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Variability in exposure level – implications for building and validating of models

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Variability in exposure level

- The exposure level is not constant over time and across different workers/exposed individuals or places
- In Occupational Safety and Health (OSH) this is called ‘between and within worker variability’
- Measurement strategies in OSH already account for variability of exposure by demanding several measurements at one work place

Reasons for exposure assessment in OSH

- Exposure assessment for the use in **epidemiological studies:**

  Need to assess the exposure of an **average worker**, in order to derive a dose-effect-relationship

- Exposure assessment for testing the **compliance** with occupational exposure limit values:

  Need to assess the **high end of the exposure distribution**, because **all workers** should be protected

=> It is important to assess the **average level** of exposure **and** the **variability** of the exposure level (including the reasonable worst case)

Variability of measured exposure

- Toluene exposure in **one** printing plant (Source: Clerc and Vincent 2014)

Homogenous Exposure Group	2h n	2 h Range (mg/m³)	2 h Factor max/min	6h n	6h Range (mg/m³)	6h Factor max/min
Winder	147	8 – 149	19	50	12 – 83	7
Driver 1	143	9 – 366	41	48	39 – 177	5
Driver 2	131	20 – 568	28	46	40 – 382	10
Receiver	221	3 – 193	64	71	12 – 105	9
Test driver	90	4 – 254	64	30	17 – 126	7

- Taking samples in **several** plants would result in even bigger ranges

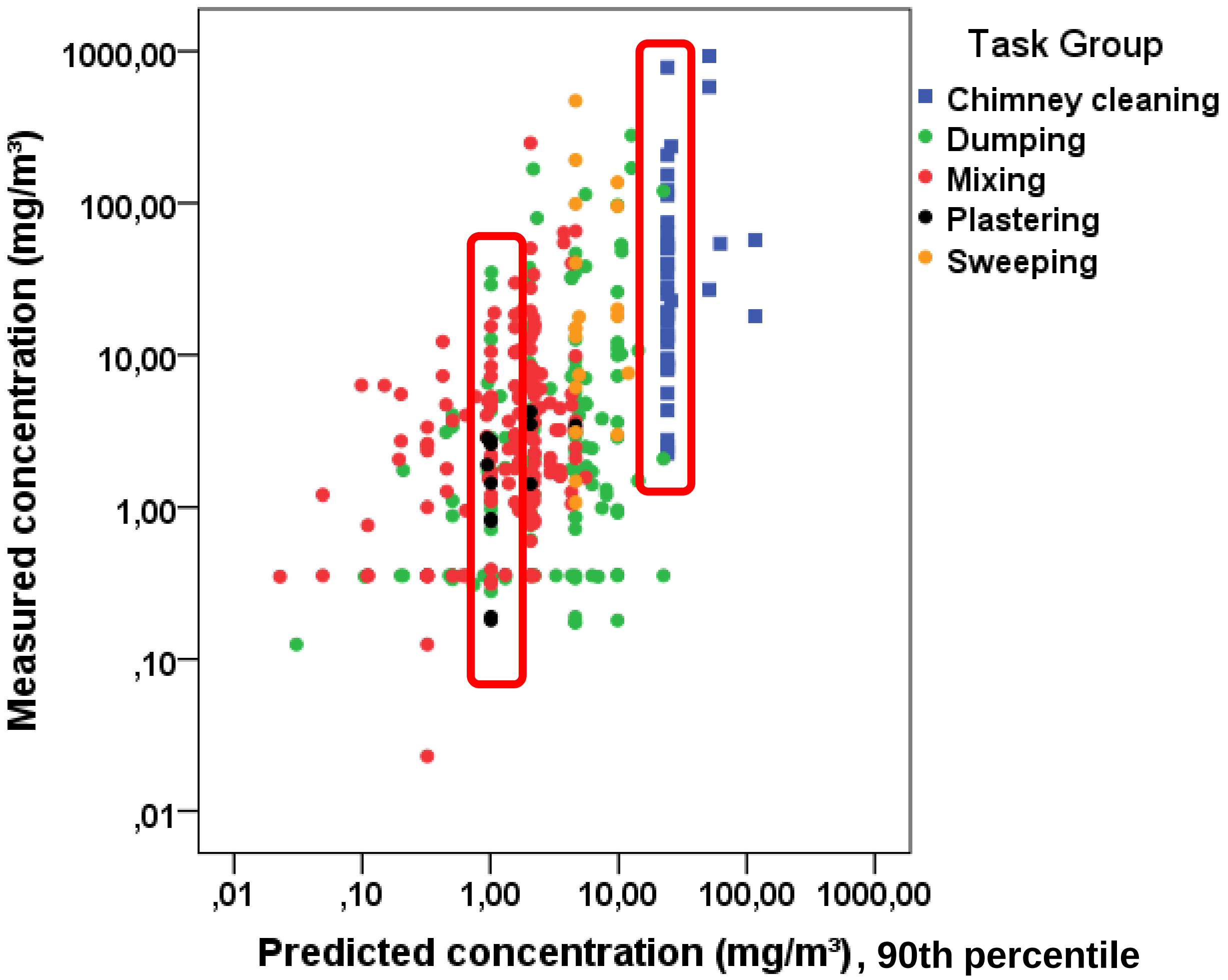
Variability of exposure ⬄ building of models

- How can modelling help to assess the variability of the exposure level?
- Which information is provided by models today?
- Examples from OSH:
  - COSHH, EMKG: Control Banding => Modelling an exposure band
  - ECETOC TRA, MEASE: Point estimate "reasonable/realistic worst case"
  - Stoffenmanager®: 90^{th} percentile as point estimate and additional percentiles from internally estimated GM and GSD
  - ART: Percentiles with confidence interval

Variability of measurement values compared to modelled exposure

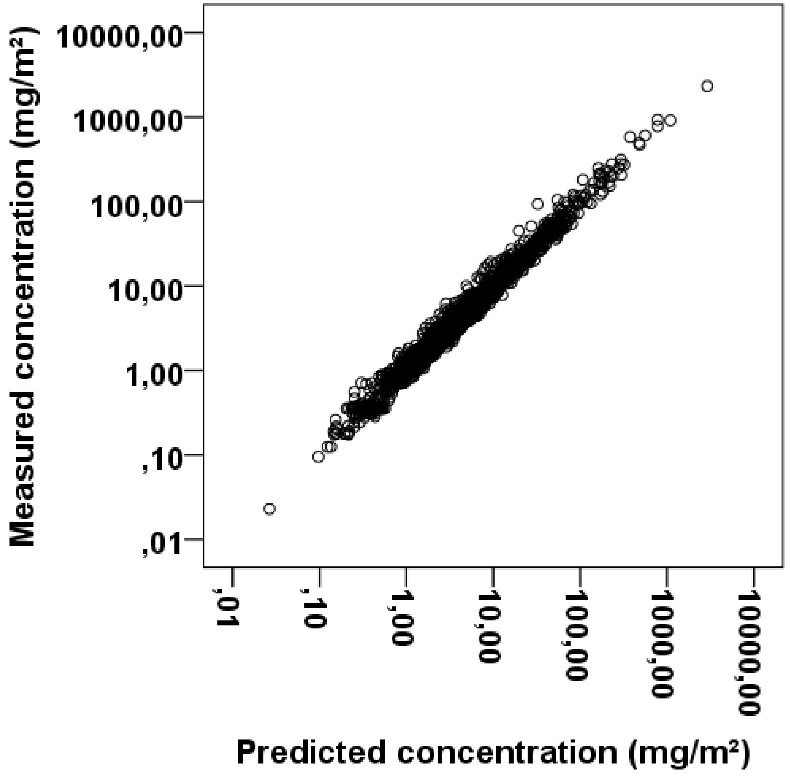
Inhalable dust concentration modelled with Stoffenmanager ®

Data from: Koppisch et al. (2012)

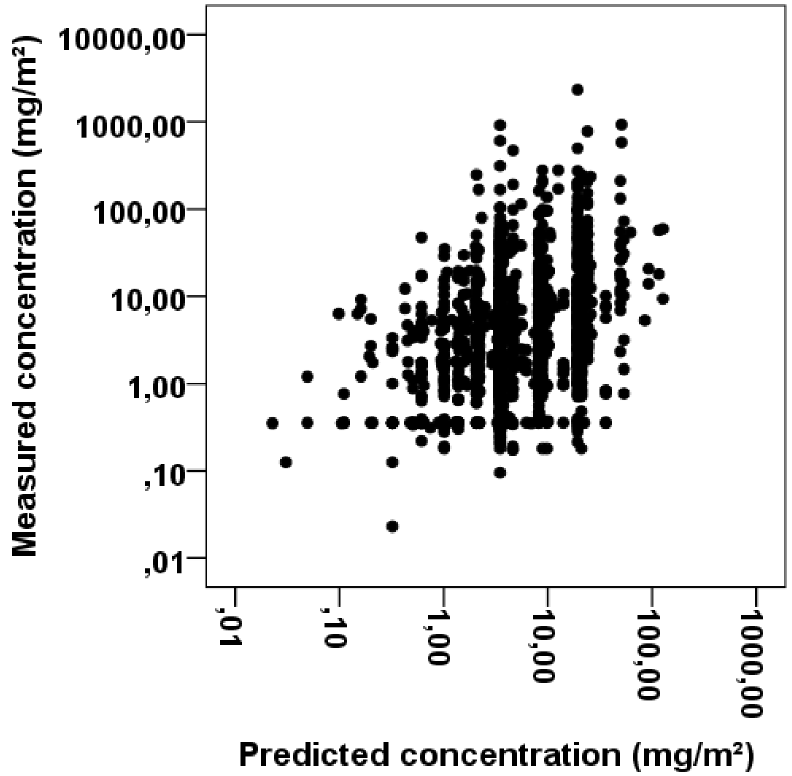


Variability of exposure ⇔ correlation model and measurement

- Situation **without** variability in exposure level



- Situation **with** variability in exposure level



Variability of exposure ⇔ validation of models

What should be tested during a validation?

- Common answers are that a validation should test **accuracy, precision, predictive power, the conservancy** of the model
- Often tested by **external validation** that compares the model outcome and data from independent sources, mostly measurement data, looking at **bias** or at the **correlation** between the two

But: If exposures show variability than this variability will have an effect on the measures used in such validation studies

Validation of models: example ETEAM study

- The authors wanted to examine the **predictive power** and the **conservancy** of the models under consideration
- **Predictive power** of the models:
  Correlation between measurements and modelled exposure => Correlation coefficient R_s
- **Conservancy** of the models:
  Percentage of measurements that lay above the modelled exposure

% Measurements >Tool Estimate		
High	Medium	Low
≤10%	11≤25%	>25%

Source:
Lamb et al. (2015)

New proposal for an ‘interval testing’

- If the tool is modelling percentiles, it is possible to test not only if 90% < 90th percentile, but a set of conditions:
  - 50% of measurement values < estimated median
  - 10% of measurement values in [est. 50th perc., est. 60th perc.]
  - 10% of measurement values in [est. 60th perc., est. 70th perc.]
  - 10% of measurement values in [est. 70th perc., est. 80th perc.]
  - …
- Advantages:
  - A validation method that considers variability
  - Possibility to test with Chi²-statistic

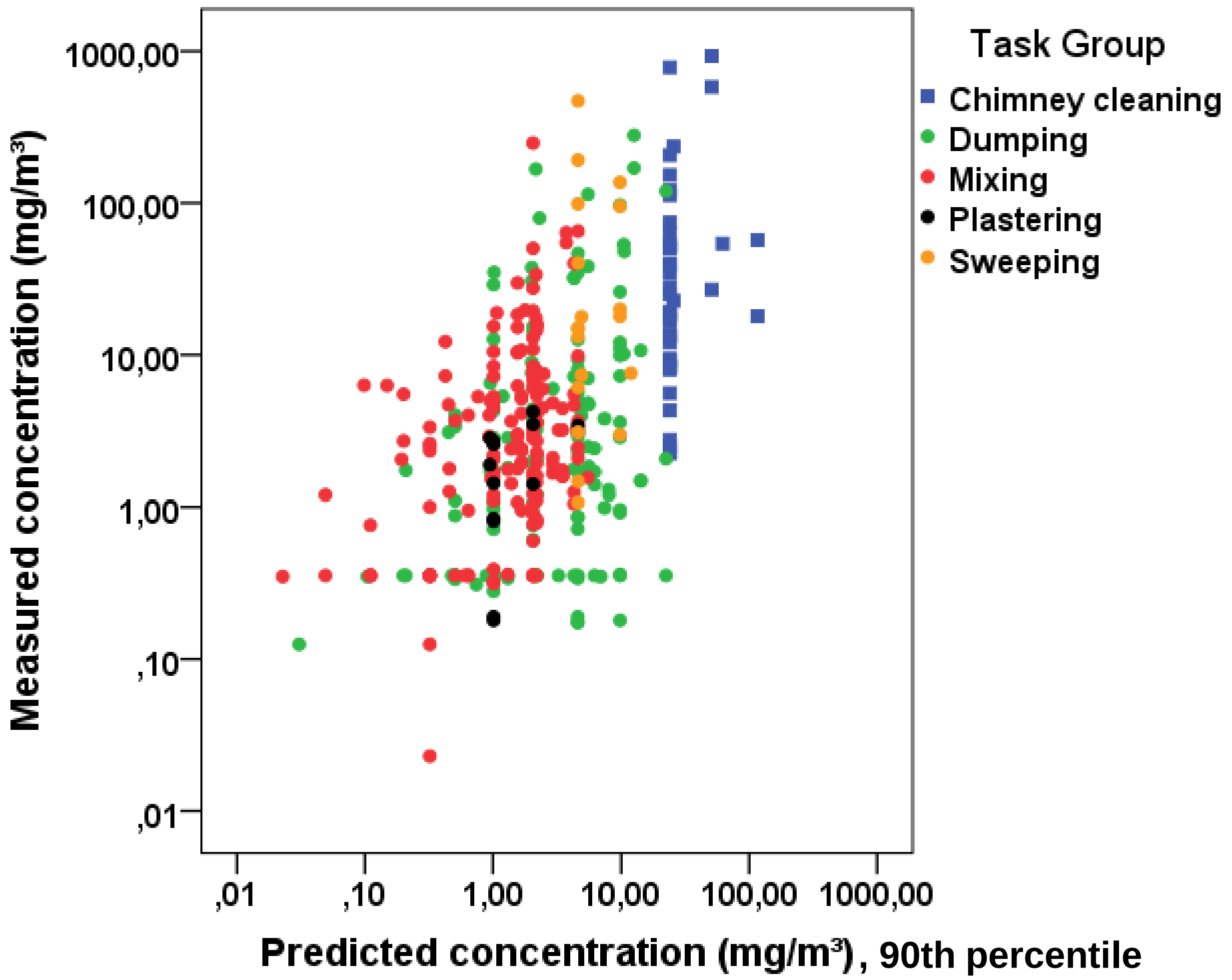
Interval testing: example data from exposure database MEGA

Exposure database MEGA

- exposure measurements from German workplaces
- about 3.4 million measurement values
- hazardous substances and biological hazards (bacteria, endotoxin, mould)
- most frequently measured substances are organic substances like solvents, dust, metals and fibres like asbestos
- used for prevention, for historical investigations regarding occupational diseases and for research
- the database is not publicly available, but results are published under https://www.dguv.de/ifa/gestis/expositionsdatenbank-mega/expositionsdaten-aus-mega-in-publikationen/index-2.jsp

Interval testing: example data from exposure database MEGA

- Inhalable dust data from MEGA
- Details of data selection look at Koppisch et al. Ann Occup Hyg 2012
- Model used is Stoffenmanager ®



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Interval testing: example data from exposure database MEGA

Intervall	Expected percentage of measurements	Number of measurements within the intervals of estimated percentiles handling of powders and granules	
		n	%
0-50	50	161	41
>50 – 60	10	43	11
>60 - 70	10	51	13
>70 - 75	5	22	6
>75 - 80	5	20	5
>80 - 90	10	46	12
>90 - 95	5	26	7
>95 - 100	5	21	5
CHI^2		13.90	p>0.05

Raw data from: Koppisch et al. (2012)

Conclusions

- Exposure height varies over time, between and within different workers and different places
- This variability is already considered in many sampling strategies when measuring exposure
- This variability should be considered in modelling:
  => model output preferentially several percentiles or GM and GSD
- This variability should also be considered during the validation of models
- Interval testing is presented here as a validation method considering variability

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Thank you for your attention.

Dedankt voor uw aandacht.

Vielen Dank für Ihre Aufmerksamkeit.

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Literature cited:

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