



Dermal exposure assessment

Dr. Karen Galea, IOM

Firstly, who am I?

- Team Lead: Workplace Exposure
- Occupational hygiene and environmental health background
- ~ 20 years research & consultancy experience focused on human exposure assessment
- Completed several dermal exposure measurement campaigns using various techniques to determine worker and consumer exposure.



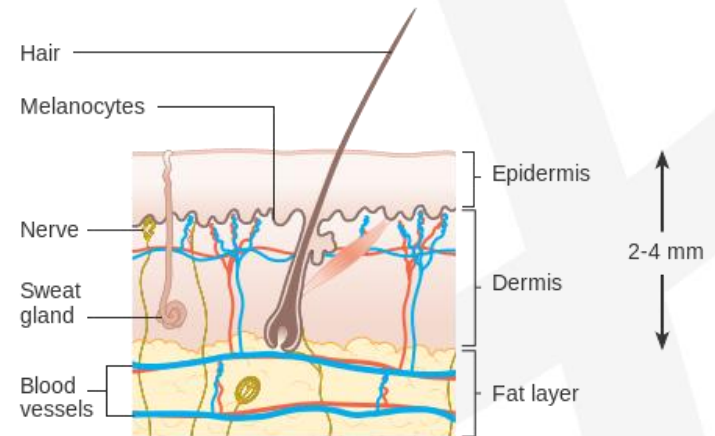
Webinar outline...

1. Importance of dermal exposure
2. Dermal exposure pathways
3. Measurement techniques
4. Modeling dermal exposure (if time allows)



1. Why is dermal exposure important?

- Skin is the body's largest organ, and functionally one of the most versatile.
- Provides a number of functions inc.:
 - Protection (e.g. against chemicals, micro-organisms)
 - water preservation
 - shock absorption
 - tactile sensation
 - vitamin D synthesis
 - temperature control
 - lubrication and waterproofing



Adverse health effects

- Occupational skin diseases are the second most common type of occupational disease and can occur in several different forms including:
 - Contact dermatitis – irritant and allergic
 - Skin cancers
 - Skin infections
 - Skin injuries
 - Other skin diseases (e.g. contact urticarial, acne)
- In US, contact dermatitis is one of the most common types of occupational illness, with estimated annual costs exceeding \$1 billion



Dermal absorption

- Transport of chemical from the outer surface of skin both into the skin and into the body.
- Chemicals where dermal uptake can significantly increase body burden can potentially result in disease.

Type of disease	Example causative agents
Damage to CNS	Methyl mercury, organophosphates
Scrotum cancer	Mineral oils
Bladder cancer	MbOCA, benzidine based dyes
Damage to red blood cells	Benzene
Heart disease	TNT, nitroglycols
Damage to reproductive systems	CS ₂ , PCB, some solvents / pesticides
Respiratory system sensitisation	Isocyanates, latex protein
Oestrogenic effect	Pharmaceutical grade female hormones

Ref: Sithamparanaderajah (2008)

Factors affecting dermal absorption

Factor affecting absorption	Examples
Exposure	Task, duration, area of skin exposed, use of PPE, concentration of agent, hygiene measures
Chemical	Molecular weight, solubility in water / oils, structure, presence of other chemicals
Skin	Skin thickness, skin integrity, anatomical area of exposure, temp, RH, occlusion, hairiness, skin metabolism

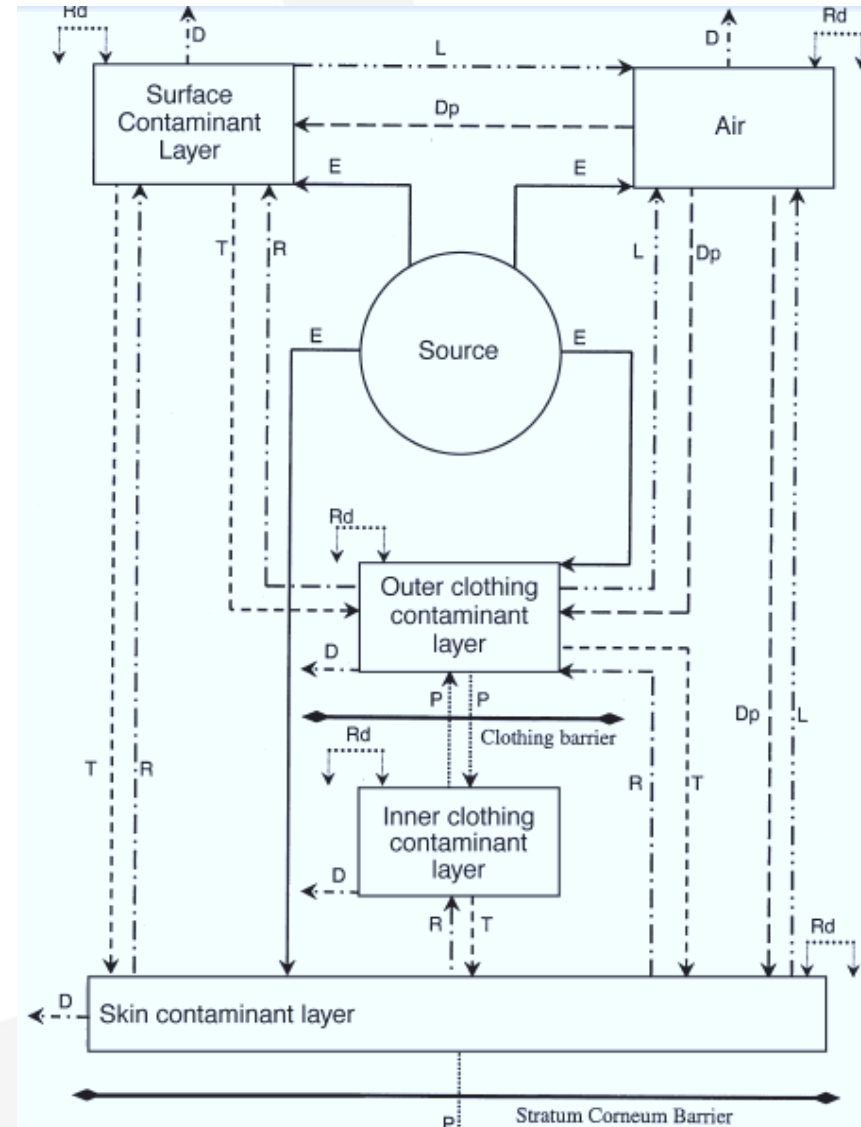
Occupations at risk include

- Health and social care
 - Hairdressers
 - Metalworking sector
 - Agriculture
 - Construction
 - “Wet-work”
-
- Cost is immense e.g. compensation, retraining, lose of employment



2. Dermal exposure pathways

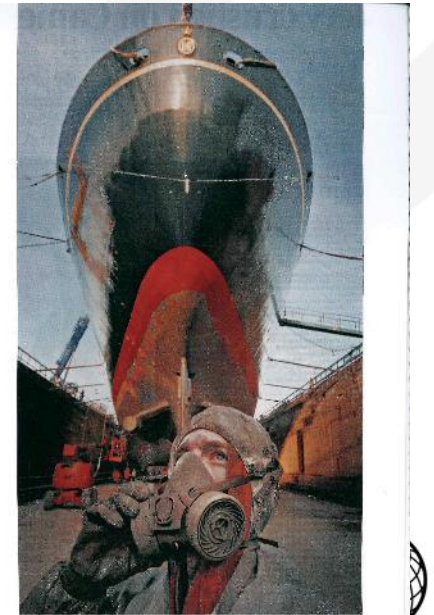
- Schneider et al. (2000)
- Source-receptor model
- 6 intermediate compartments
 - 3 environmental zones (i.e. source, air and surfaces)
 - 3 personal zones (i.e. inner and outer clothing compartment layers & skin contamination layer)
- Connected by pathways
- Uptake - transport of mass between compartments



Schneider et al. (1999) Conceptual model for assessment of dermal exposure. *Occup Environ Med* vol. 56 (11) pp. 765-73.

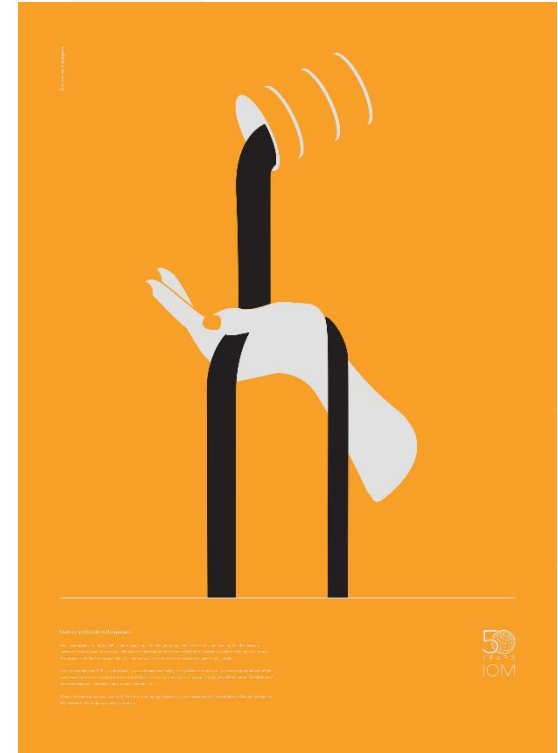
Derma exposure pathways

- Direct contact - hands, body parts
- Immersion
- Deposition
- Contact with contaminated surfaces
- Contact with contaminated clothing / personal protective equipment (PPE)
- Splashing



3. Why measure dermal exposure?

- Establish which exposure pathways are contributing to exposure
- Extent and frequency of exposure
- Areas receiving significant exposure
- Effectiveness of exposure control measures
- Raise awareness – significance of exposure, how exposure occurs, control measures



Measurement techniques

- **Interception techniques (surrogate skin)**
 - Mass of chemical that lands on the skin over the sampling time
 - Whole body, patch and wrist band methods
- **Removal techniques**
 - Mass of contaminant left on skin at given time
 - Manual wipe, tape-stripping, hand wash/wipe
- **Visualisation techniques**
 - In-situ detection of agent or tracer on skin surface at a given time (e.g. fluorescence)

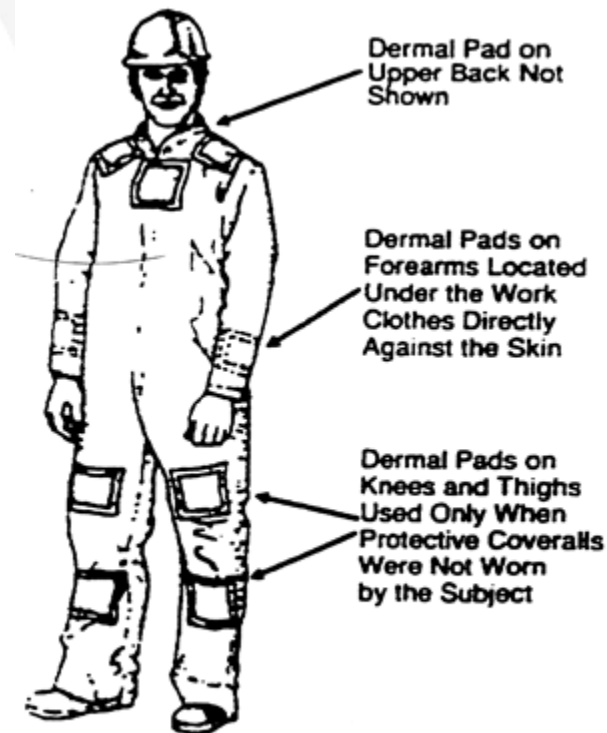
Interception techniques

- Interception of contaminant before it reaches skin
- Collection substrate attached to skin or inside / outside layer of clothing
- Measures what has been deposited during specific period
- Patch samplers – small area of skin
- Garment samplers – covering whole body or anatomical regions
- Dosimeters removed, amount deposited determined by suitable analytic method



Interception - Patch sampling

- 'Generic' protocols that prescribe sizes, numbers, location and method of attachment of patches (e.g. WHO, US-EPA, OECD)
- Dermal exposure calculated by extrapolating patch loading level to the skin surface of the entire anatomical region.



• Advantages

- Quantitative
- Ease of use, wear
- Ease of analysis
- Relatively inexpensive

• Disadvantages

- Over or under-estimation of exposure due to extrapolation errors
- Retention characteristics of sampling media

Interception- Garments



- Overcome patch limitations
- Lightweight overalls, gloves, socks, hood, hat
- **Advantages**
 - Surface area correction not necessary
 - Less time consuming
 - Sample non-invasively
 - Identify areas of high contamination
- **Disadvantages**
 - Can be awkward for wearer
 - Retention characteristics
 - Requires larger volumes of extractant

Removal techniques

- Removes /measures contaminant present and available for sampling at time of collection

Washing / rinsing



Wipe removal



Skin stripping



Removal - Hand washing & rinsing

- Removal of contaminant by providing external force that equals or exceeds force of adhesion
- Wash liquids vary – tap water, distilled, deionised, possibly in combination with surfactant, mild soaps and organic solvents

Advantages

- Does not interfere with process of skin contamination and absorption
- No burden to person

Disadvantages

- Lab. validation requires human volunteers
- Possible underestimation of exposure
- Limited to hand / wrist
- May disrupt skin barrier function (solvent)

Removal - Wiping

- Removal of contaminant from area of skin through application of mechanical force (uniform pressure) using a wet wipe, pad or swab. Fixed area or whole hands
- **Advantages**
 - Cheap(er)
 - Easy to use, no burden
 - Colourimetric pads are available for some substances to give quick visual indication of contamination
- **Disadvantages**
 - Time consuming
 - Variability – pressure, template placement
 - Skin barrier function may be disturbed



Removal - Tape stripping



- Removal of outer layers of skin and any contaminant already absorbed using tape
- Measures percutaneous absorption, not exposure

Advantages

- Permits *in vivo* observations on dermal absorption
- Established for sampling stratum corneum in dermatology

Disadvantages

- More invasive
- Skin barrier function may be disturbed
- Limited sampling area

Visualisation (in-situ) techniques

Fluorescent tracer techniques (3) VITAE

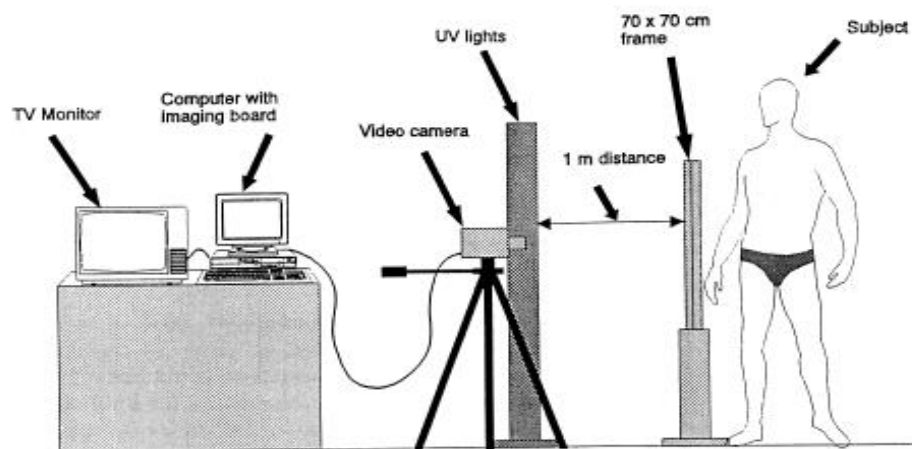


FIGURE 2. VITAE system configuration

- Direct method to quantify amount of contaminant deposited on the skin and area of skin exposed
- Video imaging
- ATR-FTIR
- Light probe
- Fluorescent tracer can be added (i.e. Tinopal) – check suitability
- Person screened before and after - images compared

Visualisation (in-situ) techniques

• Advantages

- Estimation of dermal uptake based on mass deposited on skin, exposed area and exposure duration.
- No chemical analysis
- Fast method for estimating dermal exposure
- Useful for educating and training

• Disadvantages

- Tracer integrity
- Image processing can be time consuming
- Requires specialist equipment & personnel
- Costly
- Fluorescence tracers may bind to skin for ~3 days

European and International “Standards” and guidelines

- No “gold standard” dermal sampling method(s)
- Useful guidance documents include
 - OECD (1997) Guidance document for the conduct of occupational exposure to pesticides during agricultural applications.
 - World Health Organisation (1982) *Field surveys of exposure to pesticides* WHO Standard Protocol Ref VBC/82.
- ‘Standards’
 - Workplace exposure - Strategy for the evaluation of dermal exposure (CEN/TR 15278:2006)
 - Workplace atmospheres - Measurement of dermal exposure. Principles and measurement. (ISO/TR 14294:2011).

Sampling method comparisons

- **SysDEA** 'Systematic analysis of dermal exposure to hazardous chemical agents at the workplace' project
- Generate knowledge to improve /standardize dermal exposure measurement methods
- Compare different methods
- Volunteers performed tasks under standardized conditions to increase reproducibility and decrease variability.

Table 1.2 Overview of sampling methods and application for different body parts

Principle	Method *	Body part **							
		hands	head	V-neck	torso	UA	FA	UL	LL
Interception	Gloves	+	-	-	-	-	(+)	-	-
	Coverall	-	-	-	+	+	+	+	+
	Underwear (incl. long pants, long sleeved T-shirt)	-	-	-	+	+	+	+	+
	Headband	-	+	-	-	-	-	-	-
	Patches	(wrist)	+	+	+	+	+	+	+
Removal	Wash	+	-	-	-	-			
	Rinse	+	-	-	-	-	(+)	-	-
	Wipe	+	+	+			+	-	-
	Tape strip	+	+	+	-?	+	+	-	-
In situ	Natural fluorescence (probe)	+	+	+	-	-	(+)	-	-
	FWA Tracer + Video imaging	+	+	+	***	***	+	+	+
	FWA Tracer + UV probe	+	+	+	-	-	(+)	-	-

* FWA=fluorescent whitening agent

** UA=upper arm, FA=forearm, UL=upper leg, LL=lower leg

*** Usually not applied / T-shirt

Exposure situations: pouring, rolling, spraying, & handling of objects immersed in liquid formulations, dumping and handling objects contaminated with powder.

Sampling method comparisons

- **Key results:**
 - Patch method resulted in somewhat higher exposure values compared to coverall for all situations, but differences only statistically sig. in case of liquid situations.
 - Gloves resulted in sig. higher exposure values compared to hand wash for handling immersed objects, rolling, and handling contaminated objects, and slightly higher (not sig.) exposure values during pouring and spraying.
 - In the same context, wipe sampling resulted in higher exposure values than using a headband, which was at least partly due to extrapolation of the wipe results to the surface area of the headband.
- **Conclusion:**
 - No 'golden standard' with regard to a preferred measurement method for dermal exposure could be identified from the methods as investigated in the current study.

Webinar topics covered today

1. Importance of dermal exposure 😊
2. Dermal exposure pathways 😊
3. Measurement techniques 😊

Thank you for your attention!



Email: karen.galea@iom-world.org

Dermal exposure assessment webinar, 2020

