Exposure assessment and workers' protection

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Institute of Environmental Medicine (IMM)

IMM performs

- Research
  - occupational and environmental medicine
  - epidemiology
  - toxicology
  - physiology
- Education
  - MSc Toxicology & Work and Health
  - PhD education
- Health risk assessment

https://ki.se/en/imm/institute-of-environmental-medicine

Exposure

External exposure

- Contact between an agent (chemical, physical or biological) and a target
- Exposure takes place at the point of contact (exposure surface)
  → Mainly skin, respiratory tract, gastrointestinal tract
- For a certain period of time
    - Acute, short-term, chronic, life-long exposure

Dose – internal exposure

- The amount of an agent that enters a target after crossing an exposure surface / absorption barrier of an organism

Exposure assessment

Aims to identify and quantify past, present and future exposures to chemical, physical, and biological agents that may cause health effects.

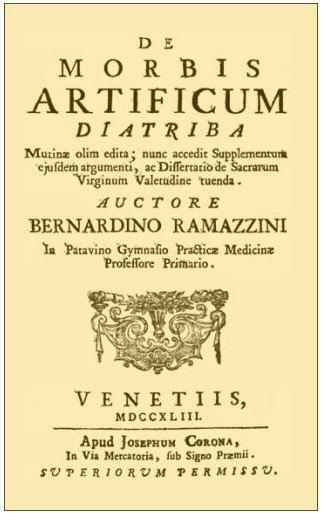
Comprises all the methods available to describe, estimate and determine, qualitatively and quantitatively, the agents' contact with, and entry into, the body.

Why occupational exposure assessment?

- **To prevent disease, injury and early death**
- 59.3% of the global population aged 15 or older is in employment (ILO 2022 estimate)
- Poor working conditions are a major issue:
  - → Each year: 340 million occupational accidents and 160 million victims of occupational disease globally;
  - → ~2.3 million fatalities (ILO.org)

- Everyone should be able to get home safe and healthy from work every day – and into retirement!

Why: Identifying hazardous exposures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MORBIS
ARTIFICUM
DIATRIBA
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AUCTORE
BERNARDINO RAMAZZINI
In Patavino Gymnasio Practicæ Medicinæ Professore Primario.
VENETIIS,
MDCCXLIII.
Apud Josephum Corona,
In Via Mercatoria, sub Signo Præmii.
SUPERIORUM PERMISSU.

- Connections between certain diseases and occupations (or exposures) have been made since long
  - ~ 400 BC Hippocrates suggested that environmental and behavioural factors might influence the development of disease.
  - 1700 Ramazzini: Diseases of Workers
- Some well-known examples:
  - Asbestos and asbestosis & mesothelioma
  - Quartz and silicosis & lung cancer
  - Benzene and leukemia
- Better exposure assessments – more information about potential exposure-response

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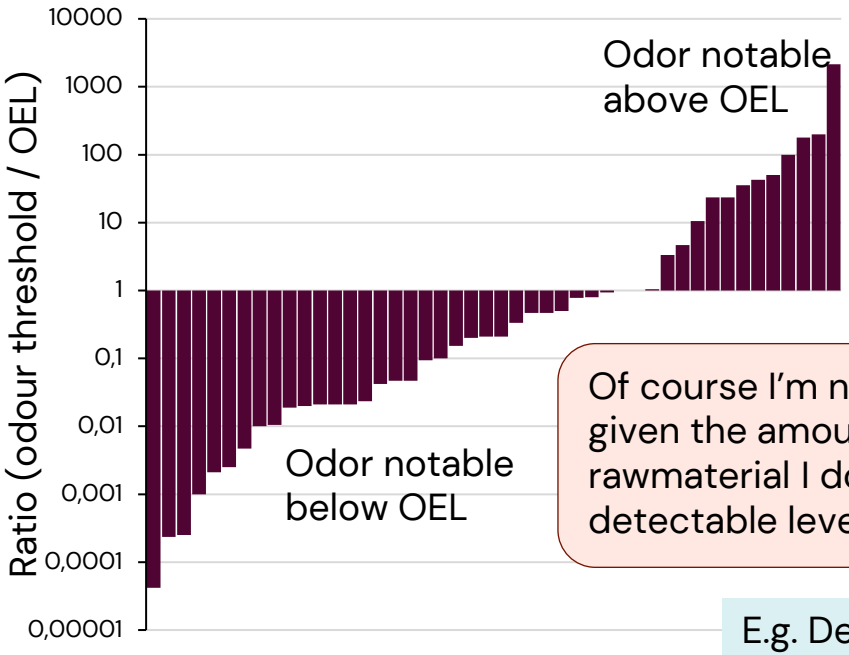
Does occupational forward bending of the back increase long-term sickness absence risk? A 4-year prospective register-based study using device-measured compositional data analysis

by Gupta N, Bjerregaard SS, Yang L, Forsman M, Rasmussen CL, Rasmussen CDN, Clays E, Holtermann A

Forward bending of the back at work is associated with higher sickness absence, but such knowledge is primarily based on self-reported forward bending, which is known to be inaccurate and biased. For the first time, we confirmed such association using device-measured forward bending and provide specific and accurate estimates of such association compared to previous studies using self-reported forward bending.

Why: Hazards not always detectable by our senses



- Nor necessarily something we predict based on products/processes:

We were told that stainless steel is only a source of Cr(VI) if you're welding…

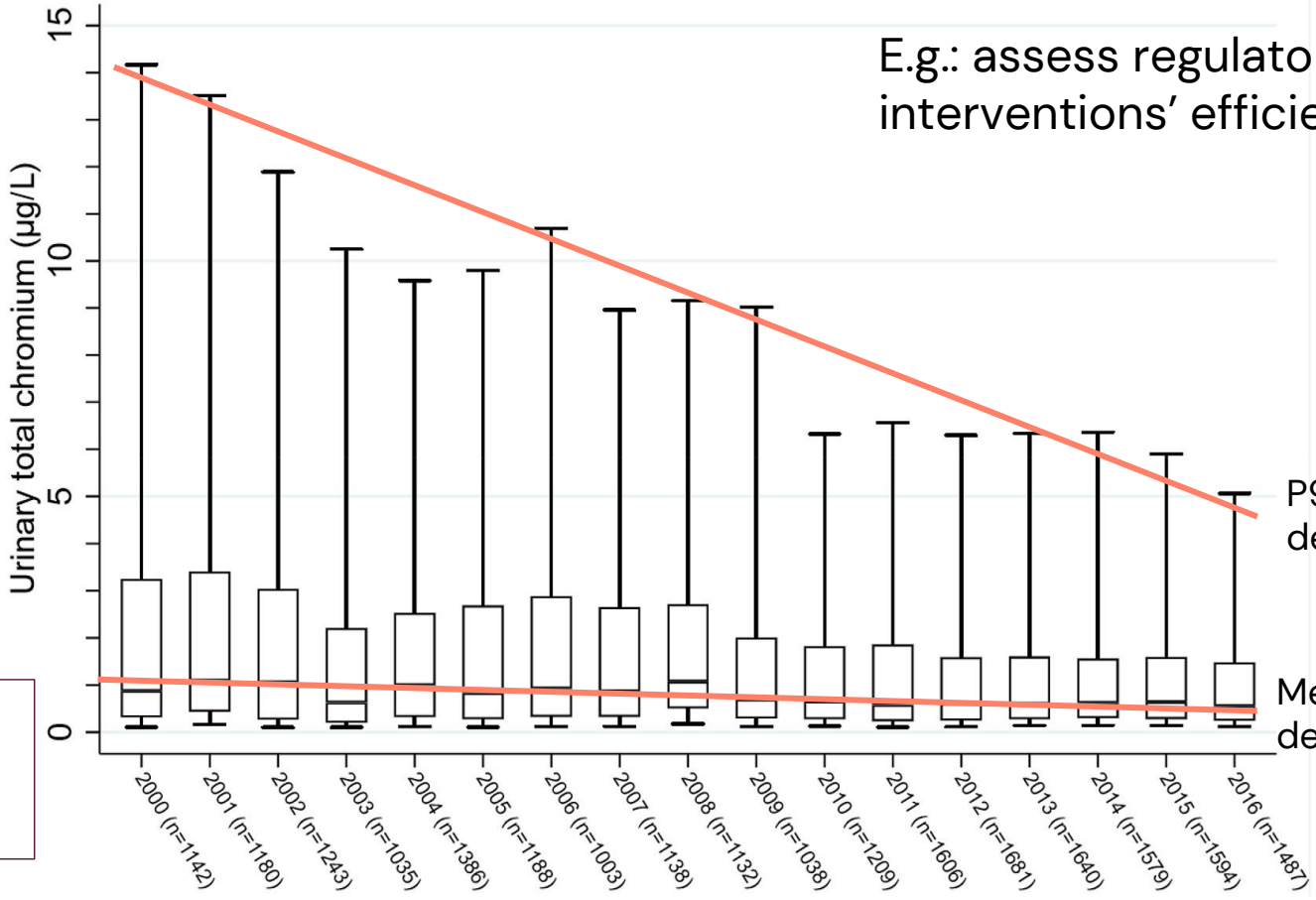
Informant, steel industry (measured Cr(VI): 1-13 µg/m^3)

Of course I'm not certain… but given the amounts of Cr in our rawmaterial I don't think we can get detectable levels of Cr(VI) in the air

Informant, recycling (measured Cr(VI): 70%>LOD, all below 0.5 µg/m^3)

E.g. Denmark intends to lower the Cr(VI) OELto 0.25 µg/m^3

Why: To evaluate developments over time



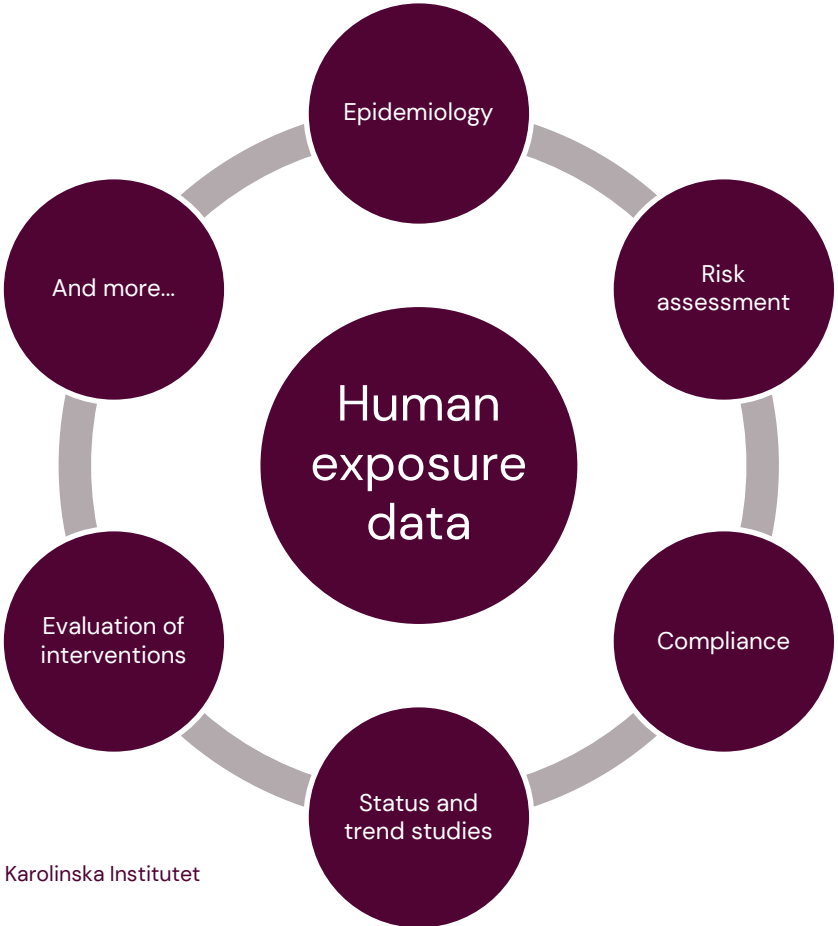
E.g.: assess regulatory or local interventions' efficiency

P95: 64% decrease

Median 40% decrease

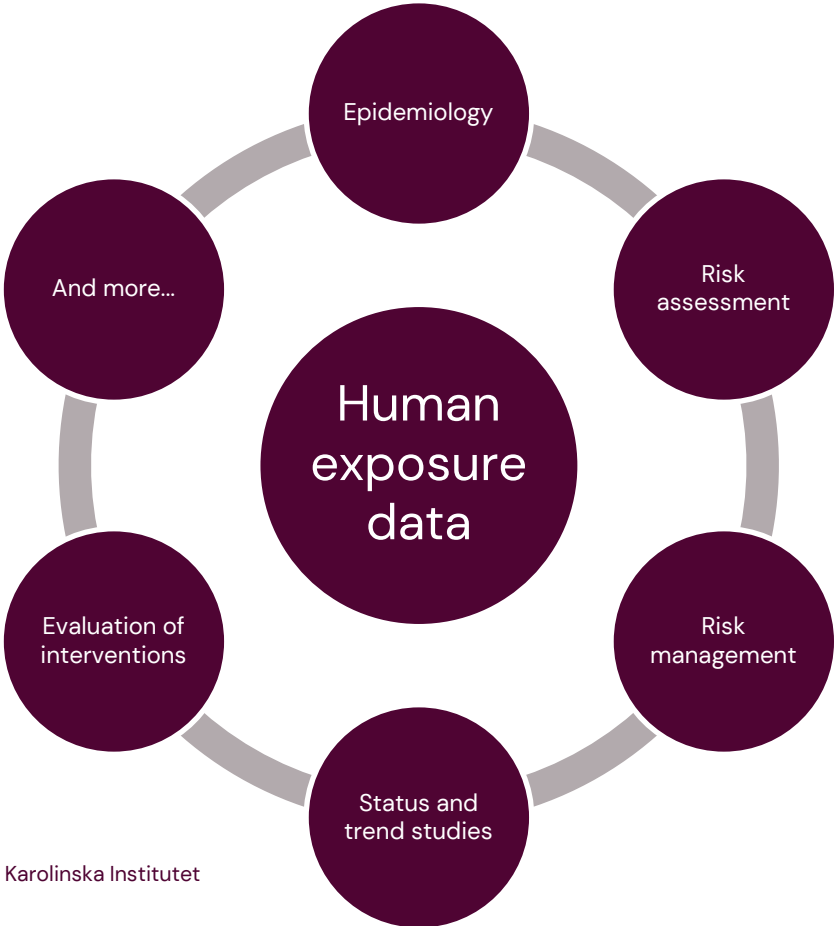
>42000 Finnish workers
Maihout et al., Regul Toxicol Pharmacol 2022

Summary: Applications of exposure assessment



- Identify hazardous exposures and exposure – response data
- Characterise nature and magnitude of health risks
- Controlling compliance with guidelines and regulations (brb!)
- Trend analysis of emerging hazards as they are recognised (and later managed)
- Identify determinants & evaluate interventions' effectiveness

Assessment strategy depends on purpose…

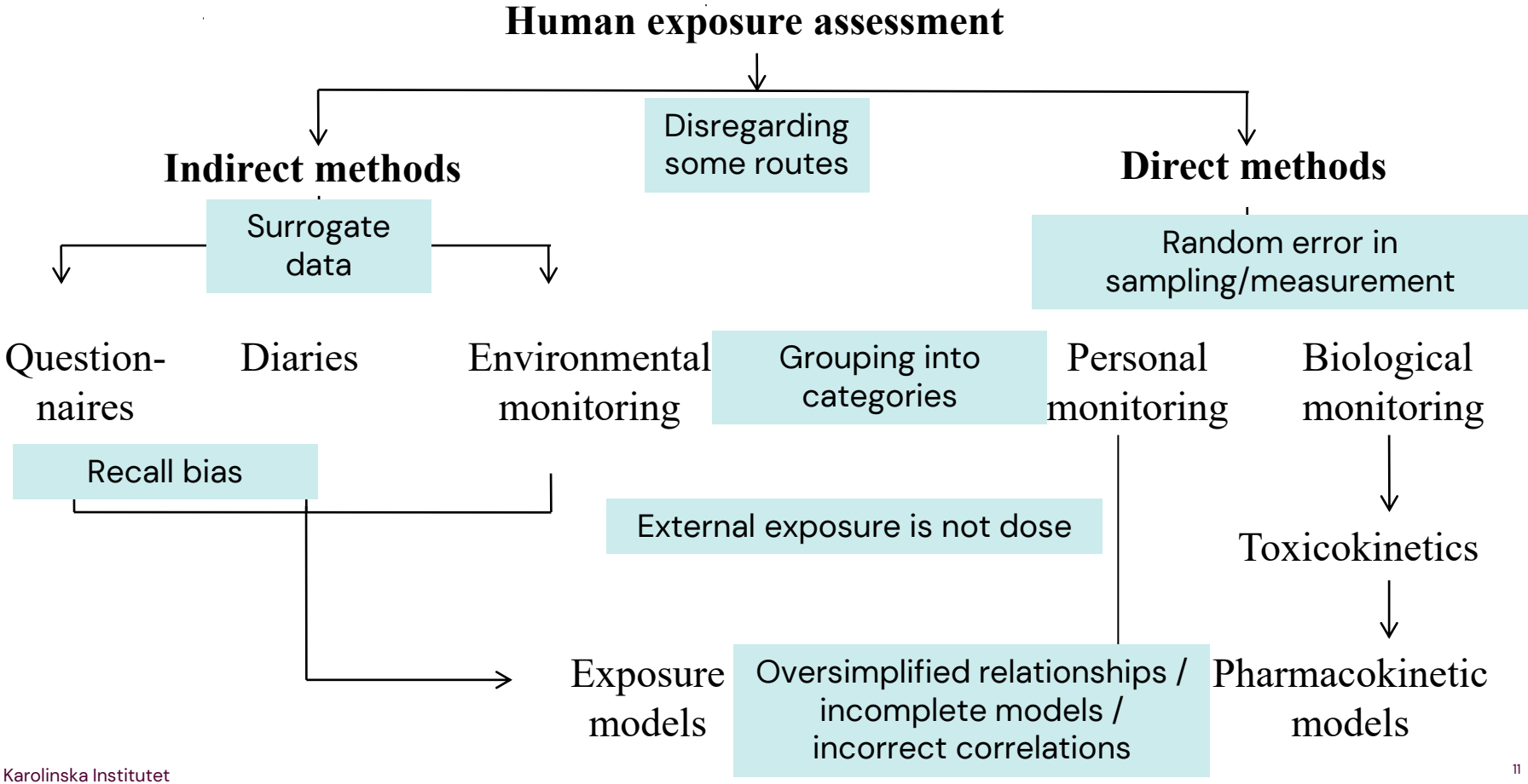


…and feasibility

- → Biological relevance (e.g. peak vs cumulative)
- → Best estimate vs worst case
- → Direct vs indirect methods

Past	Present	Future
Historic monitoring data	Measurements / Monitoring	⇨
Indirect methods (quantitative, semi-, qualitative)		

Some sources of uncertainty…

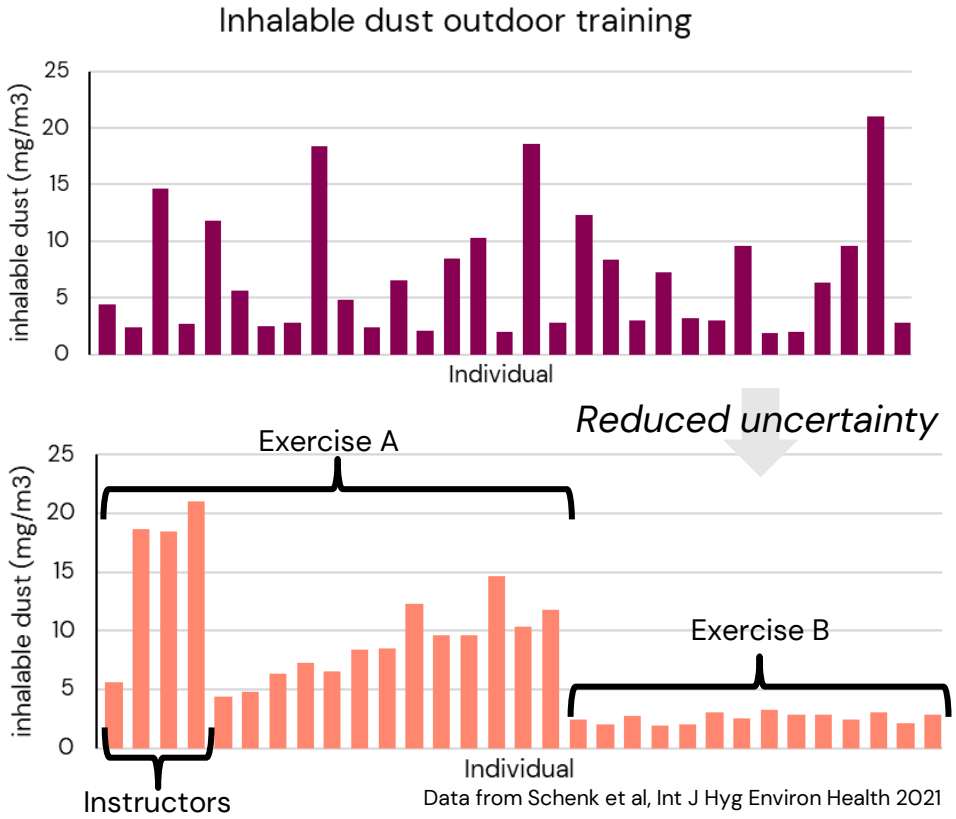


Variability between workers, tasks etc..

Exposures vary (within &) between

- Persons
- Tasks
- Shifts
- Days
- Seasons

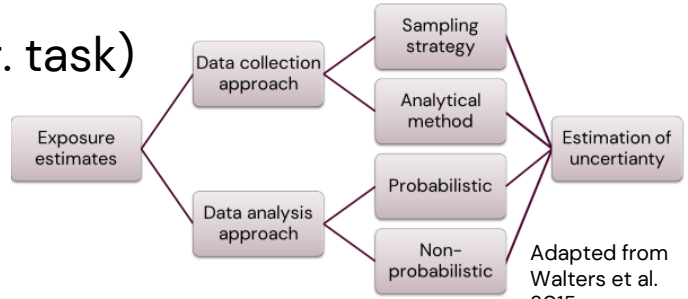
Large in comparison to analytical and sampling errors!



Uncertainty and variability

Uncertainty

- → Lack of knowledge about specific factors (e.g. task)
- → Result of measurement or sampling errors



Adapted from Walters et al. 2015

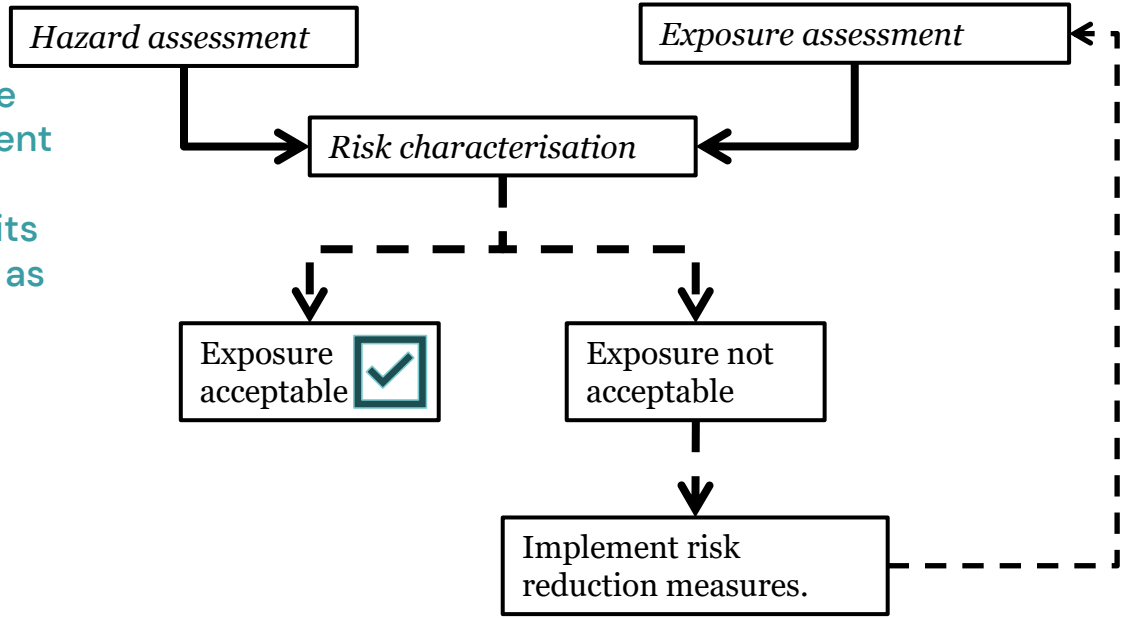
Variability

- → True differences between individual data (cannot be reduced)
- → E.g. standard deviation, variance (between or within)

To improve transparency, understanding and inform about reliability we should as far as possible characterize variability, reduce and describe uncertainty.

Health risk assessment / Compliance OELs

For workplace risk assessment occupational exposure limits may be used as the hazard assessment



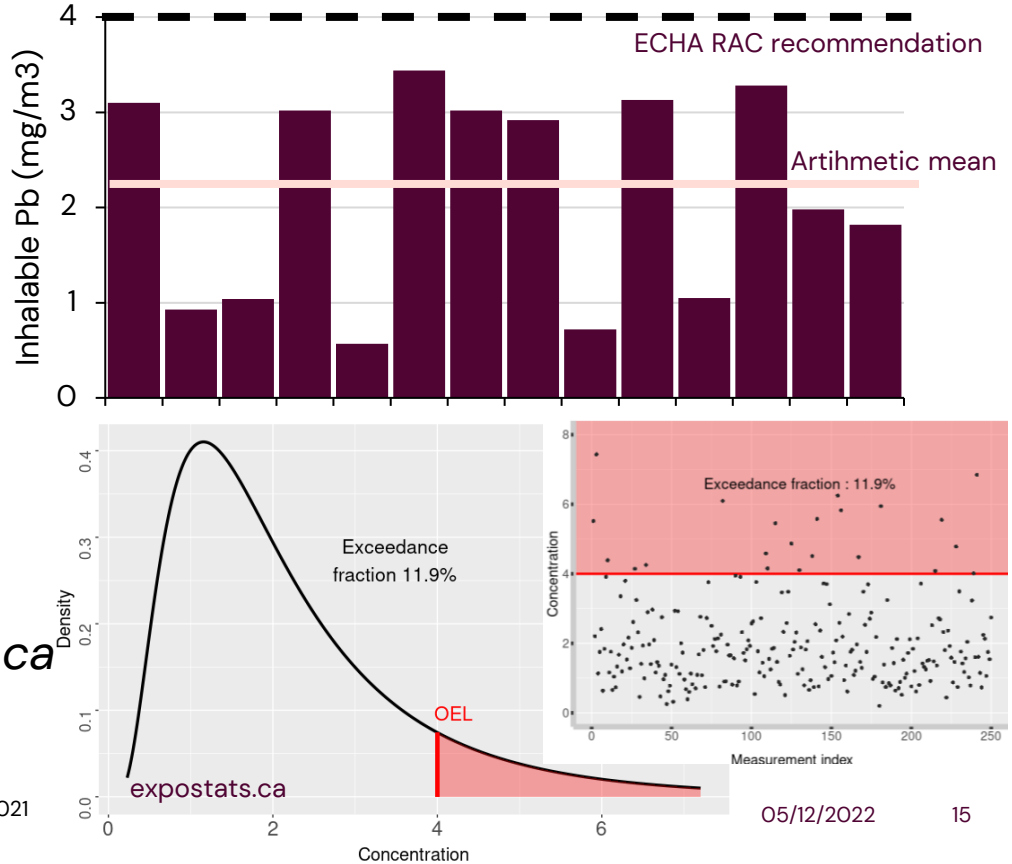
Deterministic
Point estimate compared to point estimate

Probabilisitic
Based on distributional data, takes variation between individuals into account

Compliance with Occupational Exposure Limits

- All under OEL = all good?
  (Central estimates under OEL)
- Not necessarily..

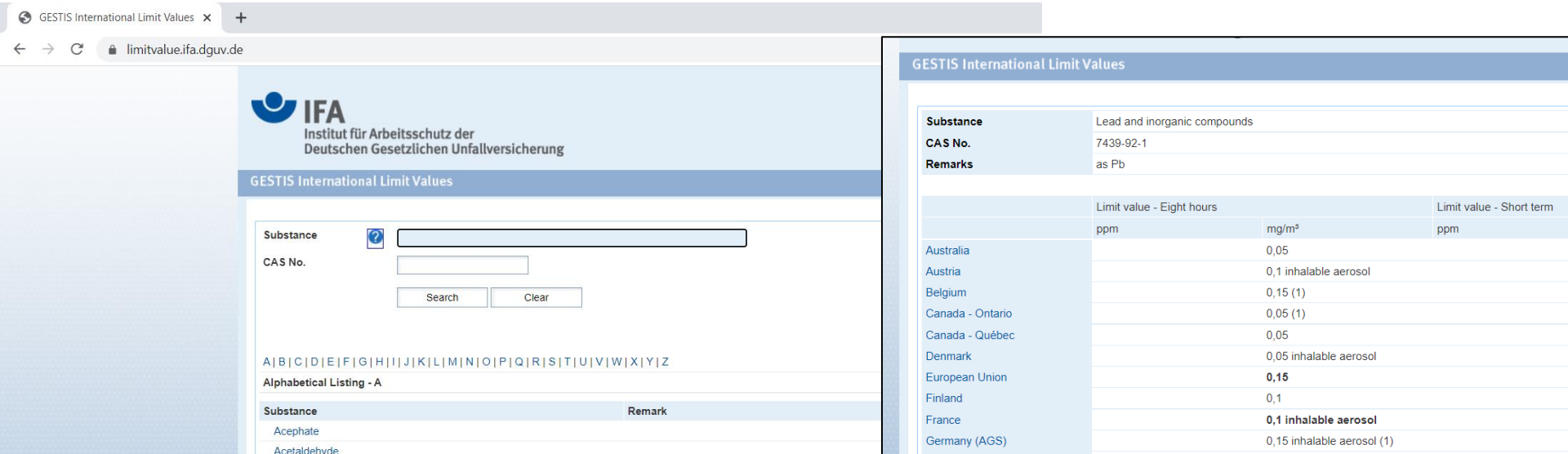
- Free tools for visualising exposure distributions:
  - → AIHA IHSTAT excel *aiha.org*
  - → AltrexChimie software *inrs.fr*
  - → **Expostats** webtool *expostats.ca*



Data from Schenk et al, Int J Hyg Environ Health 2021

Side note: Occupational Exposure Limits

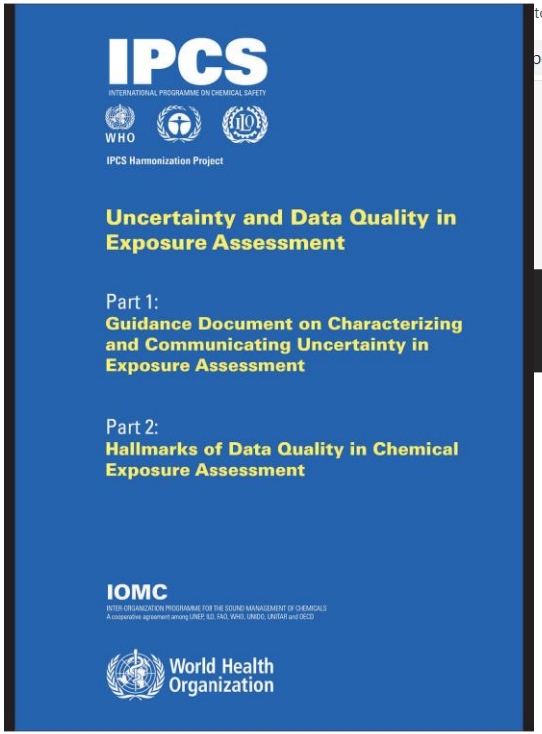
- Many sources of OELs, see e.g. GESTIS ILV database
- Organisations with robust and transparent derivation methods and open documents: MAK commission, ANSES, ECHA RAC, DECOS (Schenk&Johanson, Regul Toxcol Pharmacol, 2021)

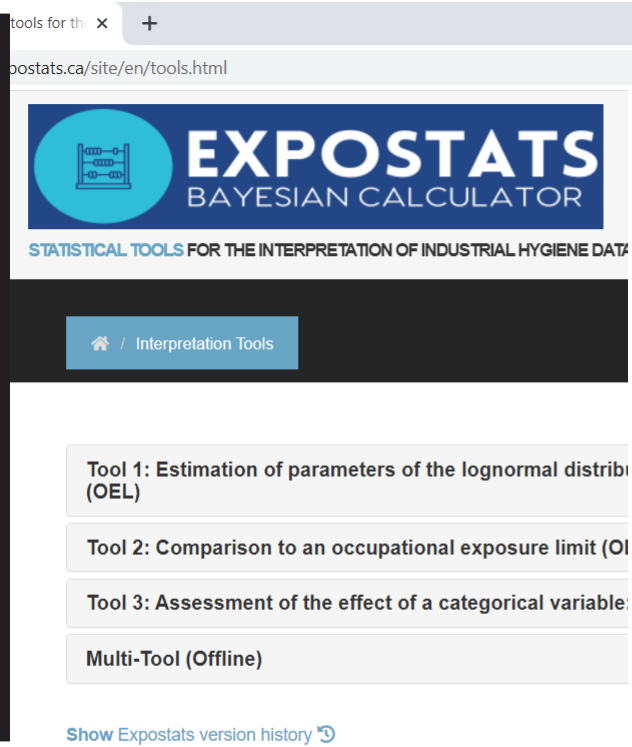


Conclusions

- Exposure assessment is key to identifying, assessing and managing risk
  - → From epidemiology to intervention
- The one certainty: no one has the exact same exposure
- Important to characterise uncertainty and variability in exposure assessments
- Probabilistic methods may offer more realistic basis for assessing risk
  - → Ideally both hazard assessment and exposure assessment
  - → There are tools available for visualising exposure distributions and evaluating likelihood of e.g. OEL compliance

Further reading (examples)





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Exposure Estimation and Interpretation of Occupational Risk: Enhanced Information for the Occupational Risk Manager

Martha Waters,[1] Lauralynn McKernan,[2] Andrew Maier,[3] Michael Jayjock,[4] Val Schaeffer,[5] and Lisa Brosseau[6]

Annals of Work Exposures and Health, 2018, 1–13
doi: 10.1093/annweh/wxy100
Original Article

Original Article

Expostats: A Bayesian Toolkit to Aid the Interpretation of Occupational Exposure Measurements

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Abstract

Introduction: Interpretation of exposure measurements has evolved into a framework based on th
lognormal distribution. Most available practical tools are based on traditional frequentist statistic
procedures that do not satisfactorily account for censored data and are not amenable to simp
probabilistic risk statements. Bayesian methods offer promising solutions to these challenges. Su
methods have been proposed in the literature but are not widely and freely available to practitioner
Methods: A set of computer applications were developed aimed at answering typical inferenti
questions that are important to occupational health practitioners: Is a group of workers compli
with an occupational exposure limit? Are some individuals within this group likely to experien
substantially higher exposure than its average member? How does an intervention influence th
distribution of exposures? These questions were addressed using Bayesian models, simultaneous

Thank you for your attention!

Acknowledgements
Thanks to Dr Anneli Julander for input to this presentation, research participants whose data were used in examples

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