Occupational hygiene data requires thorough consideration!

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Overview

- Background
- Types of occupational hygiene data
- Exposure variability
- Potential biases
- Occupational hygiene data characteristics
- Outliers
- Left censor data
- Examples

Background

- Area
- Personal
- Dermal

} Analyse individually

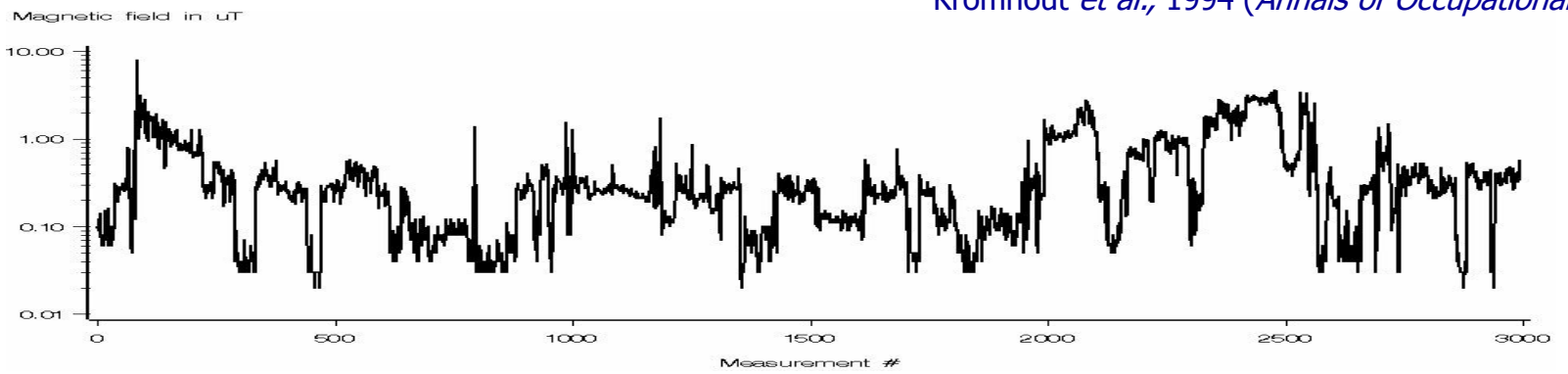
- Biological
  - ➢ Difficult to interpret
    - ✓ Physiological and health status of the individual (lifestyle)
    - ✓ Analytical errors

Types of data

- Type 1
  - All variables are known (exposure and ancillary data)
- Type 2
  - Important variables are known (exposure data, but no ancillary data)
- Type 3
  - No variables are known (summaries and anecdotal data)

Exposure variability

Kromhout *et al.*, 1994 (*Annals of Occupational Hygiene)*



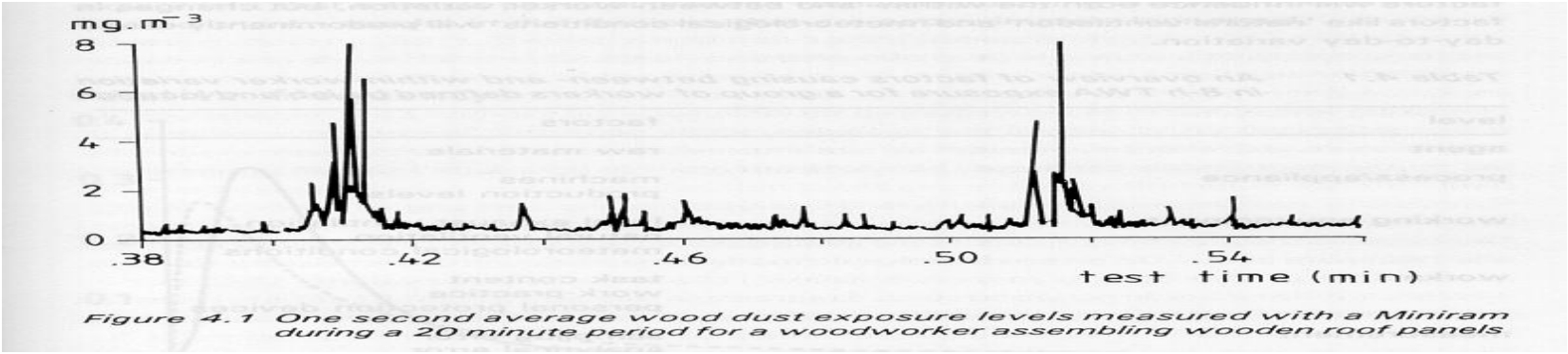


Figure 4.1 One second average wood dust exposure levels measured with a Miniram during a 20 minute period for a woodworker assembling wooden roof panels

Exposure concentrations tend to vary to a large extent and this variation is highly dependent on averaging time

Exposure variability (con't)

- Random sampling
- "Worst case sampling"

} Comply with OELs / TLVs

- Well designed exposure assessments
  - ➢ Measurements over few days
  - ➢ Example: 100 workers over 250 days
  - ➢ Within HEGs or SEGs
    - ✓ Major variability

} Characterise exposures over a year

Exposure variability (con't)

- Primary variability?
  - Variability between groups is fundamental due to epidemiological approach
  - Variability between individuals
    - ✓ Is crucial when studying chronic effects
  - Variability within individuals (temporal)
    - ✓ Is crucial when studying acute effects
  - Variability within days

Exposure variability (con't)

- Primary variability?

  - Seasons
  - Process changes
  - Measurement method and time changes

Exposure variability (con't)

- Secondary variability?
  - Old plant
  - Old controls
  - Maintenance operations

Exposure variability (con't)

- Sources of variation
  - Exposure levels
  - Measurement methods

Random and systematic errors

- Exposure levels → Temporal; Between worker
- Measurement methods → Pump flow changes

Job operations; Process changes

Pump calibration; Laboratory errors

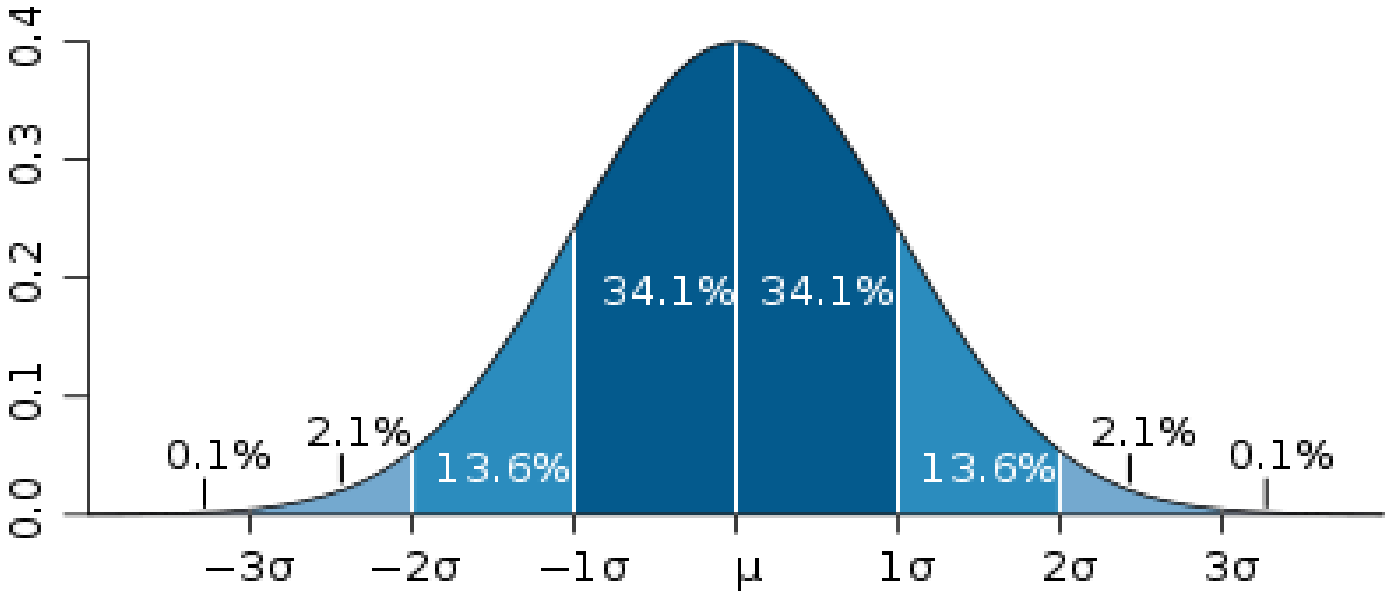
Measurement bias

- Well controlled facilities
- Worker complaints
- Evaluate engineering controls

} NOT representative of "true" exposures

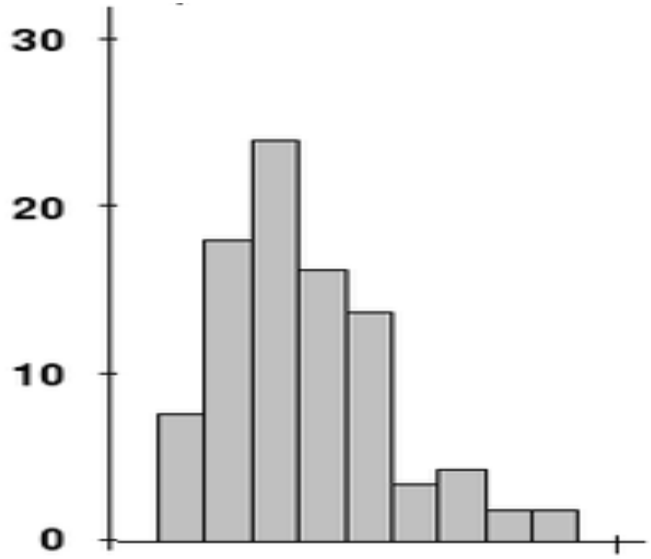
Occupational hygiene data

- Normally distributed data

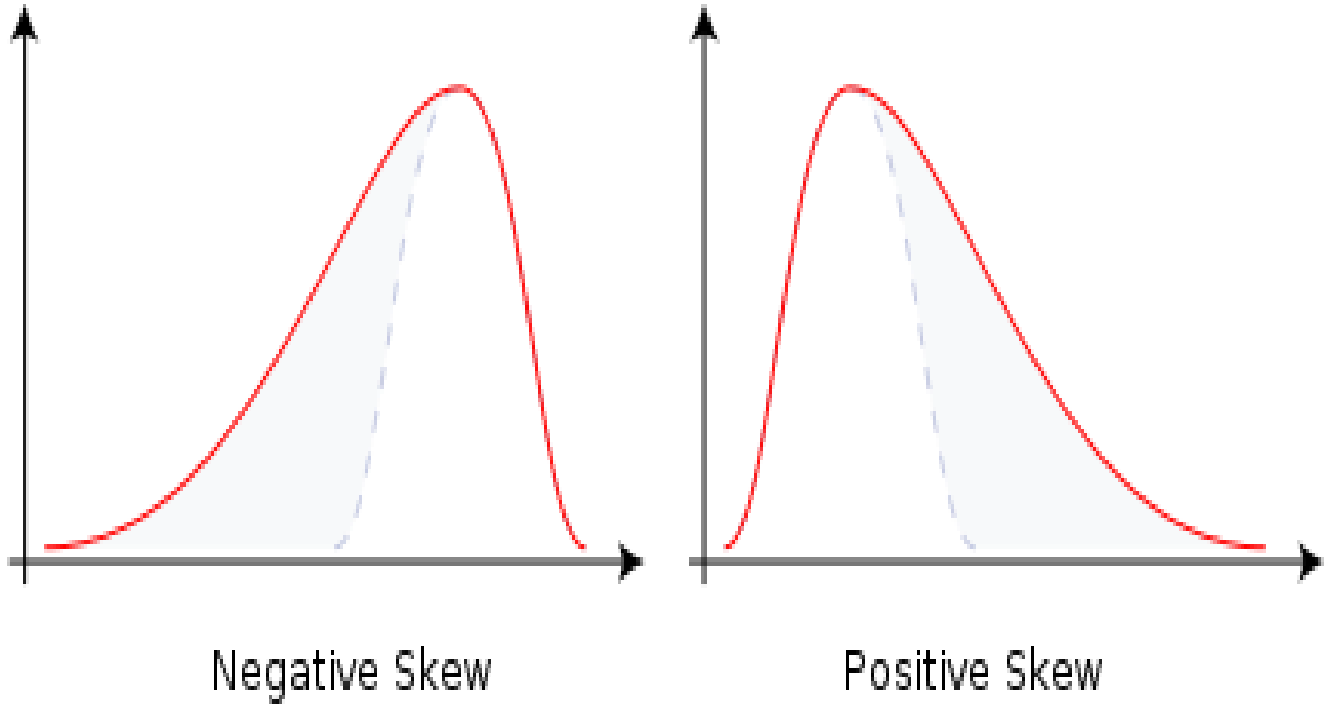


Occupational hygiene data

- Test for normally distributed data

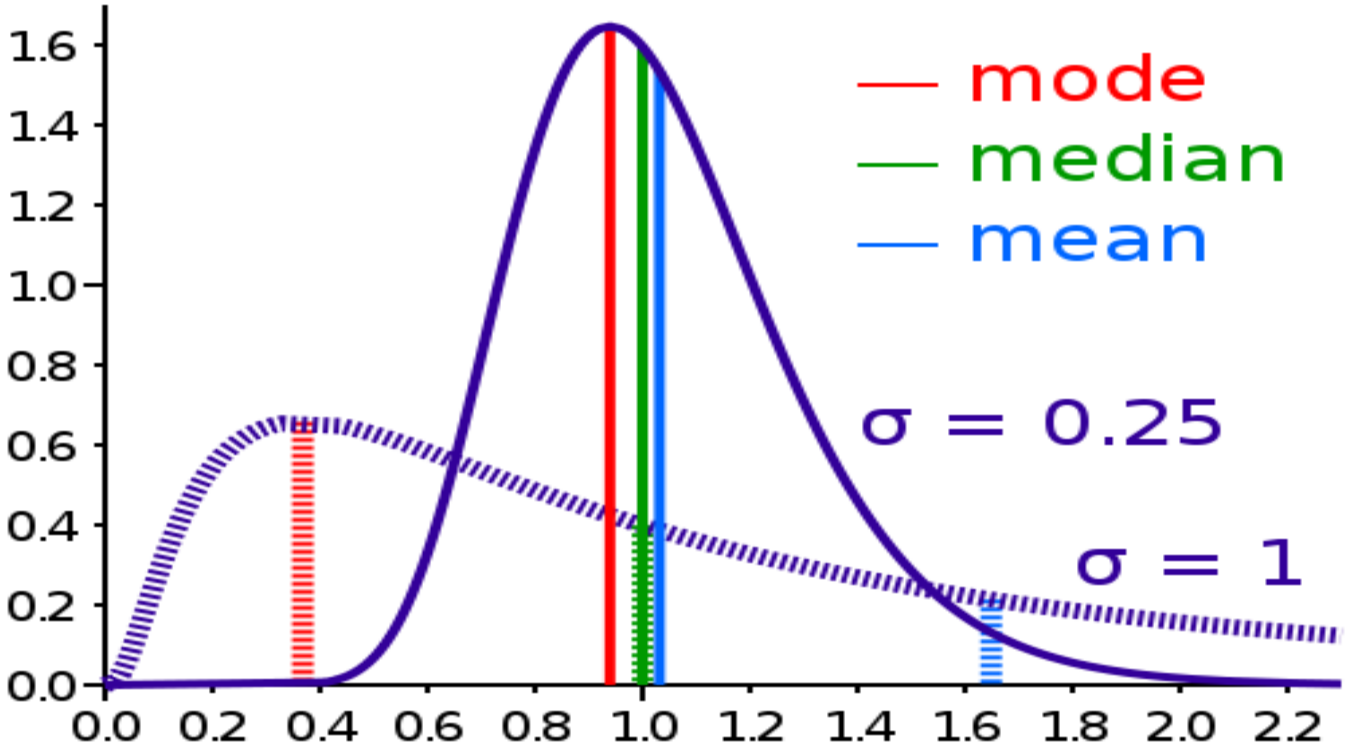


Occupational hygiene data (con't)



Occupational hygiene data (con't)

- Log - normally distributed data



Outliers

- Should NEVER be omitted for analysis

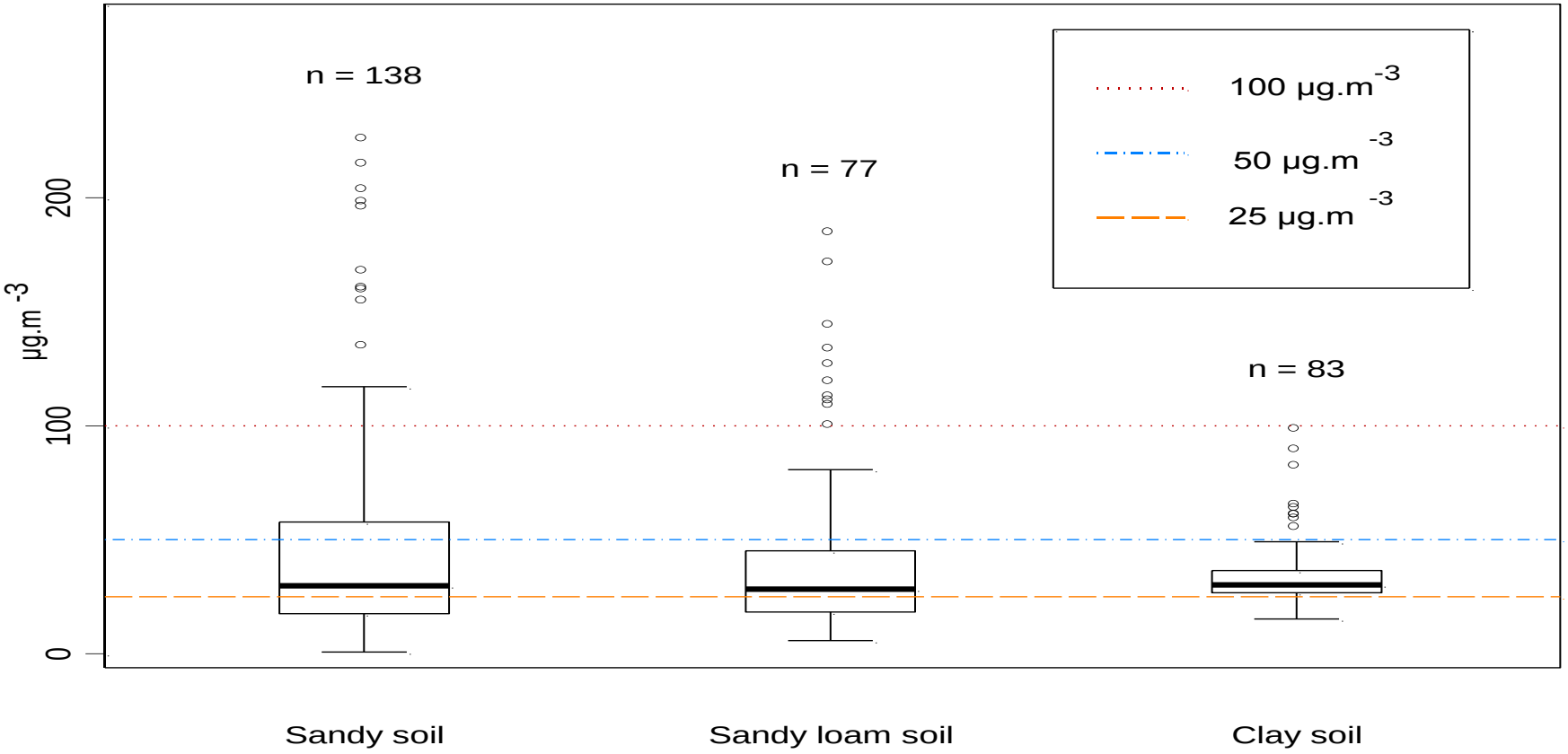
  - Outliers MUST be investigated

    - ✓ Misclassification
    - ✓ Transcription
    - ✓ Calculation error

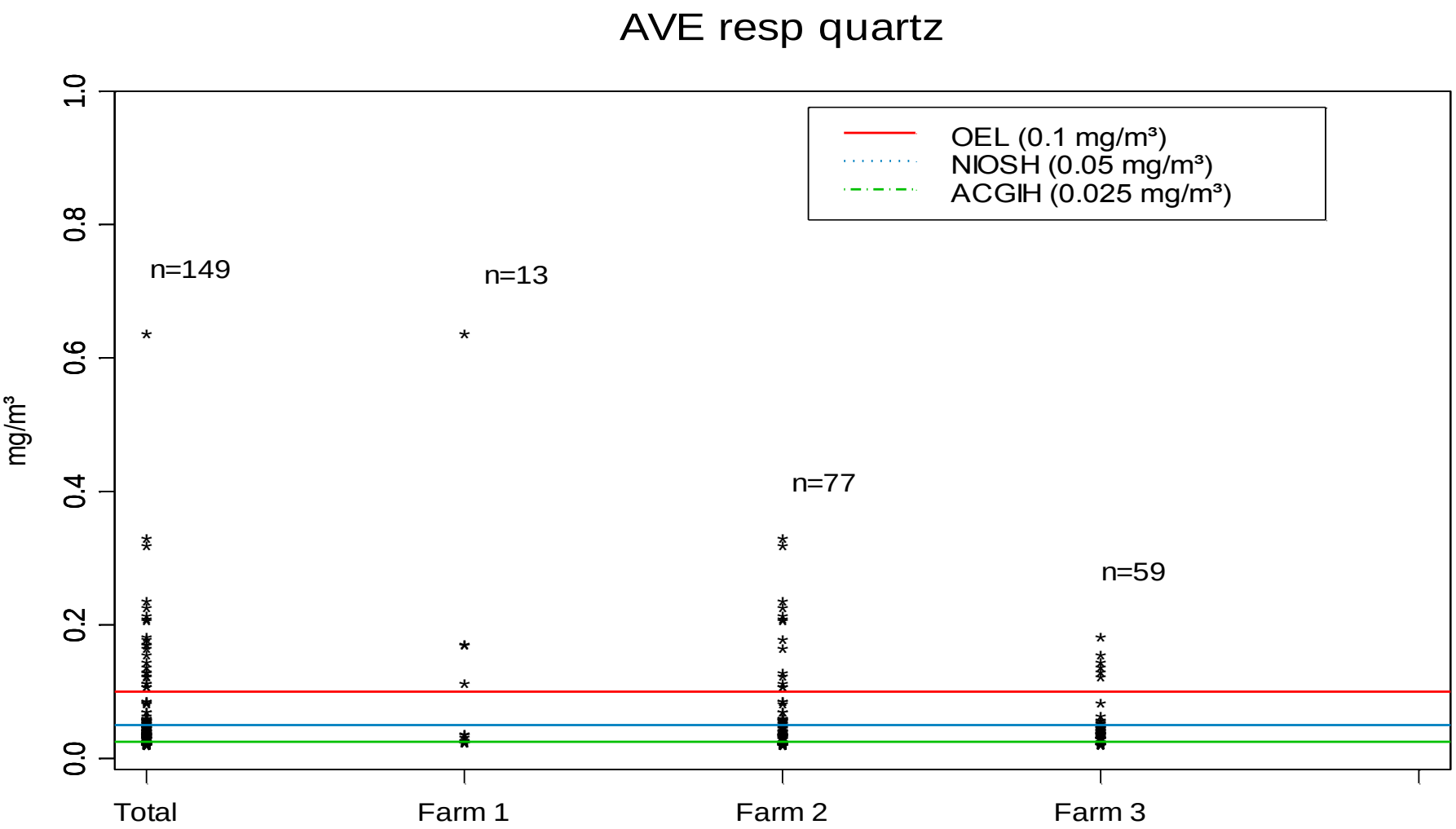
Outliers (con't)

- Box and whisker plots

Swanepoel *et al.*, 2011 *(Annals of Occupational Hygiene)*



Outliers (con't)



Left censored data (< LOD)

- LOD is defined
  - measurement has a 95% probability of being different than zero (Taylor, 1987) and corresponds to the mean blank response (i.e., the mean response produced by blank samples) plus three standard deviations of the blank response.

- Values near the LOD
  - less accurate and precise (i.e., less reliable) than values that are much larger than the LOD (though many researchers might prefer highly unreliable over nothing).

Left censored data (< LOD) (con't)

- What do we do with < LOD data?
  - Ignore it?
    - ✓ severe bias when estimating the mean and variance of the distribution (Lyles *et al.*, 2001), which may consequently distort regression coefficients and their standard errors and reduce power in hypothesis test.

Left censored data (< LOD) (con't)

- In occupational health settings the problem of estimating the parameters of distributions with non-detects (also known as left censored data) have been extensively studied and recently reviewed (Helsel, 2010).

Cohen, 1959;
Gleit, 1985;
Helsel and Gilliom, 1986;
Helsel, 1990;
Özkaynak *et al.,* 1991;
Krishnamoorthy *et al.,* 2009;
Succop *et al.,* 2004;
Hewett and Ganser, 2007
Finkelstein, 2008;
Lambert *et al.,* 1991
Finkelstein and Verma, 2001
Flynn, 2010

Left censored data (< LOD) (con't)

- Main approaches to handling left censored data are:
  - Simple replacement (substitution);
  - Extrapolation;
  - Maximum likelihood estimation (MLE).

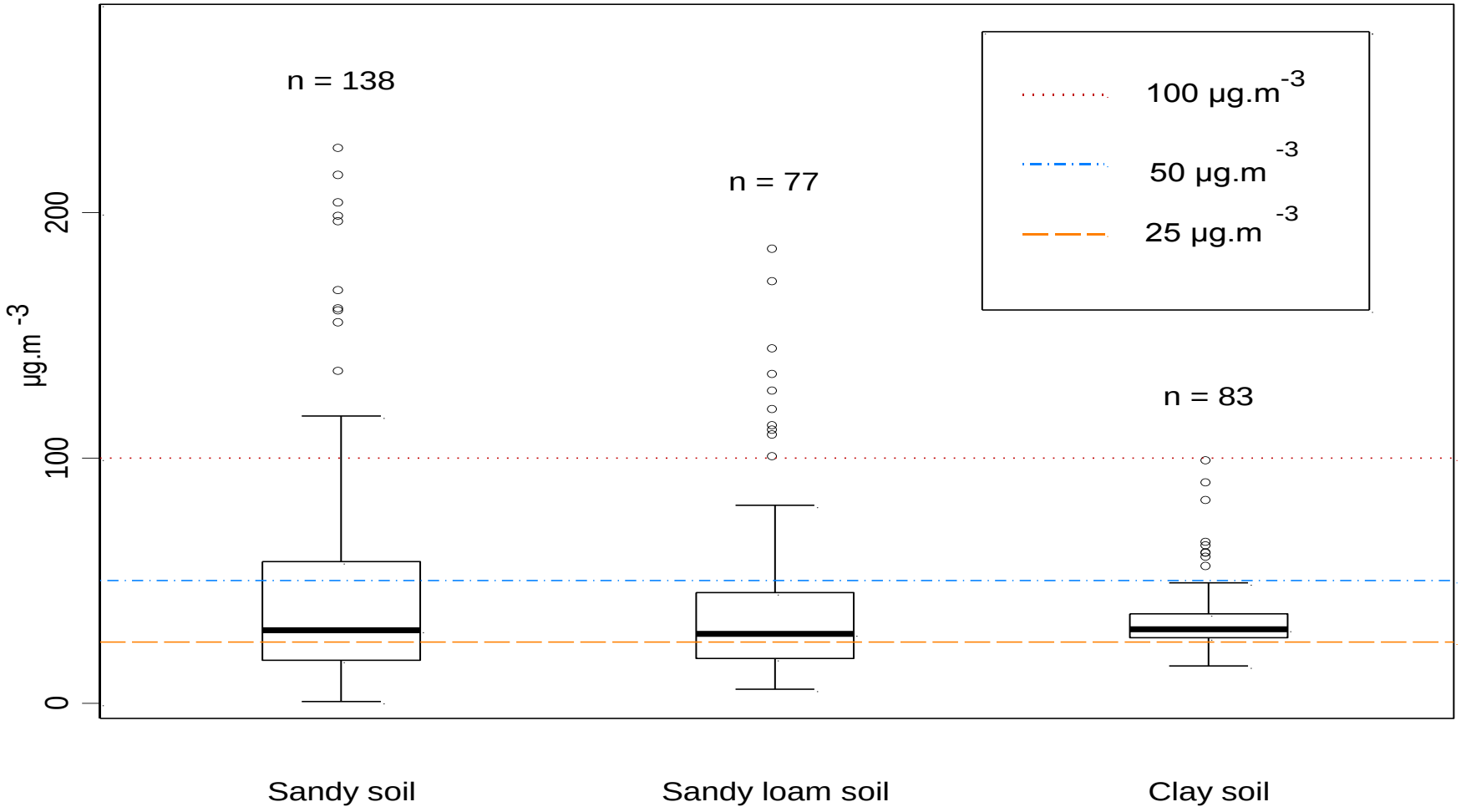
Left censored data (< LOD) (con't)

- Main approaches to handling left censored data are:
  - simple replacement (substitution);
    - ✓ estimate, or rather a guess, for what it might be
      - ✓ "0" or the LOD … "but this leads to particularly erroneous results, and it is hard to see that these approaches can be defended (Ogden, 2010)."
      - ✓ LOD/2 or LOD/√2

        (Helsel, 1990; Hornung and Reed, 1990; Helsel, 2010; Ogden, 2010)
- This approach is INCORRECT - 'reject papers that use it' (Helsel, 2010).

Left censored data (< LOD) (con't)

- Multiple imputation (Lubin *et al.*, 2004)



Examples

Table 1. Respirable quartz concentrations (µg.m^{-3}) in a three quarries of South African

Farm	n	%<LOD	AM	GM	GSD	Min-Max	%≥100 *	%≥50 †	%≥25 ‡	%quartz Median
Quarry 1	138	35	53.2	31.7	2.7	<LOD - 626	12	30	57	14.3
Quarry 2	77	27	46.85	31.6	2.3	<LOD - 413	13	22	59	14.0
Quarry 3	83	64	33.8	31.1	1.4	<LOD - 98	0	9	81	13.7
Total	**298**	**41**	**46.0**	**31.5**	**2.3**	**<LOD - 626**	**9**	**22**	**64**	**14.0**

%<LOD, % of measurements under the analytical limit of detection; AM, arithmetic mean; GM, geometric mean; GSD, geometric standard deviation.

*% Measurements greater or equal to the South African Occupational Exposure Limit (OEL) of 100 µg.m^{-3} for respirable quartz.

† Measurements greater or equal to the NIOSH Recommended Exposure Limit (REL) of 50 µg.m^{-3} for respirable quartz.

‡% Measurements greater or equal to the ACGIH Threshold Limit Value (TLV) of 25 µg.m^{-3} for respirable quartz.

Examples (con't)

- IH Stat programme (AIHA)
- STATA
- Epi INFO
- SAS
- S-PLUS
- R

Conclusion

- Occupational hygiene professional
  - NEVER ignore statistics in exposure assessments
    - Occupational hygiene data is special!
    - Consult a statistician
  - Be careful when treating “outlier” and “<LOD” data
  - Potency modifiers
    - ✓ Silica (HSE)
  - Cumulative exposures over a year?
    - ✓ even at low exposures?

Thank you !!!

BLUE
BULLS