



# **Overview of existing issues with regard to technical factors, PPE and work wear, and their impact on exposure**

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## Introduction

Focus of presentation is to present overview of work carried out on PPE and technical controls at TNO in past recent years (within aims of project)

**Not exhaustive** and does not cover important work carried out by others

Focus on exposure modelling

### Why?

PPE and technical controls important way to reduce exposure to PPPs or other chemicals

**If used properly and under correct circumstances**



# PPE and work wear



## PPE and work wear - Background and aim

- › BROWSE: Bystanders, Residents, Operators and Workers Exposure models, EU 7<sup>th</sup> framework project
  - › One of the key factors that influences (actual) exposure is use of personal protective equipment (PPE) and work wear by operators and workers.
  - › Since use of PPE and work wear is considered as an important risk management measure (RMM), this issue was considered in more detail in order to come up with a practical approach on how to deal with this in the BROWSE exposure models.
- › Outcome → PPE and work wear efficacy values



## Review papers

- › Starting point: Gerritsen-Ebben MG, Brouwer DH, van Hemmen JJ. Personal protective equipment for registration purposes of pesticides. Commun. Agric. Appl. Biol. Sci. 2007; 72 (2): 87-93  
(or TNO report V7333 + Addendum by Joop van Hemmen)

PPE / clothing	Operators	Workers
Single layer of uncoated clothing or coveralls	90%	80%
Gloves	90% liquids 95% solids	Only considered in very specific circumstances



## Review papers - Search terms and databases

Search terms		Databases
pestic* OR bioci* OR microbicid* or antibact* or disinfectant*		MEDLINE(R) 1990-to date
personal adj protect*	efficie*	CAB Abstracts 1972- to date
protect* adj equip*	comfort*	AGRICOLA 1970- to date
protect* adj cloth*	performance*	AGRIS 1974- to date
protect* adj respirat*	default*	Biosis Previews(R) 1926- to date
respirator*	effect*	ToxFile 1965- to date
breathing adj apparatus	occup*	Enviroline(R) 1975-May 2008
PPE*	expo*	Environmental Sciences 1966- to date
RPE*	glove*	Pollution Abstracts 1966-to date
	clothi*	SciSearch(R) Cited Ref Sci 1990- to date
	respi*	SciSearch(R) Cited Ref Sci 1974-Dec 1989



## Review papers - Results literature search

- › Result search: 550 titles with abstracts period 2006-2012 →  
Evaluated for relevance based on abstract → 83 relevant papers  
identified



Study type	N
Survey on PPE use	52
Field study (exposure)	16
Biomonitoring	8
Laboratory penetration tests	4
Intervention study	3
Other (review, descriptive)	7





## Review papers - Exposure reduction

Reference	Type PPE	Exposure reduction
Coble, 2011	Chemically resistant gloves	60%
Espanhol, 2012	Coverall with water repellent	>82%
Glass, SMT project	Coveralls (cottons and Tyveks)	58 - 100%
Machera, 2009	Coveralls (with and without water repellent)	96.7 - 99.6%
Mathers, 2006	Coveralls	40 - 100%
Moreira, 1999	Cotton coverall	99.5%
Protano, 2009	Full face mask, Tyvek coverall, boots, gloves Cotton garments	>97% 84 - 93%



## Review papers - Exposure reduction

Reference	Type PPE	Exposure reduction
Shaw, 2008	Coverall with and without repellent finish	82 - 94%
Tacio, 2008	Agro light set and Azeredo set	96.2 - 96.7%
Tacio, 2010	Agro light set and Kit Tratorizado	92.8 - 94.2%
Tsariakis, 2010	Coverall with and without nano water repellent	97.3 - >99%
Tsariakis, 2011	Coverall with and without nano water repellent	97.5 - >99%
Vitali, 2009	Cotton clothing	89.8%
	Tyvek	97.6%



## Review papers - conclusions

- › Most papers on use surveys
- › Limited amount papers with exposure reduction values
- › Although lot of papers from outside EU, the use surveys show that the use of PPE and work wear by farmers can't be taken for granted
- › Intervention studies aimed at training and awareness show that use of PPE can be improved and increased



## Surveys on use PPE

- › Info from surveys carried out in framework EFSA and BROWSE
- › EFSA:
  - › UK: Arable Crops, soft fruit
  - › Belgium: Greenhouse ornamentals, outdoor vegetables
  - › Spain: Greenhouse fruiting vegetables
  - › Greece: Greenhouse fruiting vegetables, arable (cotton/maize)
  - › Poland: Arable (wheat), orchard (apple)
  - › Italy: Vineyards (wine grapes)
- › unique dataset, 428 farms, 581 operators, 749 sprayers, 481 workers, 17,058 rows of PPP operator data, 10,237 rows of worker data



## Surveys on use PPE

### › BROWSE:

- › With regard to operators, 3 scenarios were included in the survey:
- › Arable: In total 50 observations in UK, of which 19 questionnaire during interview, and 31 web survey
- › Orchards: In total 52 observations, 27 in Greece and 25 in Italy, all questionnaire during interview
- › Greenhouses: In total 41 observations, 25 in Greece and 16 in Italy , all questionnaire during interview
- › Indication due to limited nr of operators and countries included and large variation in results



## Surveys on use PPE

- › Main results of surveys:
- › Lot of variation in types of PPE and work wear used
- › Use of PPE and work wear relatively low at least for some scenarios
- › *Glass R, Garthwaite D, Pote A, et al. Collection and assessment of data relevant for non-dietary cumulative exposure to pesticides and proposal for conceptual approaches for non-dietary cumulative exposure assessment. External scientific report CFT/EFSA/PPR/2010/04. Supporting publications 2012:EN-346.*



## Data analysis available exposure data - Migration

- › BROWSE database (operator and worker, PPE terminology adapted  
→ difficult with limited information)
- › Southern Greenhouse database (ECPA)
- › BfR Database: whole body garment analysis only
- › Migration is actual exposure as a proportion of potential exposure
- › Comparable sampling methods
- › Analysis per body part and whole body garment



## Data analysis - Dermal sampling methods

Body - Sampling method	# *	Hands - Sampling method	# *
Surrogate technique – pads/patches	1120 (1120 / - )	Removal techniques – washing	29 (29 / -)
Surrogate technique – whole body	2226 (1078 / 1148)	Surrogate technique – gloves	162 (162 / -)
Missing	178 (- / 178)	Surrogate technique – gloves / Removal techniques – washing	383 (126 / 257)

\* #= Number of individual body parts for which data is available  
( BROWSE database / Southern Greenhouse model)



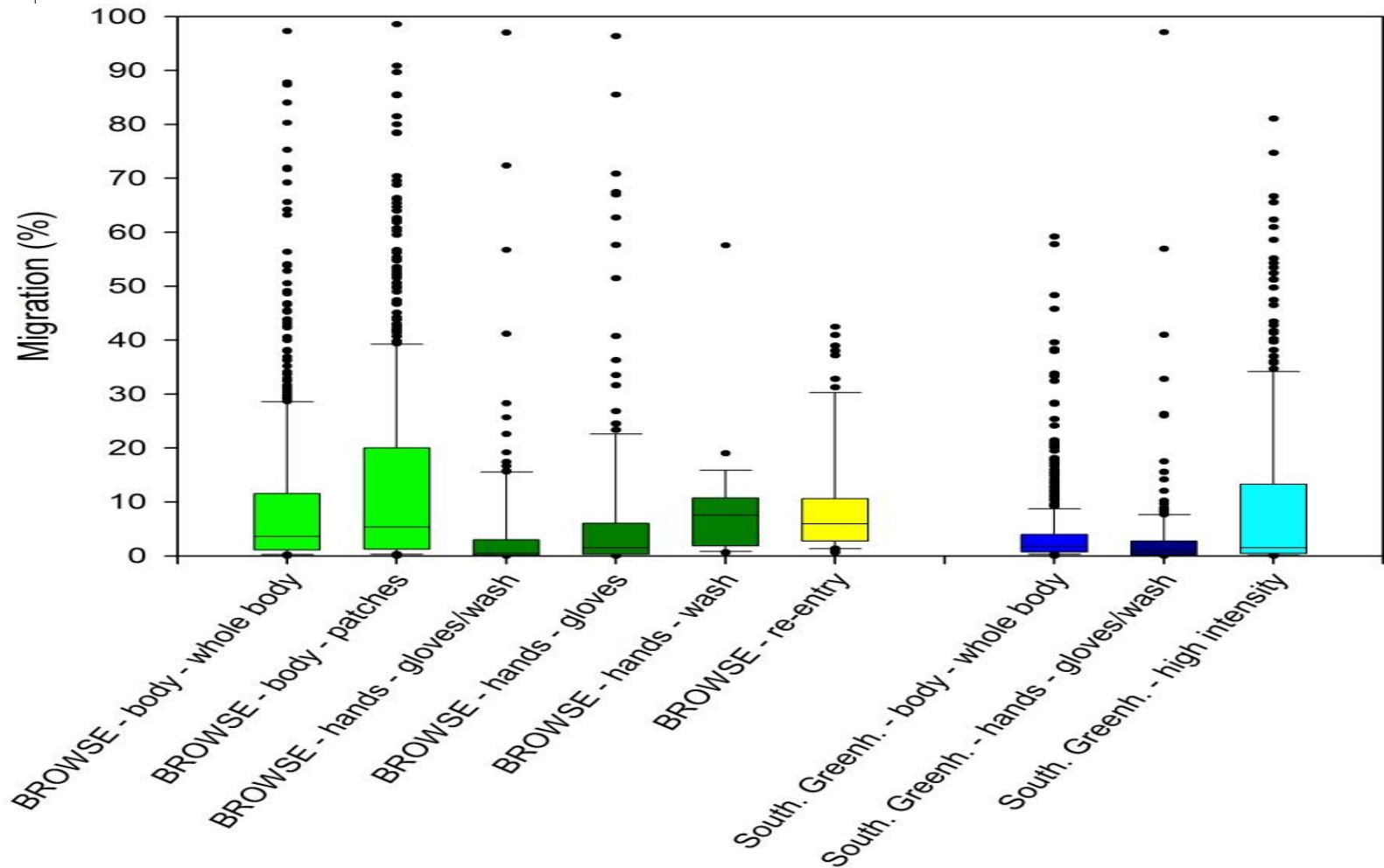


## Data analysis - Statistics

- › Migration will depend on factors difficult to take into account in all cases, for example:
  - › Magnitude of PDE (loading of PPE)
  - › Distribution of loading over the PPE
  - › Age/use history/laundry of the PPE
  - › Physical-chemical properties of the pesticide/chemical/tracer
  - › Type of contact between PPE and contaminated surface
  - › Duration of exposure (study)
  - › Environmental conditions
  - › Task performed

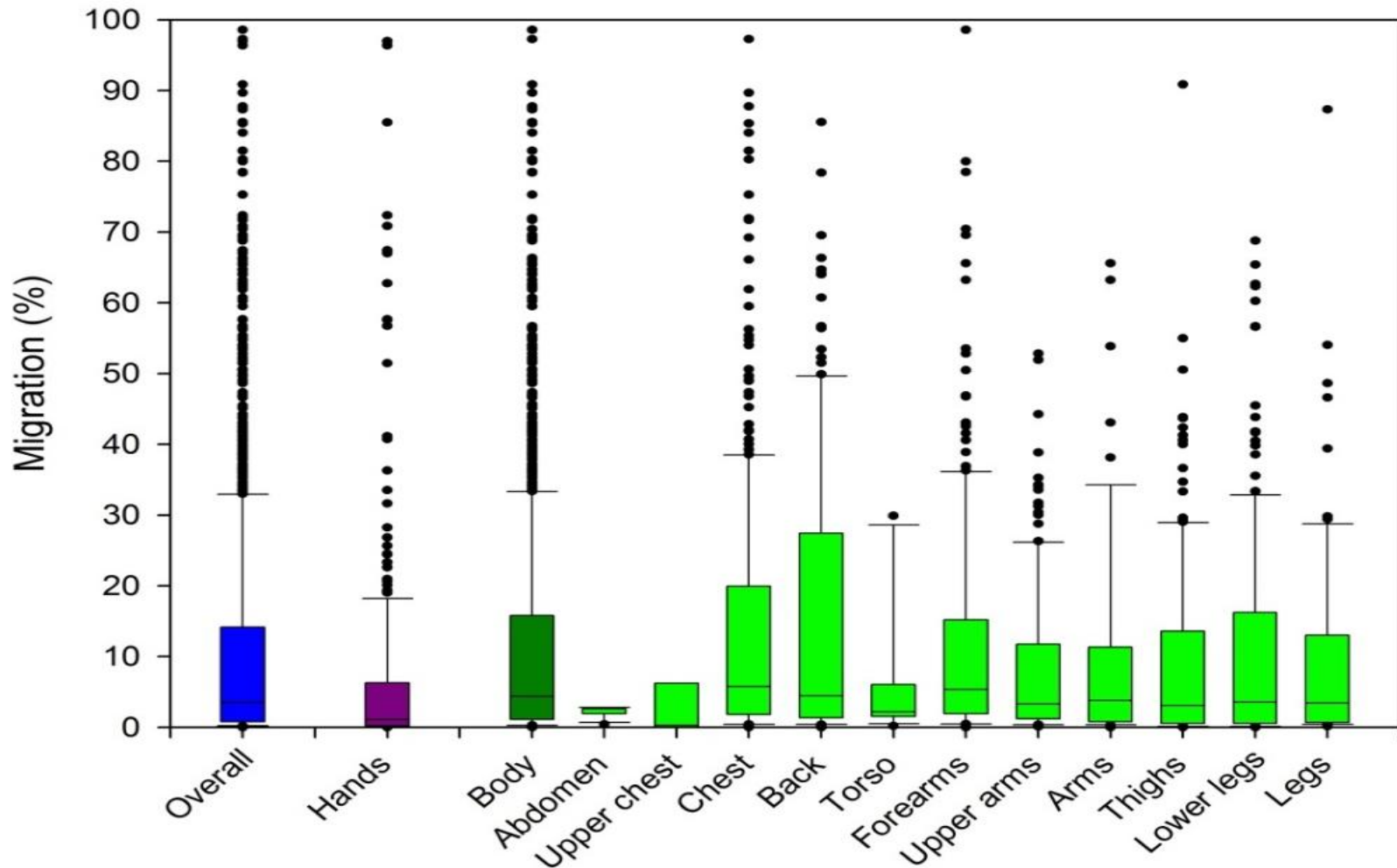


# Migration – individual body parts, database and measurement method



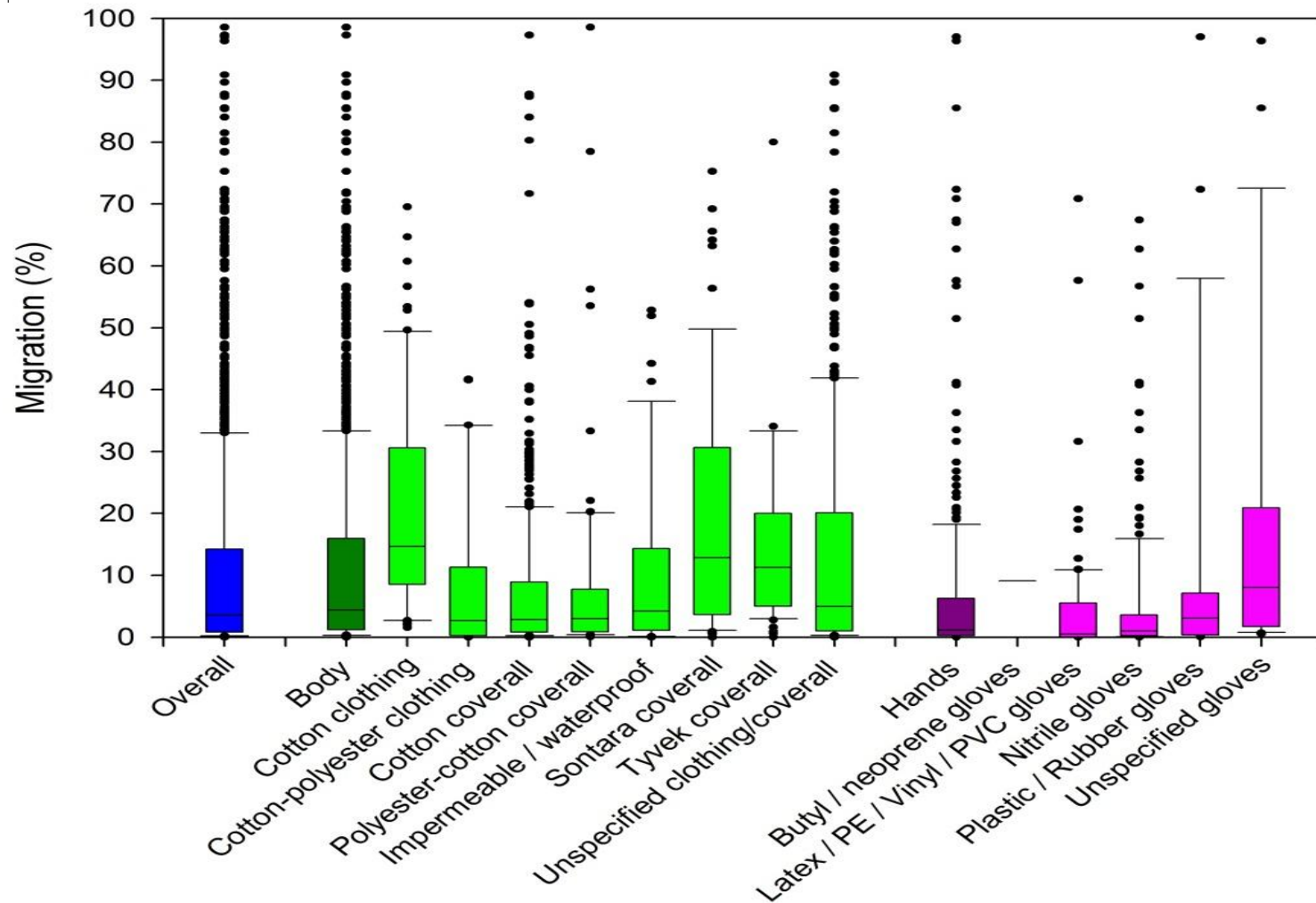


## Databases combined - Per body part



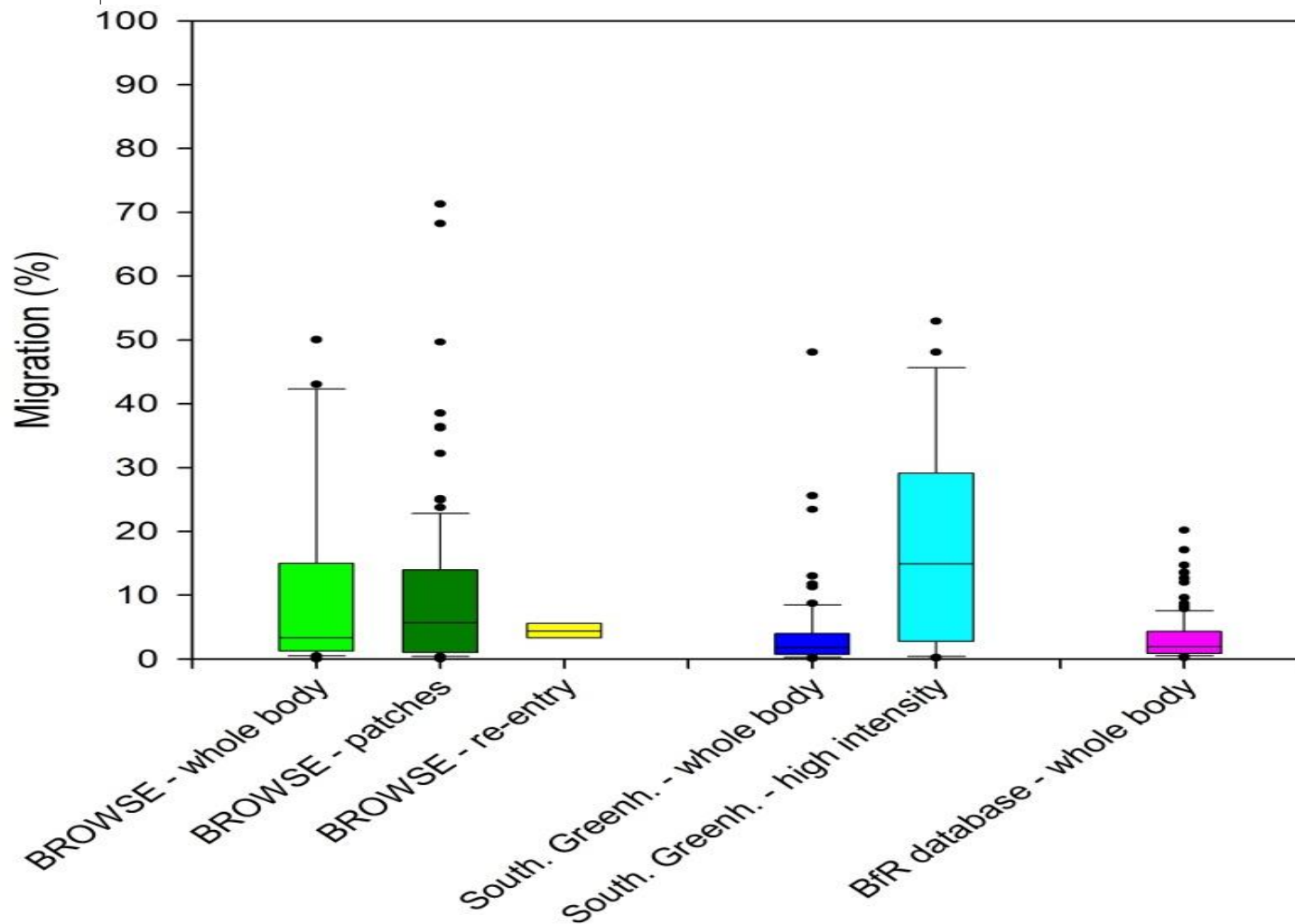


## Databases combined - Per PPE type / work wear



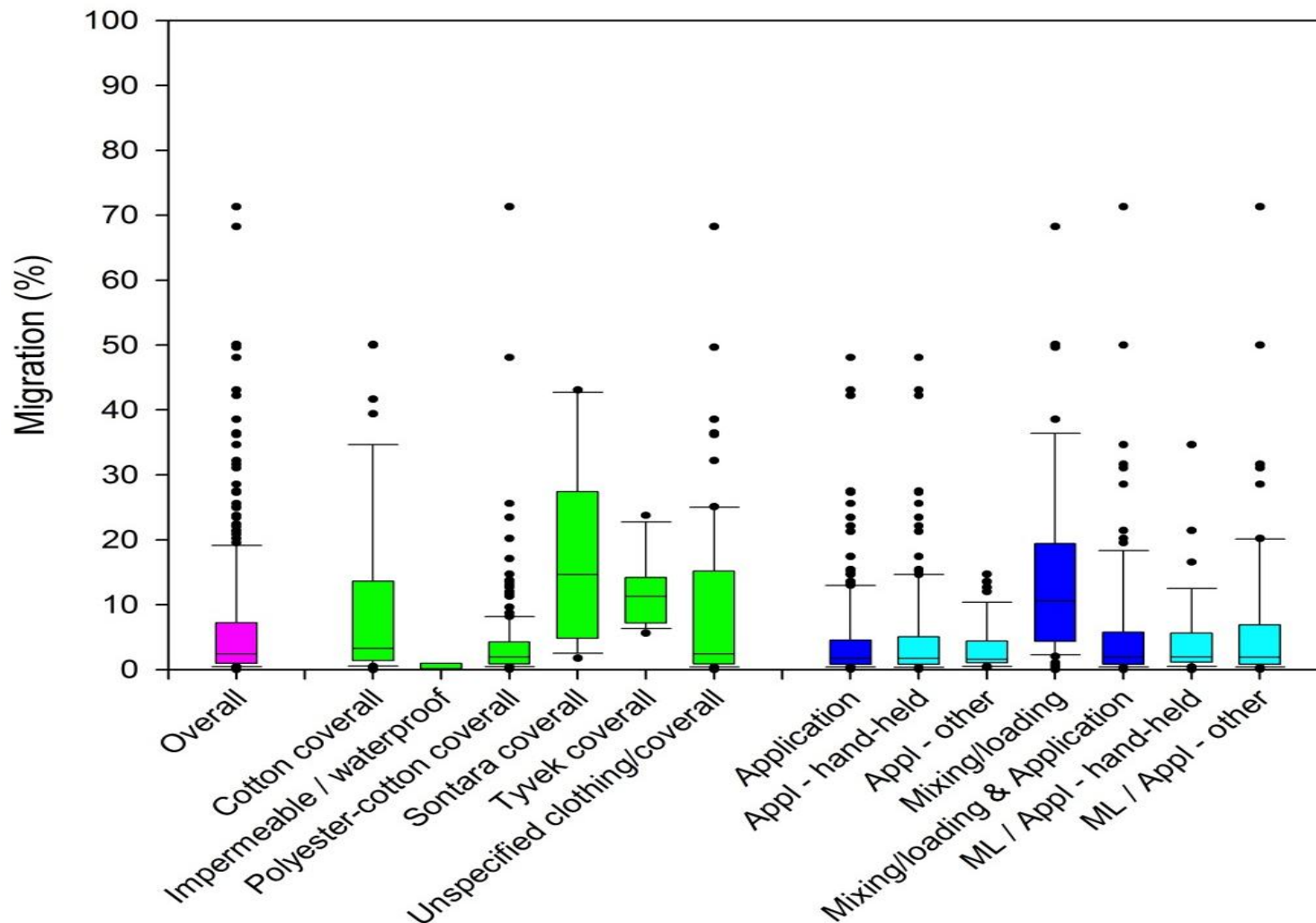


## Whole body garment - per database





## Databases combined - Whole body garment - Per PPE type / work wear and per task performed





## Proposal default efficacy values - Body

Proposed factors	N	AM	SD	GM	GSD	Min	P50	P75	P90	Max
<b>BODY</b>										
Unspecified work clothing	403	6.92	11.09	2.61	4.40	0.01	2.40	7.20	18.55	71.31
Cotton coverall	85	9.96	15.11	3.17	5.37	0.01	3.05	9.60	34.66	50.07
Polyester-cotton coverall	212	3.86	6.86	1.92	3.26	0.05	1.97	4.25	8.14	71.31
<b>BODY - Indicative factors</b>										
Re-entry (cotton clothing/coverall)	6	4.48	1.33	4.32	1.35	2.84	4.36	5.27	6.57	6.57
High intensity crop contact (polyester-cotton coverall)	28	17.99	16.42	7.71	5.68	0.16	14.92	29.08	45.40	52.92
Uncertified rain suit								0.2 *		
Certified coverall (Type 3/4)								0.1 *		

\* Based on extrapolation



## Proposal default efficacy values - Hands

Proposed factors	N	AM	SD	GM	GSD	Min	P50	P75	P90	Max
<b>HANDS</b>										
Unspecified gloves	508	5.47	13.08	0.82	9.94	0.00	1.00	3.95	14.48	97.07
- ML liquids	94	1.21	2.89	0.18	9.74	0.00	0.16	0.85	3.11	19.17
- ML solids	80	4.36	8.83	0.93	8.66	0.00	1.38	4.52	8.93	56.93
Latex / PE / Vinyl / PVC gloves	91	4.50	10.58	0.59	10.08	0.00	0.51	5.51	10.81	70.85
- ML liquids	31	0.50	1.04	0.09	6.61	0.00	0.08	0.18	1.80	4.05
Nitrile gloves	368	4.36	10.39	0.72	9.57	0.00	0.96	3.14	10.18	97.07
- ML liquids	51	1.44	3.58	0.19	11.47	0.00	0.28	0.85	2.75	19.17
- ML solids	75	4.30	9.10	0.84	8.87	0.00	1.27	4.15	9.09	56.93





## PPE and work wear - Conclusions

- › No real (significant) new information from papers reviewed to update defaults.
  - › Actual use of PPE is still relatively low
- › Statistical analysis in line with defaults in former report, but more distinction for types of PPE and work wear seems possible
- › Default setting in BROWSE operator models possible






# Screenshot BROWSE software \_ PPE/work wear

BROWSE exposure assessment software - Browse\_V4.95

File Help

 browse

Assessment Scenario Operator Resident/Bystander Console Results - Operator Results - Resident/Bystander

Control Panel

Batch Mode

Operator

Number of iterations to run 140000

Gender Male \*

Body weight Distribution - EFSA \* N(82.0, 13.1<sup>2</sup>) kg

Breathing rate Light intensity (m<sup>3</sup>/hour) Distribution - US EPA \* N(0.876, 0.129<sup>2</sup>) m<sup>3</sup>/hour

PPE or workwear

Hands - mixing & loading	Protective (chemical resistant) gloves	Constant - EFSA	10.0	% migration
Hands - spraying	Nitrile gloves	Constant - BROWSE 75th percentile	3.14	% migration
Body - mixing & loading	Protective coverall	Constant - EFSA	10.0	% migration
Body - spraying	Polyester-cotton coverall	Distribution - BROWSE	lnN(-5.18, 1.96 <sup>2</sup> )	% migration
Head - mixing & loading	None *	Constant *	100.0	% migration
Head - spraying	None *	Constant *	100.0	% migration
Respiratory - mixing & loading	Half and full face masks (FP1, P1 and similar)	Constant - EFSA	25.0	% migration
Respiratory - spraying	None *	Constant *	100.0	% migration



# Technical controls



## Technical controls - Background and aim

- › Since technical controls can also reduce exposures and thus can be considered as an important risk management measure (RMM), we considered these and investigated how to implement these in the BROWSE exposure models.
- › Limited resource allocated to this task, investigating some specific controls
- › Outcome → uptake of technical controls in the operator exposure models



## Cabin efficiencies

- › 15 recent papers available for review
- › Cabin efficiencies were evaluated using the following types of information:
  - › studies testing the ratio of the concentrations measured inside and outside of the cabin,
  - › inhalation and dermal exposure measured with and without cabins, and
  - › default values derived in other models.
- › Important to note: Cabin efficiencies are context- and scenario-specific (depend on e.g. physical state, particle/droplet size, type of filters, concentration levels of the airborne contaminant)



## Cabin efficiencies

- › Results show that cabin efficiencies are highly variable ranging from 31 - >99 %
- › For model development the following was considered important:
  - › Open or closed cabins
  - › Opening the cabin door (when exiting / entering)
  - › Open or closed windows
  - › Type of ventilation (e.g. positive pressure)
  - › Filtering of air



## Cabin efficiencies

- › In the models 3 categories implemented:
  - › No cabin (factor 1)
  - › Cabin without positive pressure and filtered ventilation (factor 0.4)
  - › Cabin with positive pressure and filtered ventilation (factor 0.1)
- › Since cabin effectiveness is highly variable, probability distributions (lower and upper values) are included in the models



## Screenshot BROWSE software - Cabin

Activity

Sprayed area	<input type="text" value="12.0"/> ha	<input checked="" type="checkbox"/> Boom spraying
Tank volume	<input type="text" value="120.0"/> litres	
Total spray volume	<input type="text" value="2400.0"/> litres	
Tankfuls applied	<input type="text" value="20"/>	
Vehicle-sprayer type	<input type="text" value="Unknown *"/>	
Vehicle or trailer mounted boom	<input type="text" value="Unknown *"/>	
Cabin	<input type="text" value="No cabin *"/>	
Number of nozzle maintenance events	<input type="text" value="With pressurised/filtered ventilation"/> <input type="text" value="Without pressurised/filtered ventilation"/> <input type="text" value="No cabin *"/>	
Front-mounted boom	<input type="text" value=""/>	
Boom shielding	<input type="text" value="No *"/>	
Spraying time	<input type="text" value="Indicative model estimate *"/>	<input type="text" value="31.2437512497501"/> mins

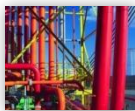
Windows taskbar icons: Internet Explorer, Google Chrome, Microsoft Word, Microsoft PowerPoint, Microsoft Excel, Microsoft Lync, Firefox, and others.





## Boom shielding

- › Only 6 relevant papers available
- › Effect depends on factors such as nozzle type and angle, droplet size, shield type and angle → a lot of varying conditions
- › For model development the following was considered important:
  - › Since we may get access to more contextually-rich data (indicating the presence of boom shields) in the future, it was decided to include this parameter in the model
  - › Default is set at 'no shielding' due to limited use
  - › In the absence of detailed information a fixed factor is proposed in the lower range of spray drift reductions, namely 30% (factor 0.7)



## Screenshot BROWSE software - Boomshielding

Activity

Sprayed area	<input type="text" value="12.0"/> ha	<input checked="" type="checkbox"/> Boom spraying
Tank volume	<input type="text" value="120.0"/> litres	
Total spray volume	2400.0 litres	
Tankfuls applied	<input type="text" value="20"/>	
Vehicle-sprayer type	<input type="text" value="Unknown *"/>	
Vehicle or trailer mounted boom	<input type="text" value="Unknown *"/>	
Cabin	<input type="text" value="No cabin *"/>	
Number of nozzle maintenance events	<input type="text" value="3"/>	
Front-mounted boom	<input type="text" value="No *"/>	
Boom shielding	<input type="text" value="No *"/>	
Spraying time	<input type="text" value="Yes"/> <input type="text" value="No *"/>	<input type="text" value="31.2437512497501"/> mins



## Other controls or options that can reduce exposure


- › Since the BROWSE models offer a lot of options and parameters to detail the exposure assessment you can vary these options to see the “best option” with regard to exposure
- › Parameters that can vary:
  - › Vehicle set up
  - › Mixing and loading method
  - › Package size
  - › Dilution factor
  - › Etc.



## Screenshot BROWSE software - Other controls

BROWSE exposure assessment software - Browse\_V4.8

File Help

 Calculate

Assessment Scenario Operator Resident/Bystander Console Results - Operator Results - Resident/Bystander

Hands - spraying	None *	Constant *	100.0	% migration
Body - mixing & loading	None *	Constant *	100.0	% migration
Body - spraying	None *	Constant *	100.0	% migration
Head - mixing & loading	None *	Constant *	100.0	% migration
Head - spraying	None *	Constant *	100.0	% migration
Respiratory - mixing & loading	None *	Constant *	100.0	% migration
Respiratory - spraying	None *	Constant *	100.0	% migration

Activity

Sprayed area	12.0 ha	<input checked="" type="checkbox"/> Boom spraying
Tank volume	120.0 litres	
Total spray volume	2400.0 litres	
Tankfuls applied	20	
Vehicle-sprayer type	Unknown *	
Vehicle or trailer mounted boom	Small quad, golf cart, mini tractor (e.g. John Deere compact 1 series)	
Cabin	Average-sized tractor (e.g. John Deere 2 series)	
Number of nozzle maintenance events	Large-sized tractor, 4WD (e.g. John Deere 9R/RT series)	
Front-mounted boom	Unimog or similar	
Boom shielding	Small self-propelled ( $\leq 1000\text{L}$ tank)	
Spraying time	Indicative model estimate *	31.2437512497501 mins

Mixing and Loading

☒ Mixing and Loading

Mixing and loading method Tank-top (open) pour \*

Product formulation type Liquid

Formulation Fine dust or powder \*

Measuring jug used No \*

Container size 15.0

Location Small room \*


Localised controls None \*



## Screenshot BROWSE software - Other controls

BROWSE exposure assessment software - Browse\_V4.8

File Help

 Calculate

Assessment Scenario Operator Resident/Bystander Console Results - Operator Results - Resident/Bystander

Hands - spraying	None *	Constant *	100.0	% migration
Body - mixing & loading	None *	Constant *	100.0	% migration
Body - spraying	None *	Constant *	100.0	% migration
Head - mixing & loading	None *	Constant *	100.0	% migration
Head - spraying	None *	Constant *	100.0	% migration
Respiratory - mixing & loading	None *	Constant *	100.0	% migration
Respiratory - spraying	None *	Constant *	100.0	% migration

Activity

Sprayed area 12.0 ha ☒ Boom spraying

Tank volume 120.0 litres

Total spray volume 2400.0 litres

Tankfuls applied 20

Vehicle-sprayer type Unknown \*

Vehicle or trailer mounted boom Unknown \*

Cabin No cabin \*

Number of nozzle maintenance events 3

Front-mounted boom No \*

Boom shielding No \*

Spraying time Indicative model estimate \* 31.243751249750 mins

Mixing and Loading

☒ Mixing and Loading

Mixing and loading method Tank-top (open) pour \*

Product formulation type Tank-top (open) pour

Formulation Induction bowl (open) pour  
Mechanical transfer/coupling devices (MTD) fitted on induction bowls  
Closed transfer systems (CTS)

Measuring jug used No \*

Container size 15.0

Location Small room \*

Localised controls None \*



## Available info on other RMM

- › ECEL: Exposure Control Efficacy Library ([www.ecellibrary.com](http://www.ecellibrary.com))

The screenshot shows a web browser window with the URL <http://www.ecellibrary.com/Account/SignIn>. The page features the TNO logo and the title "Exposure Control Efficacy Library". It contains two main sections: "BACKGROUND INFORMATION" and "LOGIN PROCEDURE & USE".

**BACKGROUND INFORMATION**

The identification and implementation of measures to control chemical exposure in the workplace, in addition to the appropriate conditions of use, are essential for health risk management. For this purpose, Risk Management Measures (RMM) are deliberate measures with the intention to reduce chemical exposure. The [Exposure Control Efficacy Library \(ECEL\)](#) is a database with information on the effectiveness of different types of Risk Management Measures (RMM).

RMM effectiveness data were retrieved from the ECEL database and analysed in 2008 (Fransman et al, 2008). Since then the ECEL database was reviewed and updated and launched as an online web-tool in December 2012. The ECEL version 1.0 contains data on the effectiveness of RMM to control inhalation (personal) exposures to airborne contaminants. It focuses on RMMs of a technical nature like suppression techniques, enclosure, (general) ventilation systems, vapour recovery systems and glove boxes. ECEL only contains data where it was possible to derive a quantitative estimate of the effectiveness of a given RMM during a specific workplace scenario. Presently, information from 67 references are available with a total of 414 entries on RMM efficiencies. For each entry in the database an ECEL card or factsheet is presented with a brief outline of the workplace scenario and the effectiveness of the investigated RMM. This provides the ECEL user with useful information regarding RMMs, their potential effectiveness and important contextual information to make informed decisions.

**LOGIN PROCEDURE & USE**

The ECEL database is, after a login procedure, freely available to all users. The library allows the user to search on various items (e.g. industry, RMM, product) to retrieve relevant information on the effectiveness of different RMM. Please note that every RMM is context-specific, and that the users of ECEL should apply their own discretion as the information presented here is intended for informative purposes only.

After login the user is provided with more background information about the selection criteria, the content of the database and the estimation of the efficiency of the RMMs.

**SIGN IN**

Please enter your email address and password or [register](#) if you don't have an account.

☐ Remember me?

**SIGN IN**



**Thank you for your attention, any questions?**

