



HEALTHIER WORKPLACES | A HEALTHIER WORLD

**AIHA VIDEO SERIES:
MAKING ACCURATE EXPOSURE RISK
DECISIONS**

**Video 3C:
Introduction to IHSTAT_Bayes™**



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[next]

OUTLINE

- Prerequisites
- What is IHSTAT_Bayes
- Setup
- What will IHSTAT_Bayes tell you
- IHSTAT_Bayes under the hood : The Webexpo open source library
- IHSTAT_Bayes outputs
- Examples

Basic understanding

- about assessment and management of occupational exposures
- of probability and statistical inference, including notions of *Bayesian statistics*.
- of industrial hygiene statistics, including the lognormal distribution and associated ...
 - geometric mean
 - geometric standard deviation
 - 95th percentile
 - exceedance fraction

What is IHSTAT_Bayes

AIHA Risk Assessment Tools

The following software tools provide the practicing industrial hygienist with quick and easy access to the information necessary to evaluate exposure profiles and determine if the exposures are acceptable, not acceptable or if more data is needed to make the determination of acceptability.

IHSTAT_Bayes (latest version: 1.00, June 2022) is an Excel-based application that calculates various exposure statistics using a Bayesian model. It is intended as an enhanced version of IHSTAT including, thanks to the Bayesian engine, optimal treatment of non-detects and the probabilities associated with each AIHA exposure control categories. Multiple languages are available. The book "A Strategy for Assessing and Managing Occupational Exposures" is intended to accompany this tool. It provides critical detail on the use and interpretation of the various statistical outputs.

IHSTAT-Bayes

is in essence the **IHSTAT user interface** on top of the **Expostats bayesian model**.

Running example Styrene in the fiberglass industry

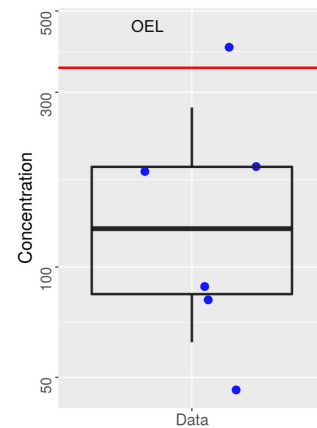
Dataset of real styrene measurement in the fiberglass manufacturing industry (1980s) reported in:

Rappaport and Kupper, Quantitative Exposure Assessment (2008).

Each value simulates making one “representative” full shift measurement among workers performing the same job

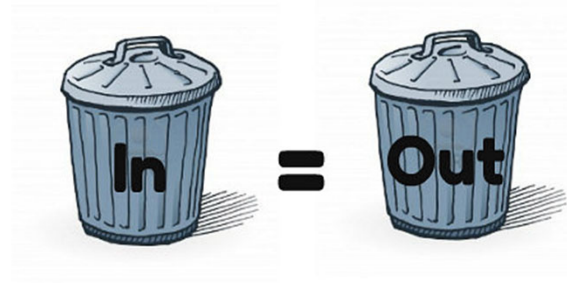
For illustration we will use an 8-h OEL of 350 mg/m³

Our sample : 190 , 47 , 181 , 89.5 , 391 , 82.7 mg/m³



Theoretical setup for interpreting data with IHSTAT_Bayes

- A target population has been defined
- Exposure levels for this population are expected to be reasonably lognormal
- Measurements are available, adequately reflecting variations in the target population



Practical setup for interpreting data with IHSTAT_Bayes

Last update : July 19th 2022

IHSTAT_Bayes README page



This webpage is the portal for instructions regarding the installation and use of IHSTAT_Bayes. The information below will allow you to download and install the software. All comments / suggestions are welcome and should be made on the relevant expostats subforum (linked on this box)

AIHA website description

IHSTAT_Bayes is an Excel-based application that calculates various exposure statistics from exposure measurements using a Bayesian model.
It is intended as an enhanced version of IHSTAT including, thanks to the Bayesian engine, optimal treatment of non-detects and the probabilities associated with each AIHA exposure control categories.
Multiple languages are available

Download link :

Note : Download the 2 files, put them in any folder and double click on setup to launch the installer.

References

Scientific article describing the Expostats Bayesian model

Scientific report describing the open source WEBEXPO library used to implement the Expostats model in C#

Data entry setup for interpreting data with IHSTAT_Bayes

At least 3 detects recommended

Measurement results

Censored data (entered in the same unit):
left censored (enter as $<x$)
right censored (enter as $>x$)
interval censored (enter as $[x_{\text{lower}}-x_{\text{upper}}]$)

This is a recommendation;
actual calculation is even
possible with a single non
detect.

Exposure limit Same unit as measurement data

Decision statistics Your choice of lognormal percentile (default 95th)

What will IHSTAT_Bayes tell you ?

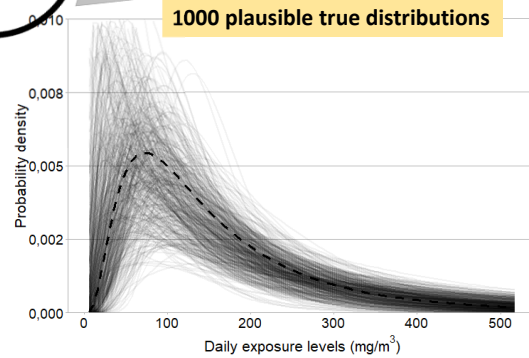
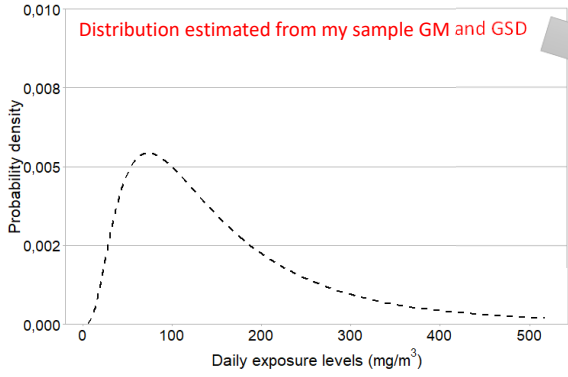
About your sample

- Sample size (check that input went fine)
- QQplot (check that lognormality assumption seems reasonable)

About the exposure distribution underlying your sample (i.e. what happens when you are not there)

- Point estimates and 95% upper credible limits for GM and GSD
- Point estimates and 70% and 95% upper credible limits for 3
- lognormal decision statistics (any percentile, exceedance fraction, arithmetic mean)
- Probability of each AIHA exposure control category
- Estimated exposure distribution probability density curve

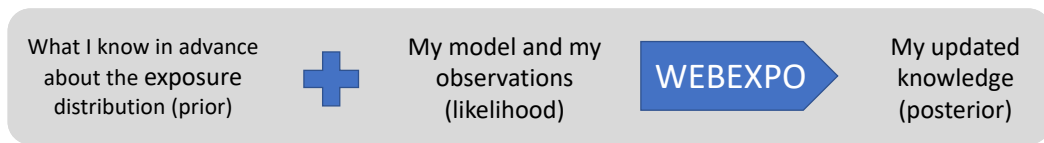
IHSTAT_Bayes: looking under the hood



The bayesian engine in IHSTAT_Bayes provides a way to generate a picture of the possibilities for the population (the true exposure distribution) from our small sample of measurements (here 1000 possibilities are illustrated)

IHSTAT_Bayes: looking under the hood

Calculations in IHSTAT_Bayes rely on a Bayesian model run with a custom engine from the WEBEXPO **open source** library



Lavoué, J., Joseph, L., Kirkham, T., Labrèche, F., Mater, G., Clerc, F. (2020)
Towards a better interpretation of measurements of occupational exposure to chemicals in the workplace.
Institut de recherche Robert-Sauvé en santé et en sécurité du travail, Montréal, QC.

<https://www.irsst.qc.ca/en/publications-tools/publication/i/101066/n/webexpo>

IHSTAT_Bayes and the Webexpo project



Funded 2015-2019

<https://github.com/webexpo>

A

Create a list of calculations deemed important for risk assessment

- Literature review
- International expert committee

B

Implement calculations using Bayesian statistics

- Non detects
- probabilistic results
- Measurement error
- Various informed priors

C

Program the Bayesian models

- R / Javascript / Csharp
- Prototypes for Web / Csharp / (new in 2021) EXCEL

An engine



Webexpo is the engine



For anyone to create their own vehicle



IHSTAT_Bayes and the Webexpo project

Webexpo

- Normal distribution
- Various priors
 - Bounded Uniform
 - Exposure control category probabilities
 - Historical relevant data
 - Output from a statistical prediction model for GM.
- Measurement error

IHSTAT_Bayes

- Lognormal distribution
- Fixed, weakly informative prior (Expostats prior)

Webexpo is the engine



Publications and Tools > IRSSST's Production > WebExpo – Towards a Better Interpretation of Measurements of Occupational Exposure to Chemicals in the Workplace

WebExpo – Towards a Better Interpretation of Measurements of Occupational Exposure to Chemicals in the Workplace

Download: [French \(en /fran\)](#) [English \(en /fran\)](#)

Summary

A significant part of industrial hygiene activities is the measurement of workers' occupational exposure levels. Considerable spatial and temporal variability is usually observed in most exposure assessment surveys, frequently with up to 10-fold variations in exposure intensity, despite apparently similar conditions. This has historically represented an important challenge to the interpretation of measured levels with regard to comparison with occupational exposure limits (OEL). There now exists a consensus framework, progressively developed during the last two decades, for the analysis of exposure levels related to exposure limits. Within this framework, exposure levels are assumed to follow, at least approximately, a lognormal distribution. Several parameters from the underlying distribution, deemed associated with health risk, are estimated from a number of measurements and are interpreted relative to the OEL.

These developments, although permitting a better assessment of risk compared to historical approaches, have not been widely adopted by industrial hygiene practitioners, and involve notions of statistics not usually taught in traditional education programs. Moreover they require calculations not usually feasible with common tools such as calculators or spreadsheet programs. While some specific tools have been developed over the years, usually through volunteer initiatives, most are lacking in some areas, be it accessibility, functionality, user-friendliness or complexity. In addition, uncertainty in parameter estimates has mostly been taken into account through formal hypothesis tests or the calculation of confidence intervals, the results of which are not easily conveyed to decision makers, hampering the ability of practitioners to efficiently communicate risk. Finally, available tools are stand-alone, and are not easily integrated within an existing data management structure.

- From the same project
- + Scientific Publications
- + Related Publications

Additional Information

Collection: Scientific and Expert Reports

Category: Research Report

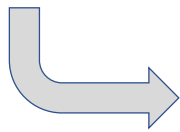
Author(s)

- Jérôme Lavoué
- Lawrence Joseph
- Tracy L. Kirkham
- France Labrèche
- Gautier Mater

IHSTAT_Bayes : underlying bayesian model

The statistical model is the lognormal distribution

The parameters that we are trying to estimate
exceedance fraction, 95th percentile, arithmetic mean

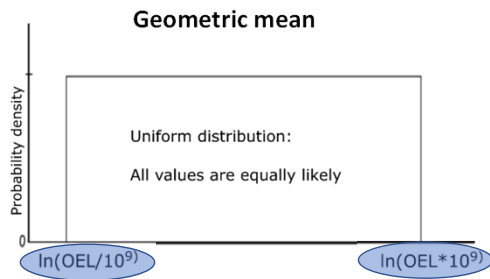


all depend on the GM and the GSD

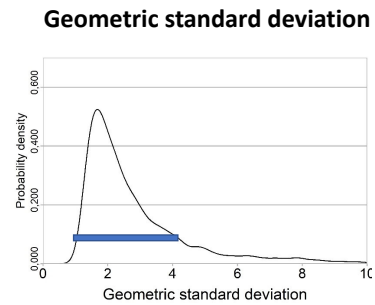
We need to provide prior information on these parameters.

IHSTAT_Bayes : underlying bayesian model

Prior distributions in IHSTAT_Bayes (same as EXPOSTATS)

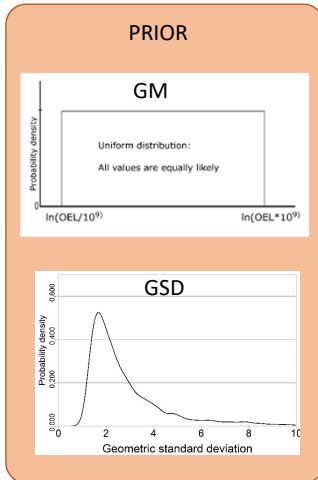


Uninformative prior on GM, defined as uniform on $\ln(\text{GM})$ within a very wide range of potential values relative to the OEL

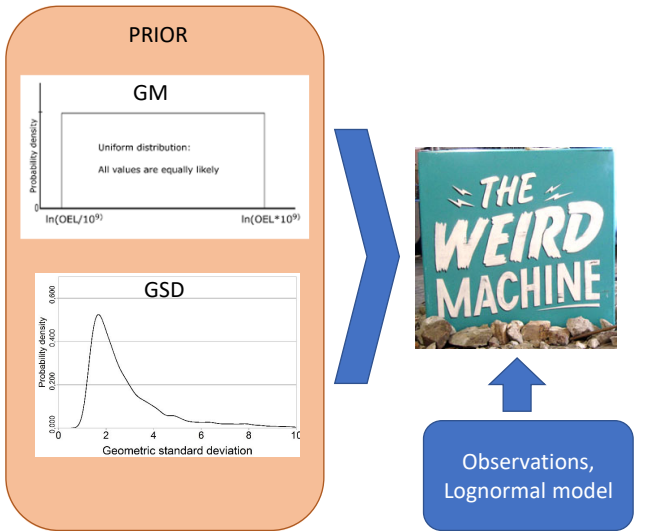


Slightly informative prior on GSD, defined based on the database of GSD values reported for hundreds of SEGs by *Rappaport, Kromhout and Symansky* in the mid 90s.

IHSTAT_Bayes : underlying bayesian model

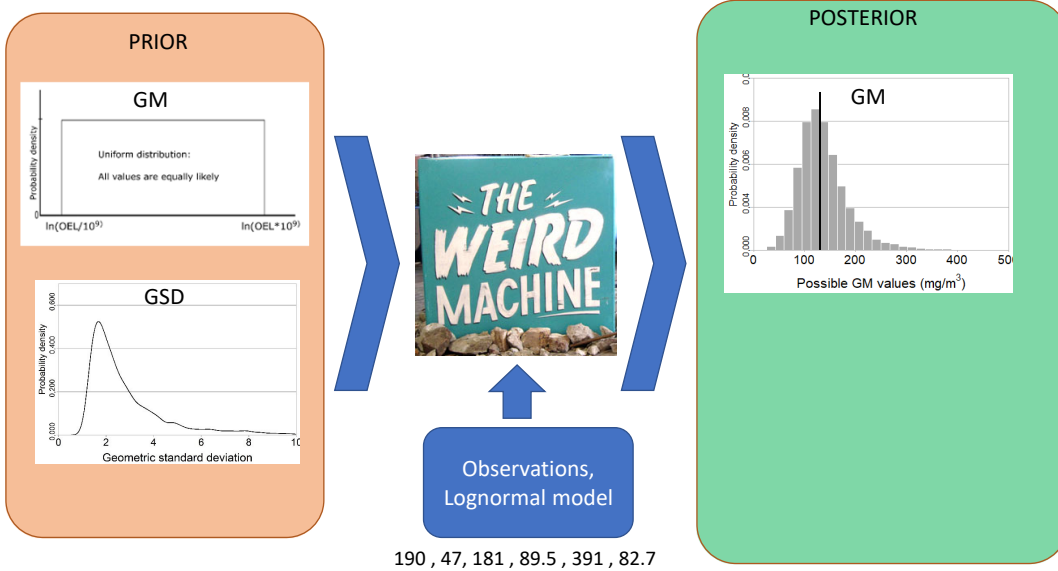


IHSTAT_Bayes : underlying bayesian model

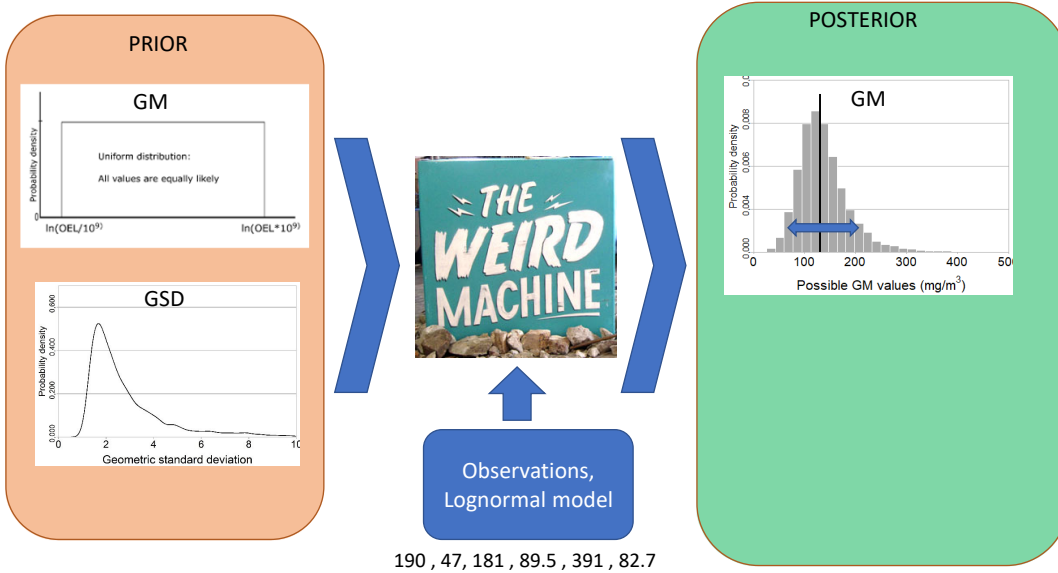


190 , 47 , 181 , 89.5 , 391 , 82.7

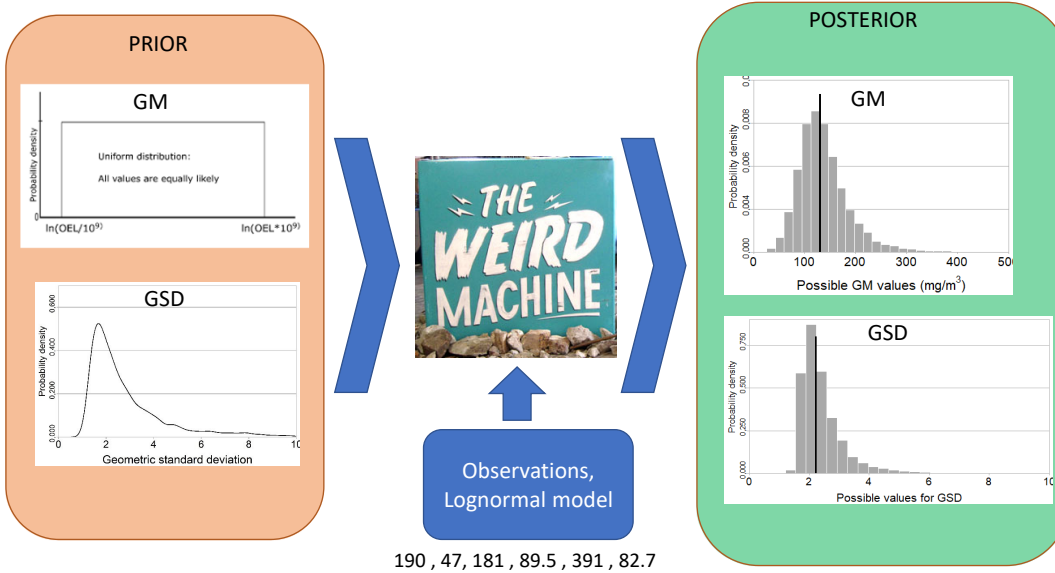
IHSTAT_Bayes : underlying bayesian model



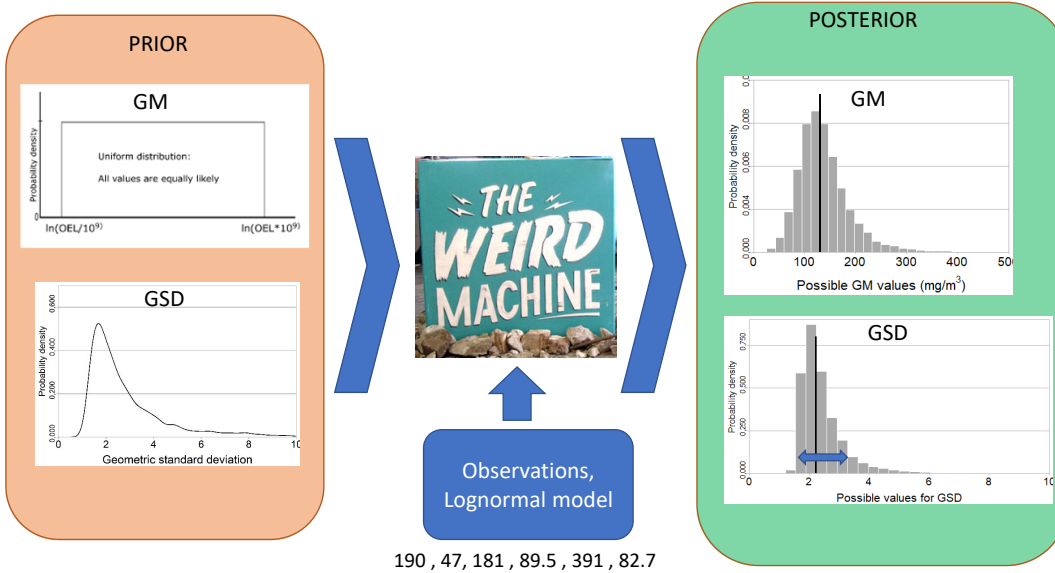
IHSTAT_Bayes : underlying bayesian model



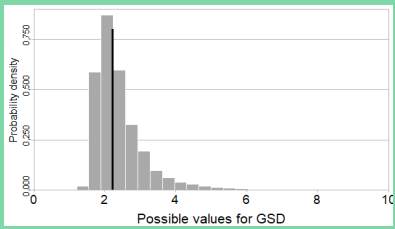
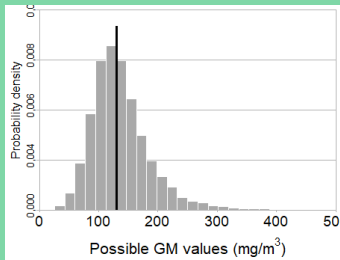
IHSTAT_Bayes : underlying bayesian model



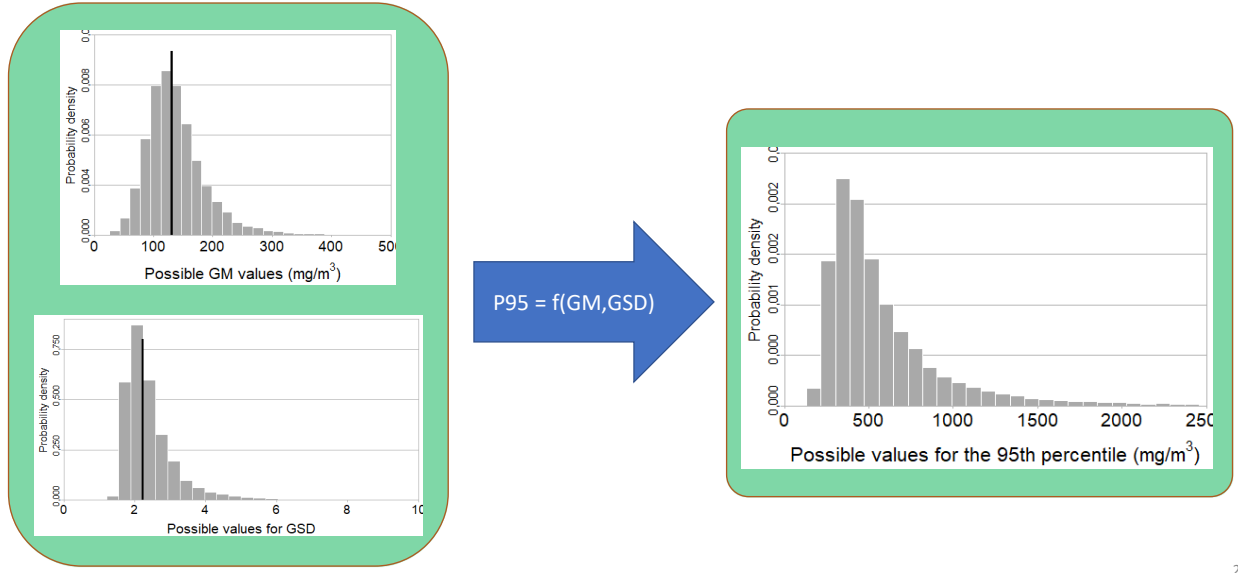
IHSTAT_Bayes : underlying bayesian model



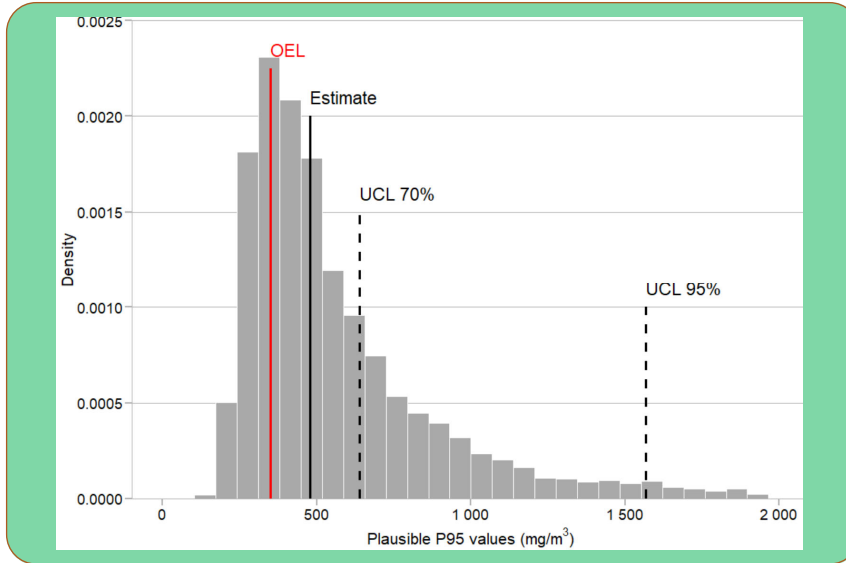
IHSTAT_Bayes : underlying bayesian model



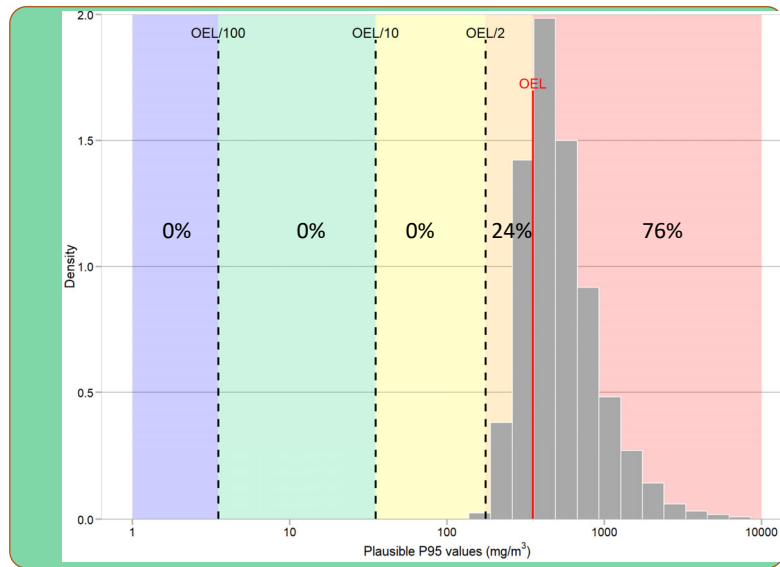
IHSTAT_Bayes : underlying bayesian model



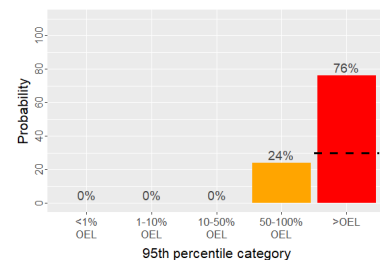
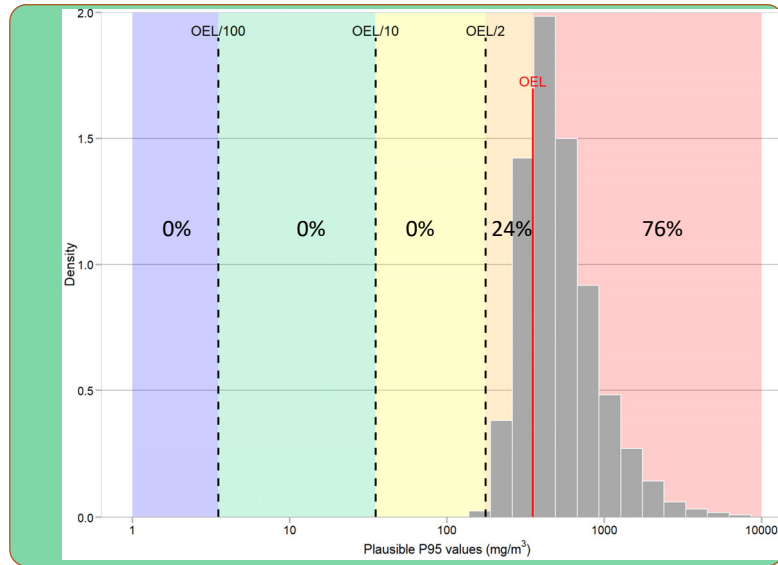
Traditional interpretation of the posterior : upper credible limits



Probabilistic interpretation of the posterior : ECC probabilities



Probabilistic interpretation of the posterior : ECC probabilities



IHSTAT_Bayes main output window

EXPOSTATS

AIHA

OEL

350

n Values

6

Start

Delete

Examples

PDF

IHSTAT-Bayes

Contact: John Doe Date: 2/19/2022

Department: XXX

SEG Name: Seg number xxx

Substance: Substance name

| | Estimate | UCL ₉₅ |
|----------------|----------|-------------------|
| Geometric Mean | 129 | 237 |
| GSD | 2.24 | 4.01 |

| | Estimate | UCL ₉₅ | UCL ₉₅ |
|--------------------------|----------|-------------------|-------------------|
| Percentile ₉₅ | 484 | 653 | 1620 |
| Exceedance Fraction (%) | 10.7 | 16.8 | 35.4 |
| Arithmetic Mean | 181 | 226 | 462 |

Quantile - Quantile Plot

| | Estimate | UCL ₉₅ (P ₉₅) | UCL ₉₅ (P ₉₅) |
|----------------------|----------|--------------------------------------|--------------------------------------|
| Percentile 95 (AIHA) | 484 | 653 | 1620 |
| Percentile 90 (User) | | | |

Exposure Profile

AIHA: Exposure Categories Distribution (95th perc)

29

IHSTAT_Bayes main output window

EXPOSTATS

AIHA

OEL

350

n Values

6

Start

Delete

Examples

IHSTAT-Bayes

Contact: John Doe Date: 2/19/2022

Department: XXX

SEG Name: Seg number xxx

Substance: Substance name

| | Estimate | UCL ₉₅ |
|----------------|----------|-------------------|
| Geometric Mean | 129 | 237 |
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| Percentile 90 (User) | | | |

Exposure Profile

AIHA: Exposure Categories Distribution (95th perc)

IHSTAT_Bayes main output window

EXPOSTATS

AIHA

OEL

350

n Values

6

Start

Delete

Examples

PDF

IHSTAT-Bayes

Contact: John Doe Date: 2/10/2022

Department: XXXX

SEG Name: Seg number xxx

Substance: Substance Name

Exposure Profile

Results

| | Estimate | UCL ₉₅ | UCL ₉₉ |
|----------------|----------|-------------------|-------------------|
| Geometric Mean | 129 | 237 | |
| GSD | 2.24 | 4.01 | |

| | Estimate | UCL ₉₅ | UCL ₉₉ |
|--------------------------|----------|-------------------|-------------------|
| Percentile ₉₅ | 484 | 653 | 1620 |
| Exceedance Fraction (%) | 10.7 | 16.8 | 35.4 |
| Arithmetic Mean | 181 | 226 | 462 |

Percentile 95 (AIHA)
 Percentile 90 (Isher)

Quantile - Quantile Plot

AIHA: Exposure Categories Distribution (95th perc)

| Exposure Category | Percentage |
|-------------------|------------|
| < 1% | 0.0% |
| [1-10%] | 0.0% |
| [10-50%] | 0.1% |
| [50-100%] | 23.5% |
| > OEL | 76.3% |

IHSTAT_Bayes main output window

EXPOSTATS

AIHA

OEL

350

n Values

6

Start

Delete

Examples

PDF

IHSTAT-Bayes

Contact: John Doe Date: 2/19/2022

Department: XXX

SEG Name: Seg number xxx

Substance: Substance name

Results

| | Estimate | UCL ₉₅ | UCL ₉₅ |
|----------------|----------|-------------------|-------------------|
| Geometric Mean | 129 | 237 | |
| GSD | 2.24 | 4.01 | |

| | Estimate | UCL ₉₅ | UCL ₉₅ |
|--------------------------|----------|-------------------|-------------------|
| Percentile ₉₅ | 484 | 653 | 1620 |
| Exceedance Fraction (%) | 10.7 | 16.8 | 35.4 |
| Arithmetic Mean | 181 | 226 | 462 |

Percentile 95 [AIHA]
 Percentile 90 [User]

Quantile - Quantile Plot

Exposure Profile

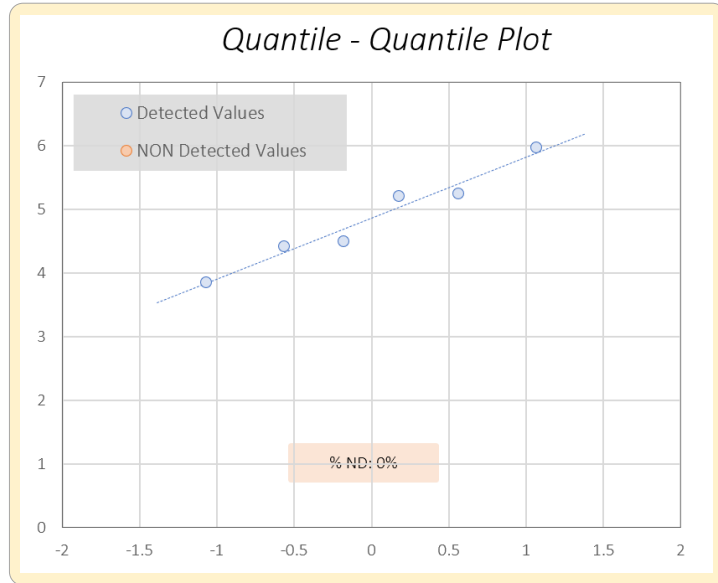
AIHA: Exposure Categories Distribution (95th perc)

| Exposure Category | Percentage |
|-------------------|------------|
| < 1% | 0.0% |
| [1-10%] | 0.0% |
| [10-50%] | 0.1% |
| [50-100%] | 23.5% |
| > OEL | 76.3% |

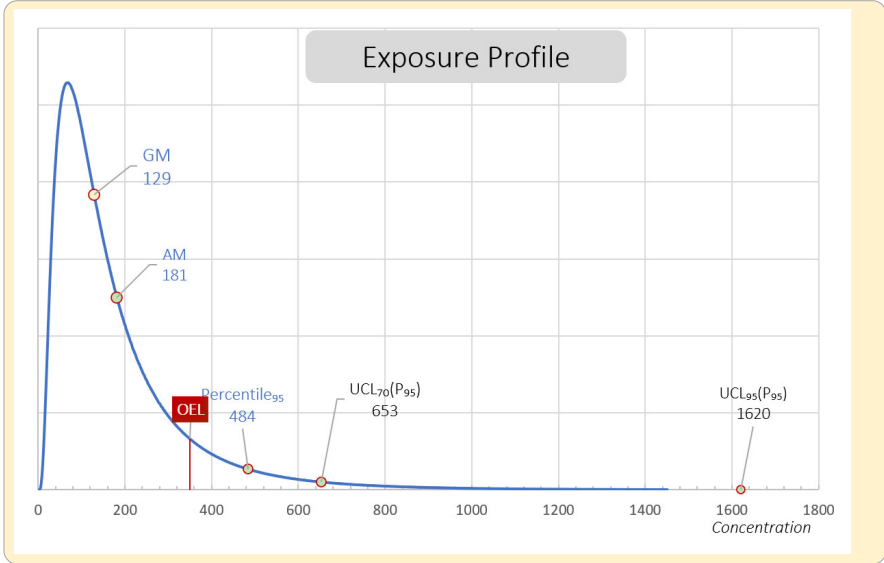
32

32

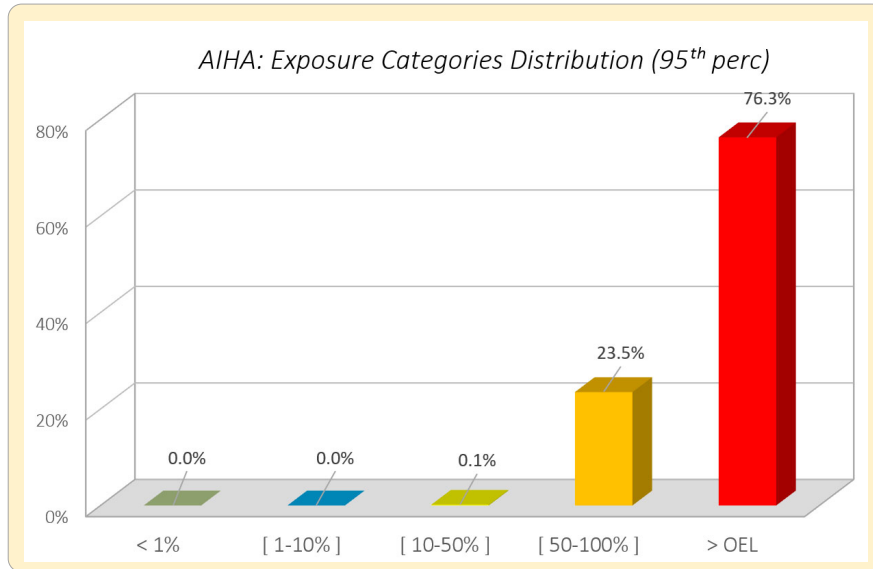
IHSTAT_Bayes quantile quantile plot



IHSTAT_Bayes Estimated exposure distribution



IHSTAT_Bayes AIHA exposure control categories



35

IHSTAT_Bayes salient features

Uses the familiar IHSTAT user interface

Essential results presented in a single screen

All calculations made with the same Bayesian engine
(non detects, probabilistic results)

Powered by University of Montreal : FREE

Thank you !

Daniel Drolet : EXCEL wizard

Daniel Margulius and Amine Mezzi

IHSTAT_Bayes C# programmers

EXAMPLES

KEY RESOURCES

Key References

- **Papers:**

- Jérôme Lavoué, Lawrence Joseph, Peter Knott, Hugh Davies, France Labrèche, Frédéric Clerc, Gautier Mater, Tracy Kirkham, “Expostats: A Bayesian Toolkit to Aid the Interpretation of Occupational Exposure Measurements”, *Annals of Work Exposures and Health*, Volume 63, Issue 3, April 2019, Pages 267–279

- **Reports**

- Lavoué, J., Joseph, L., Kirkham, T., Labrèche, F., Mater, G., Clerc, F. (2020) Towards a better interpretation of measurements of occupational exposure to chemicals in the workplace. Institut de recherche Robert-Sauvé en santé et en sécurité du travail, Montréal, QC.
<https://www.irsst.qc.ca/en/publications-tools/publication/i/101066/n/webexpo>

- **Introductory books on Bayesian statistics**

- Donovan, T.M. (2019) *Bayesian statistics for beginners, a step-by-step approach*. Oxford University Press. Oxford, United Kingdom.
- McElreath, R. (2020) *Statistical rethinking, A Bayesian course with examples in R and Stan*, second edition. CRC press. Boca Raton, FL.

- **Introductory videos on Bayesian statistics**

- https://www.youtube.com/watch?v=3OJEae7Qb_o&t=6s
- <https://www.youtube.com/watch?v=mAUwjSo5TJE&t=2s>



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