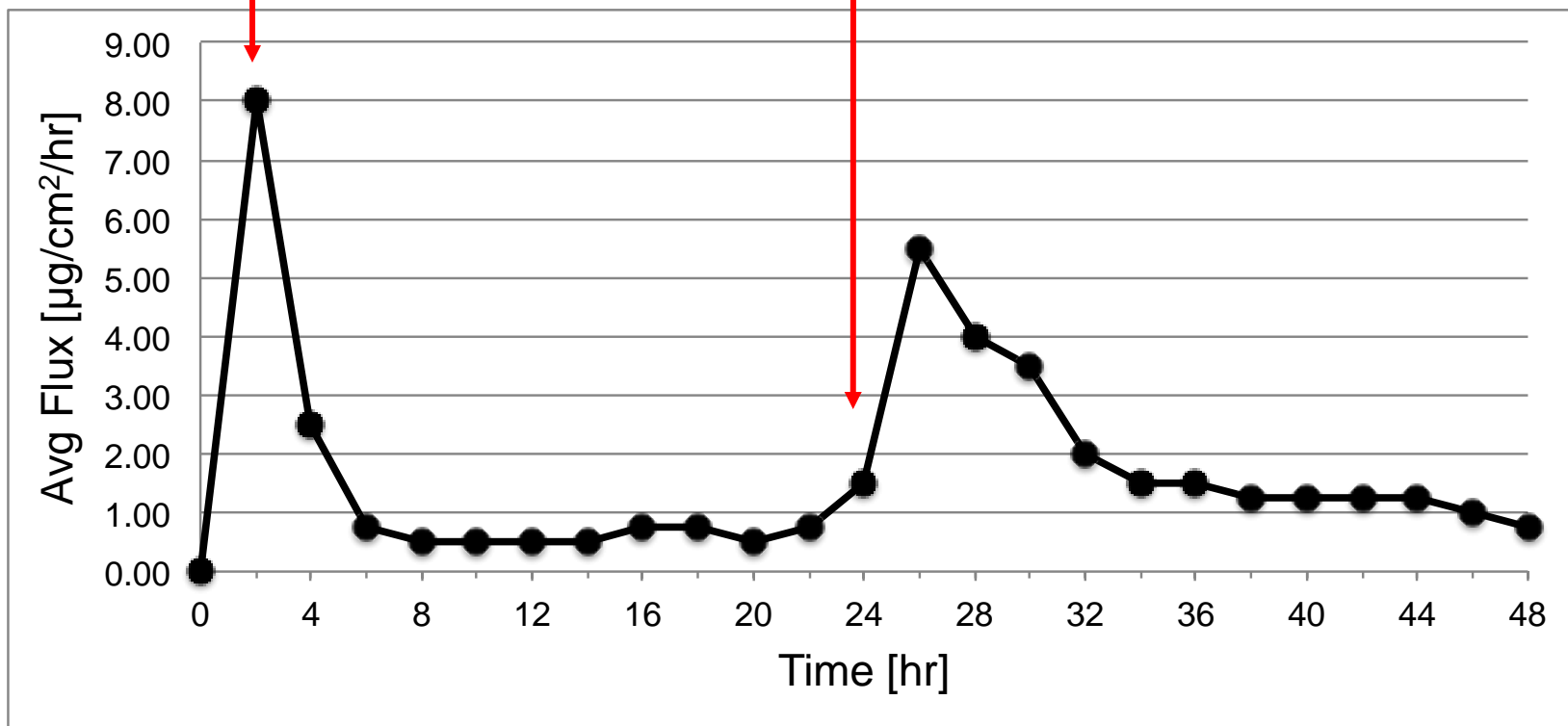
Kissel (2011)

$$N_{\text{derm}} = \frac{\text{supply/duration}}{\text{loss rate}} = [-]$$

Experiment fails

Failed experiment allowed to continue

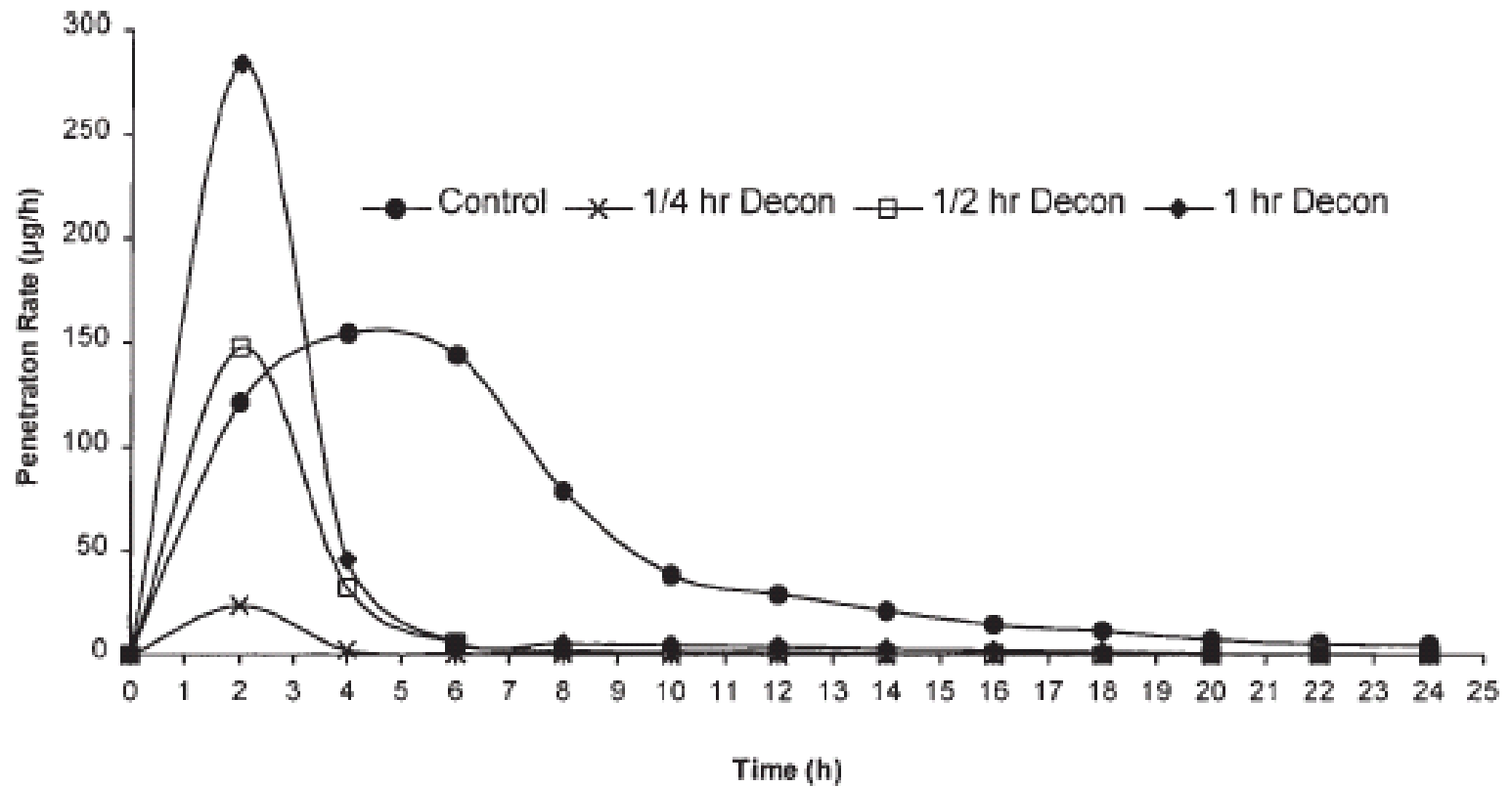
Failed experiment poked with swab



Loke et al., 1999

- in vitro, human cadaver skin
- challenged with diethylmalonate, a surrogate for G series nerve agents
- varied delay prior to washing

Loke et al., 1999



Loke et al., 1999

- highest apparent uptake rate w/ wash @ 1 hr
- no statistical comparison
- AUC for 1 hr case < control, total dose appears reduced
- peak blood level for acutely toxic compounds?

Misik et al., *Tox Mech Meth*, 2012

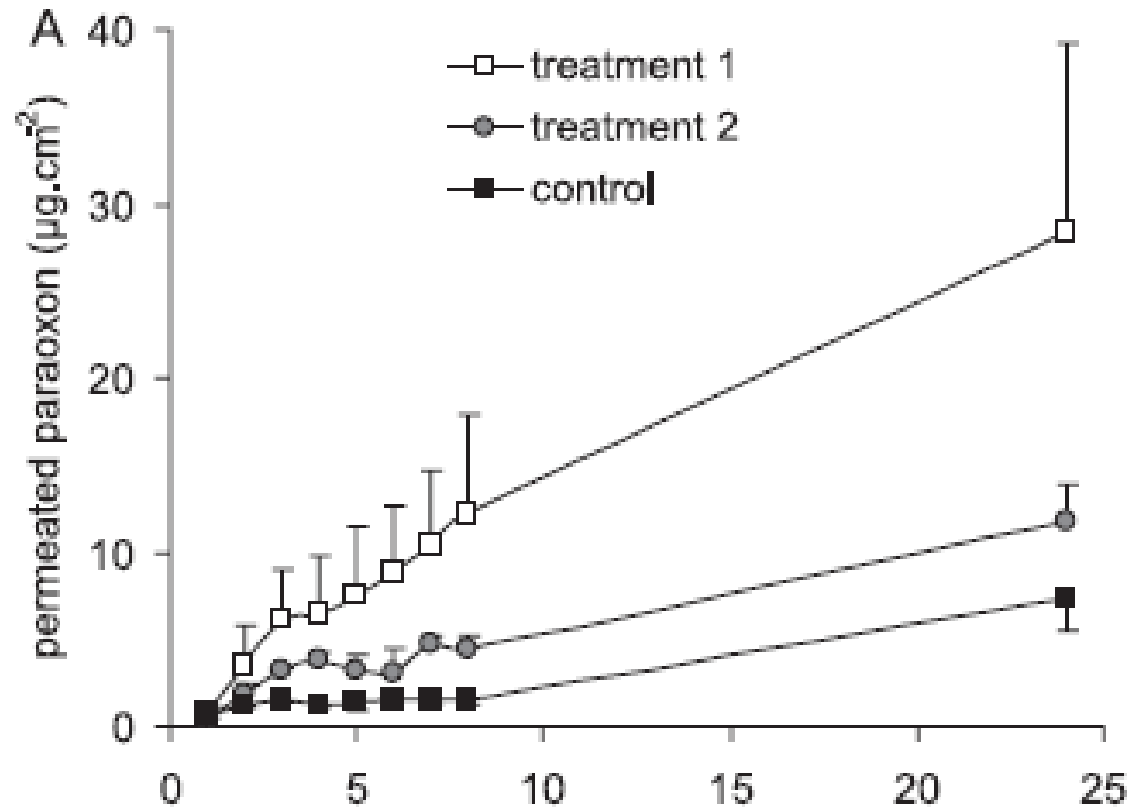
- “In contrast, the skin permeation of paraoxon ... increased up to 60 to 290% following decontamination compared to non-decontamination controls. This has been previously described as the wash-in effect.”

Misik et al., *Tox Mech Meth*, 2012

- in vitro/pig
- paraoxon added as droplet of pure liquid (c. 5% of 1.7 cm² skin area)
- two washing techniques: 3 ml w/o removal; 0.5 ml w/ blotting
- resulting emulsion concentrations greater than solubility in water alone
- wet/dry/warm/cold

Misik et al., 2012

(dry skin case)



Zhu et al., *J Appl Tox*, 2016

- heat separated human epidermis
- 30 minute exposure before “washing”
- “washing” by passive, sequential placement of wet cotton
- experiments 90 minutes total
- comparison of “washed” to no washing

Zhu et al., *J Appl Tox*, 2016

			Decon result	
	MW	Log K _{ow}	Peak penetration rate	Cumulative penetration
Hydroquinone	110.1	0.59	decreased	decreased
Benzoic acid	122.1	1.63	increased	no effect
Paraoxon	275.2	1.98	increased	increased
Clonidine	230.1	2.49	not reported	no effect

Case for Wash-In Effect

- Selective examination of the literature
- Weak/missing statistical analysis
- Poor experimental technique
- Redefinition of washing to exclude a rinsing step

Counter evidence

- Feldmann & Maibach, 1974
- Koizumi, 1991 (hexachlorobenzene, rat, in vivo)
- Nielsen, 2010 (4 compounds, human, in vitro)
- CW agents

Hanssen et al., 2006

- U.S. Army Medical Research Institute of Chemical Defense, Aberdeen Proving Ground, MD
- in vivo
- guinea pigs
- challenged with nerve agents
- alternative decon agents (vs. none)

Hanssen et al., 2006 (also Braue et al., 2011) VX/guinea pigs in vivo

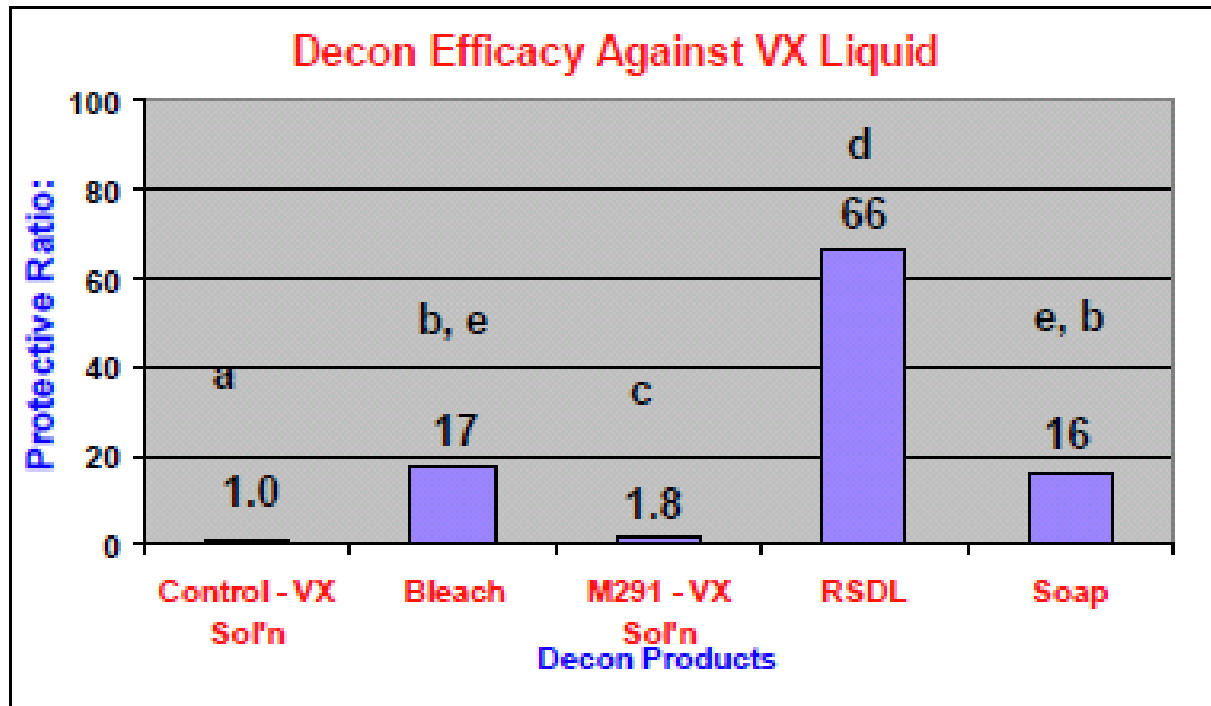
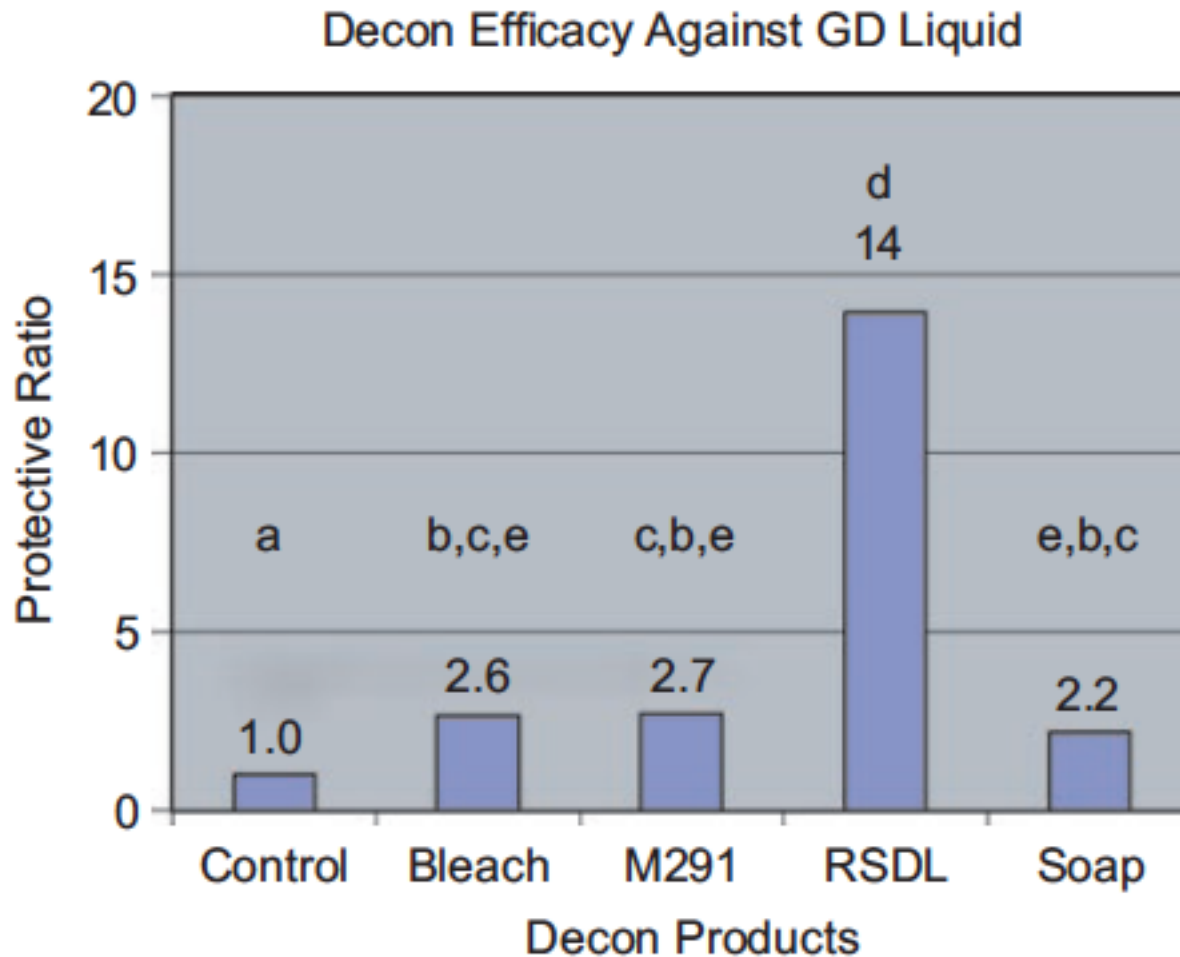


Fig. 5. Decon Efficacy Against VX Liquid. PRs with same letter were not statistically different at the 0.05 decision level.

Braue et al., 2011

Soman (GD)/guinea pigs in vivo



Conclusions

- There is a significant wash-off effect
- In contrast, a significant “wash-in” effect has not yet been demonstrated
- A “spreading around” effect is logical (and only surprising if you accept the fixed fractional absorption myth)

Latest Lessons Learned No. 1

- If a person presents at an emergency care facility with possible splatter exposure to a hazardous chemical, do not spread the chemical around on his skin and then tell him to come back tomorrow

Latest Lessons Learned No. 2

- If a person presents at an emergency care facility with possible dermal exposure to a hazardous chemical, do not wrap the victim in wet cotton and tell him to sit down and wait

Washing Protocols

- Loke et al.

$$\frac{500 \text{ ml}}{0.8 \text{ cm}^2 \cdot 60 \text{ s}} \cong 10 \frac{\text{cm}^3}{\text{cm}^2 \cdot \text{s}}$$

- lab simulated handwash

$$\frac{500 \text{ ml}}{800 \text{ cm}^2 \cdot 30 \text{ s}} \cong 0.02 \frac{\text{cm}^3}{\text{cm}^2 \cdot \text{s}}$$