AIHA™

HEALTHIER WORKPLACES | A HEALTHIER WORLD

AIHA VIDEO SERIES: MAKING ACCURATE EXPOSURE RISK DECISIONS

Video 3C:

Introduction to IHSTAT_Bayes™

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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

Prerequisites

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**

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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.

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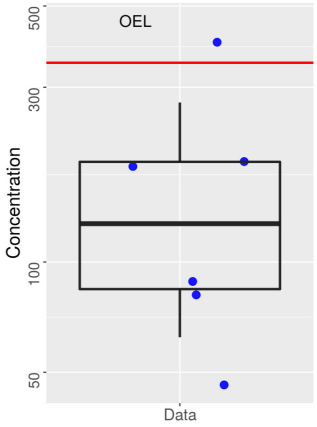
Running example Styrene in the fiberglass industry

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/m^3

Our sample : 190 , 47, 181 , 89.5 , 391 , 82.7 mg/m^3



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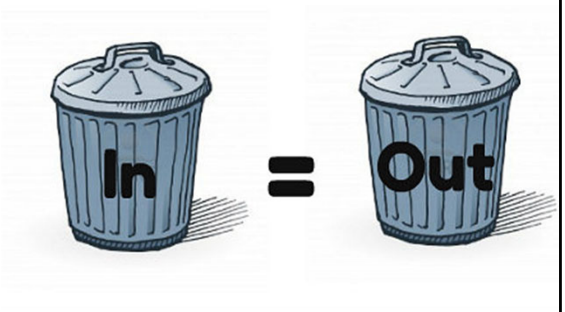
Theoretical setup for interpreting data with IHSTAT_Bayes

- 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



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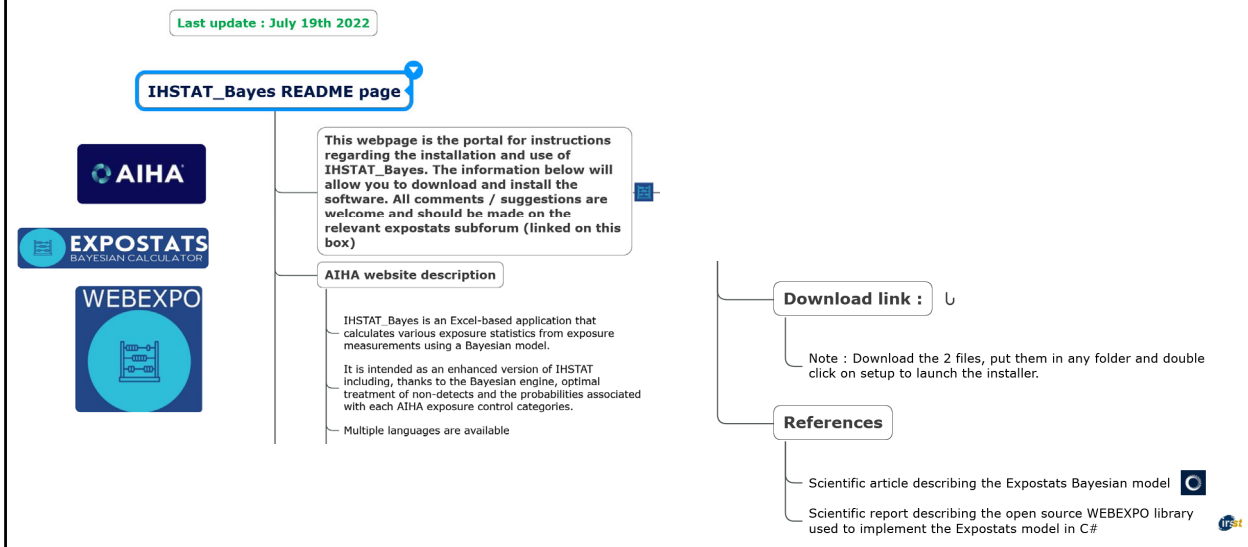
Practical setup for interpreting data with IHSTAT_Bayes



Data entry setup for interpreting data with IHSTAT_Bayes

Measurement results	**At least 3 detects recommended** Censored data (entered in the same unit): *left* censored (enter as as <x) *right* censored (enter as as >x) *interval* censored (enter as as [x_{lower}-x_{upper}])
Exposure limit	Same unit as measurement data
Decision statistics	Your choice of lognormal percentile (default 95th)

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

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

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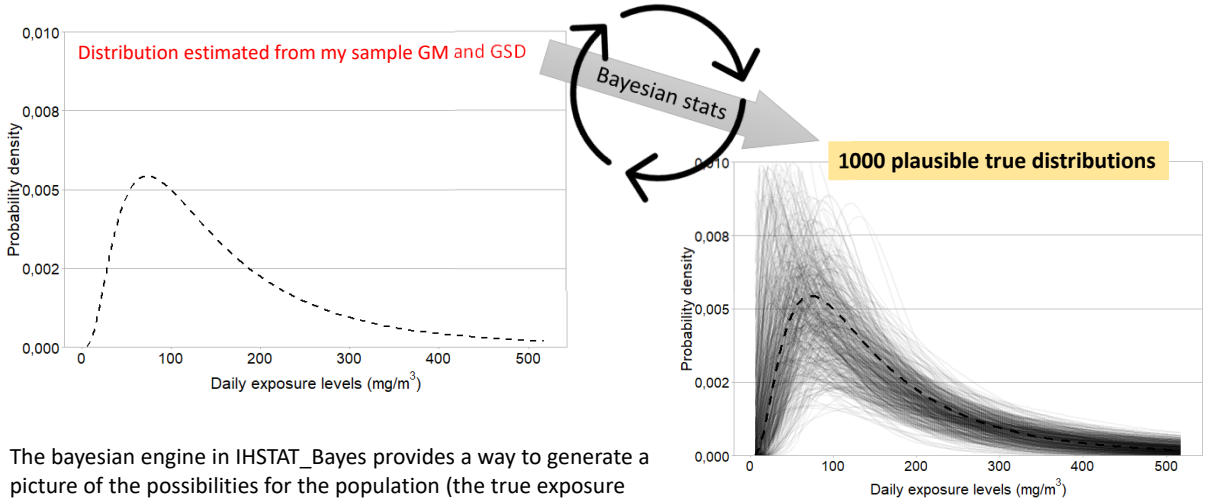
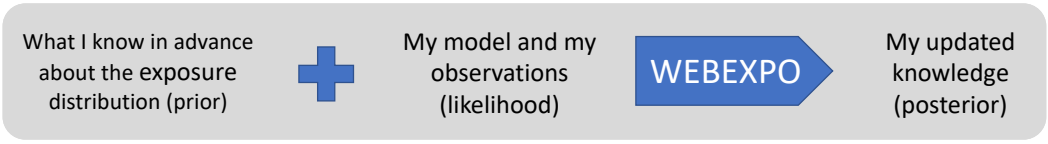
IHSTAT_Bayes: looking under the hood



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

For anyone to create their own vehicle

Webexpo is the engine

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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

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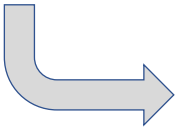
IHSTAT_Bayes : underlying bayesian model

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.

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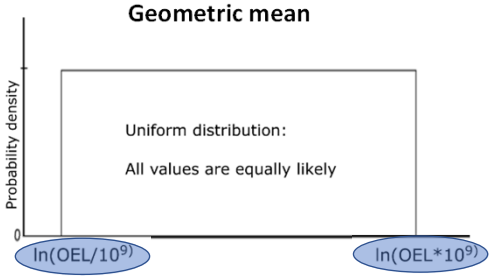
IHSTAT_Bayes : underlying bayesian model

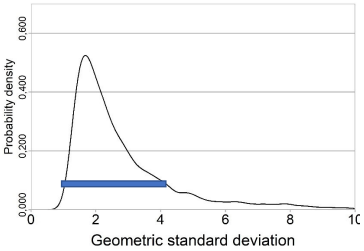
Prior distributions in IHSTAT_Bayes (same as EXPOSTATS)

Geometric mean



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

Geometric standard deviation



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.

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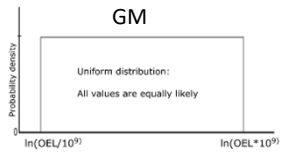
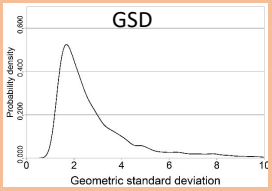
IHSTAT_Bayes : underlying bayesian model

PRIOR

GM



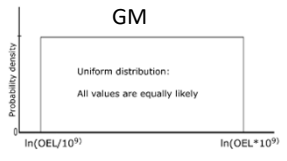
GSD



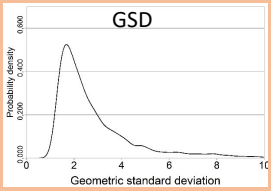
IHSTAT_Bayes : underlying bayesian model

PRIOR

GM



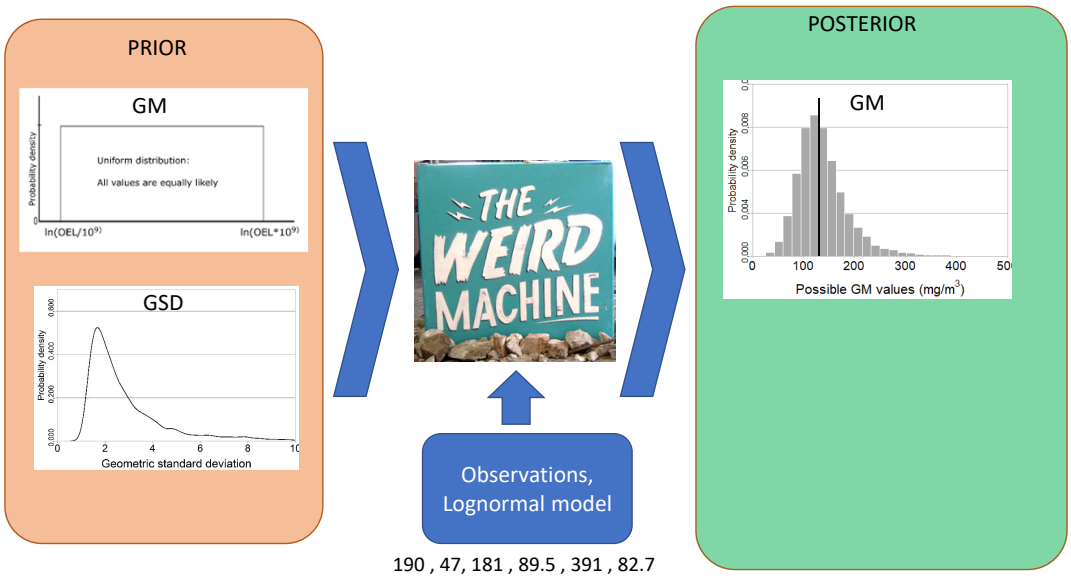
GSD



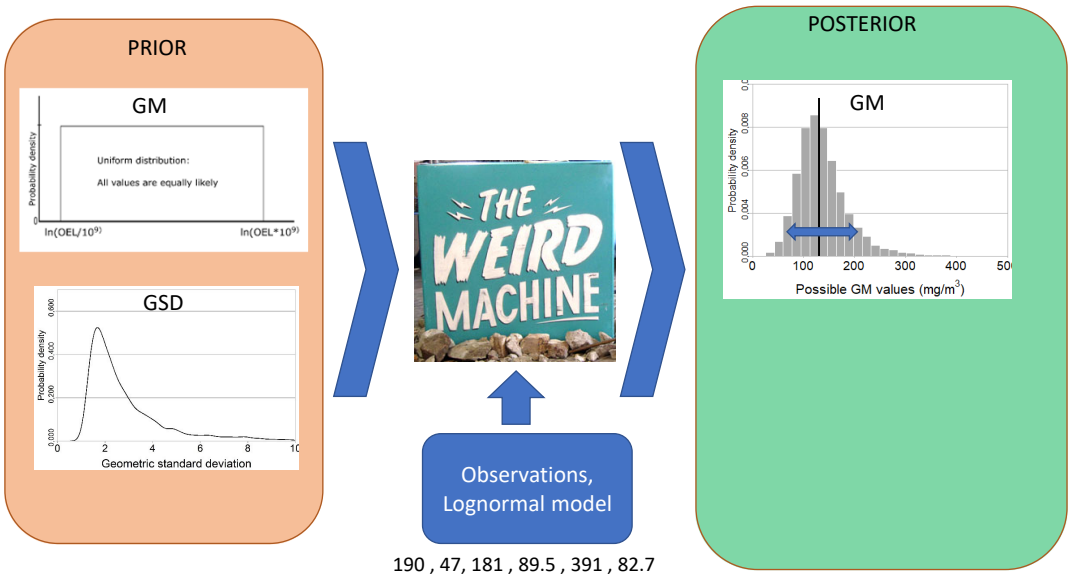
Observations, Lognormal model

190 , 47, 181 , 89.5 , 391 , 82.7

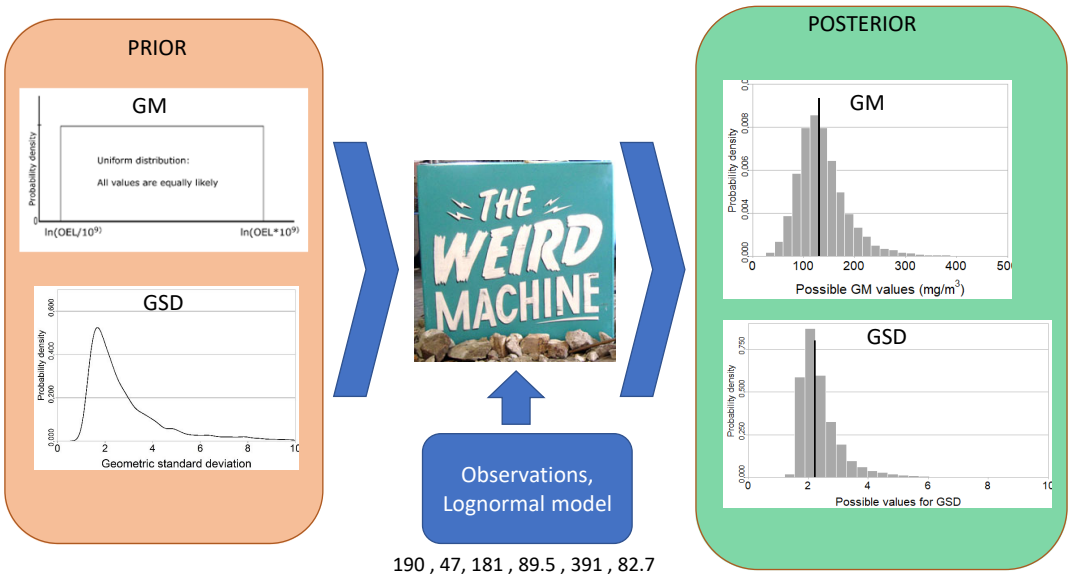
IHSTAT_Bayes : underlying bayesian model



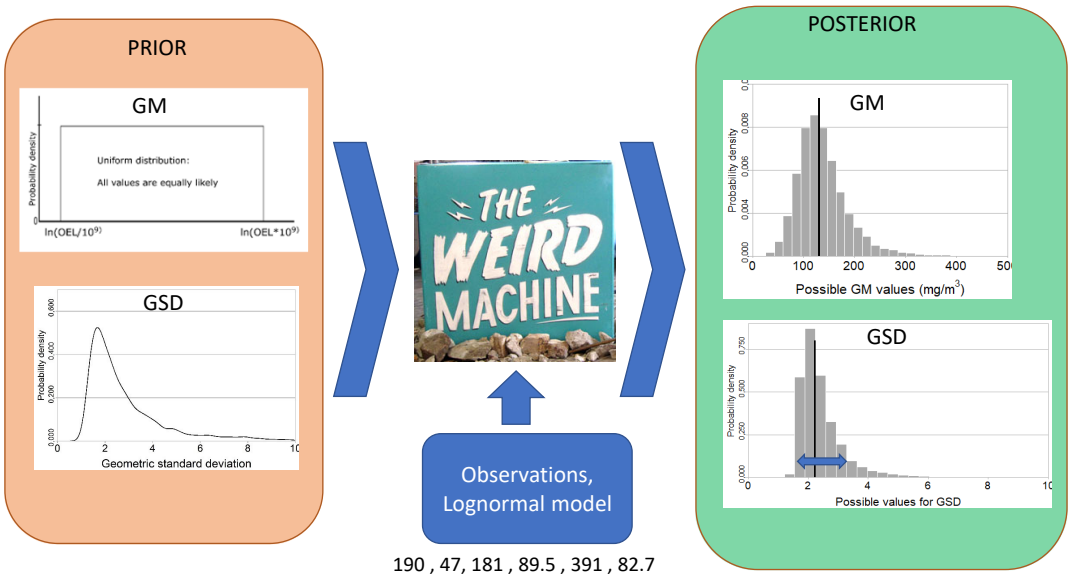
IHSTAT_Bayes : underlying bayesian model



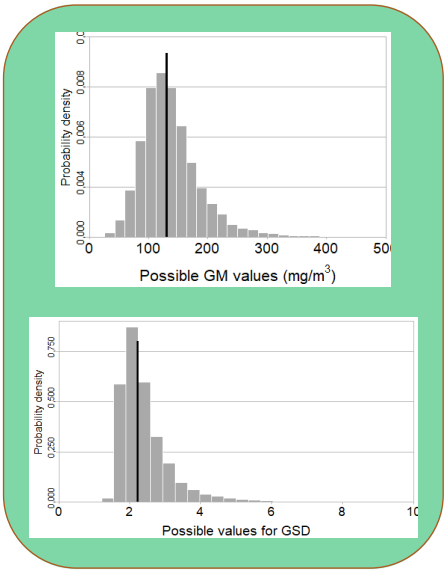
IHSTAT_Bayes : underlying bayesian model



IHSTAT_Bayes : underlying bayesian model



IHSTAT_Bayes : underlying bayesian model



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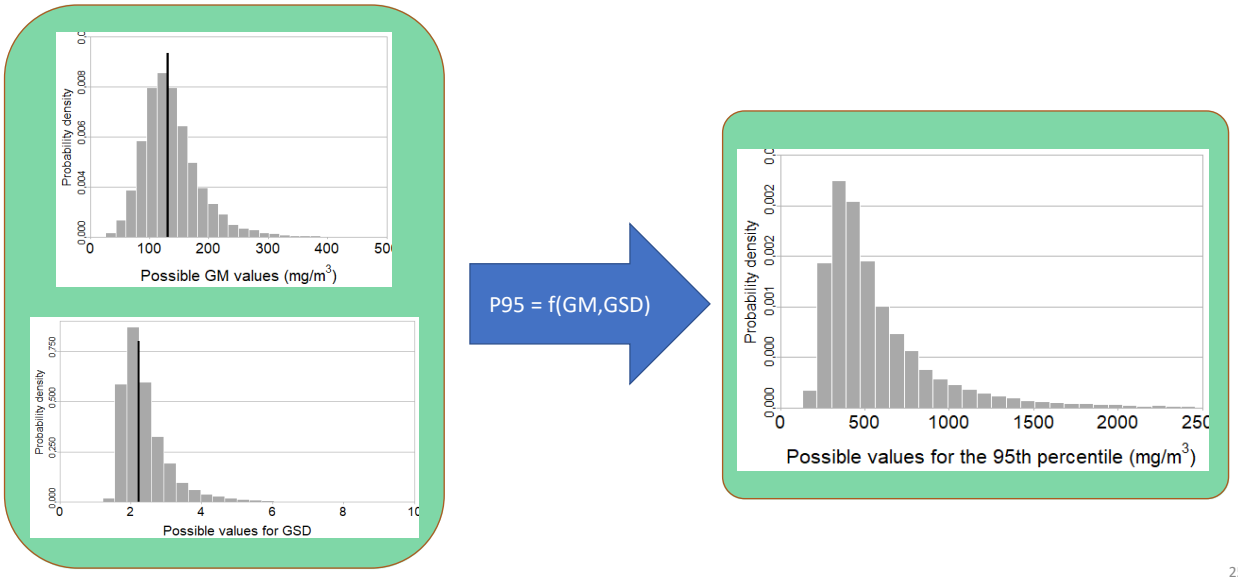
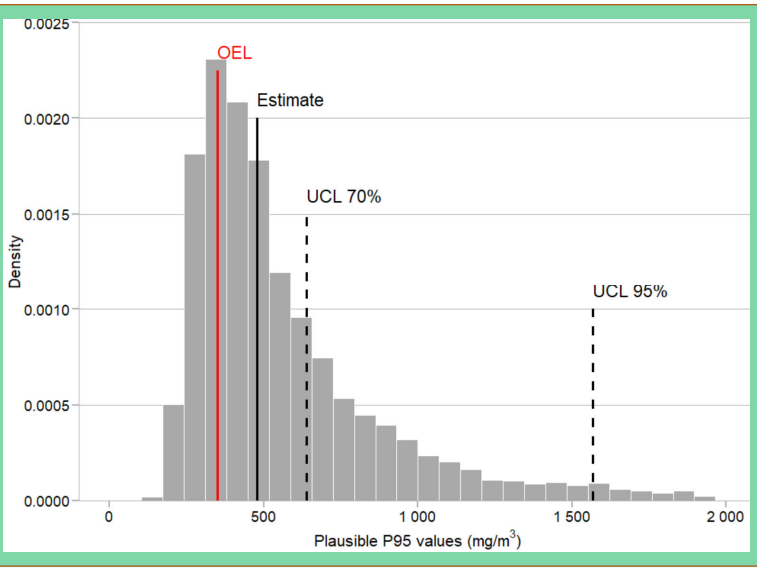


Traditional interpretation of the posterior : upper credible limits



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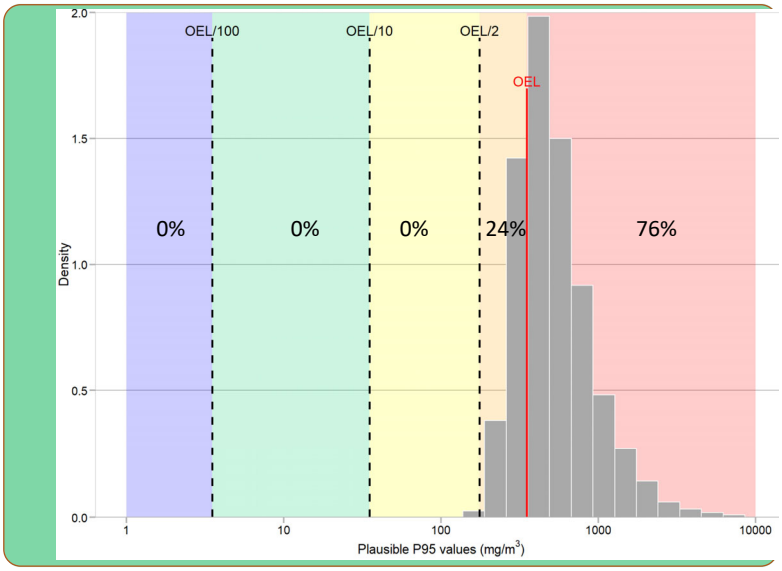
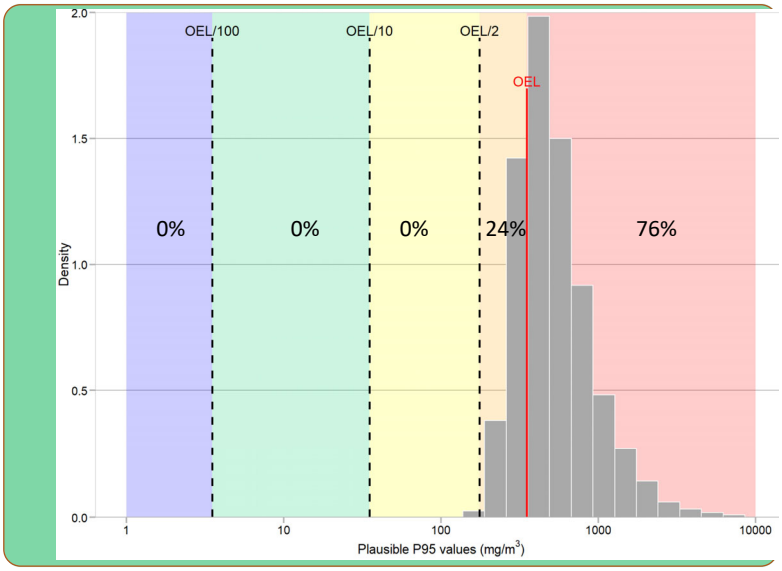
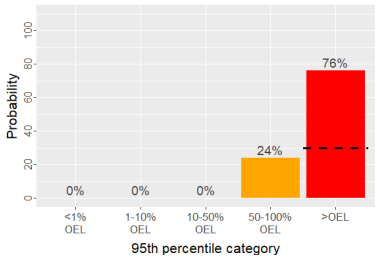
Probabilistic interpretation of the posterior : ECC probabilities



Probabilistic interpretation of the posterior : ECC probabilities





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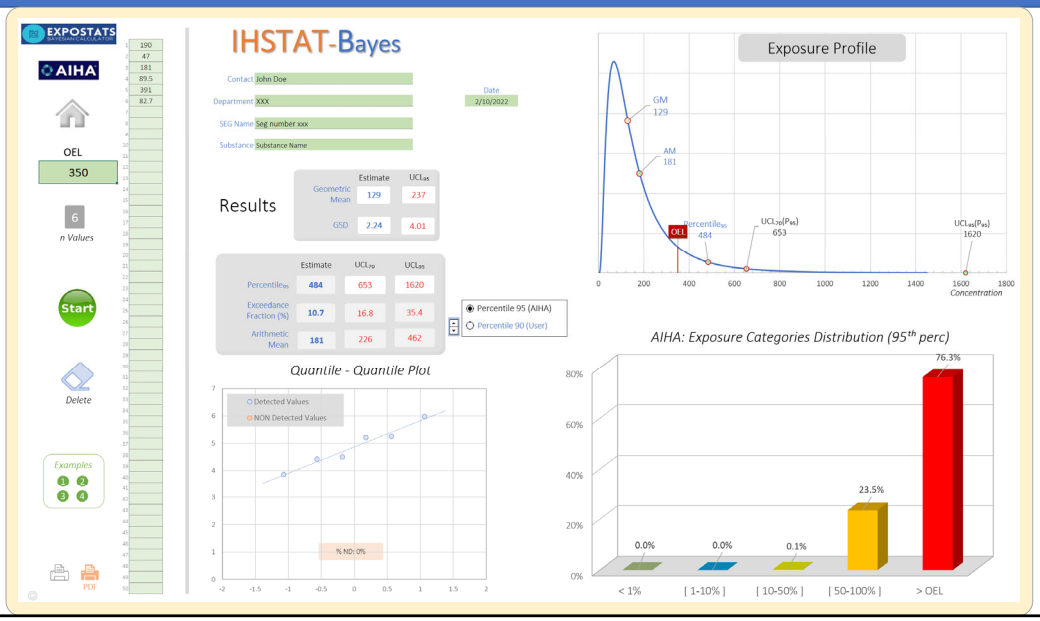
IHSTAT_Bayes main output window



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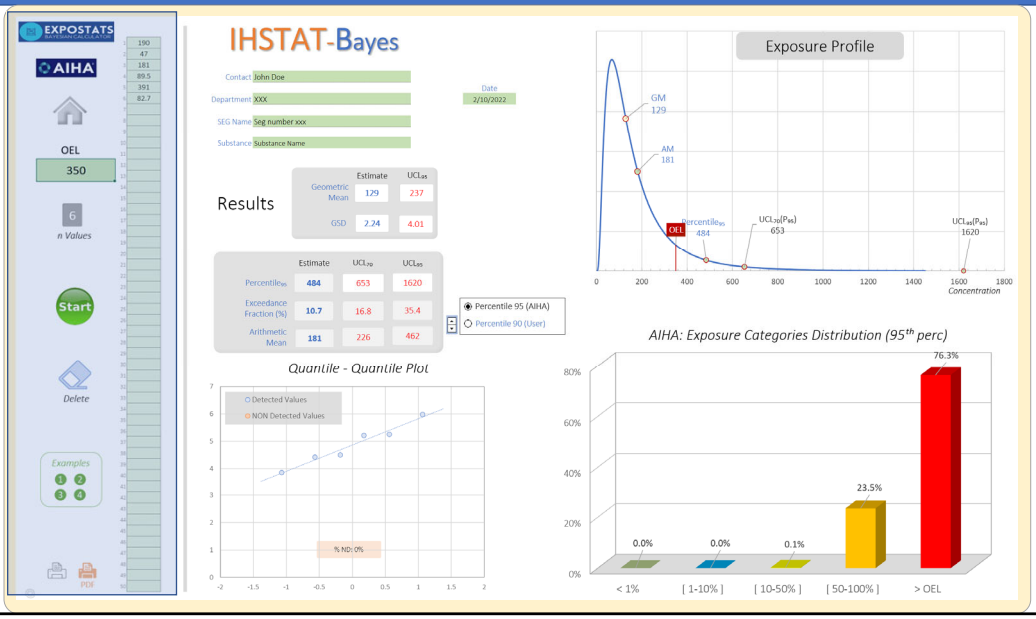
IHSTAT_Bayes main output window



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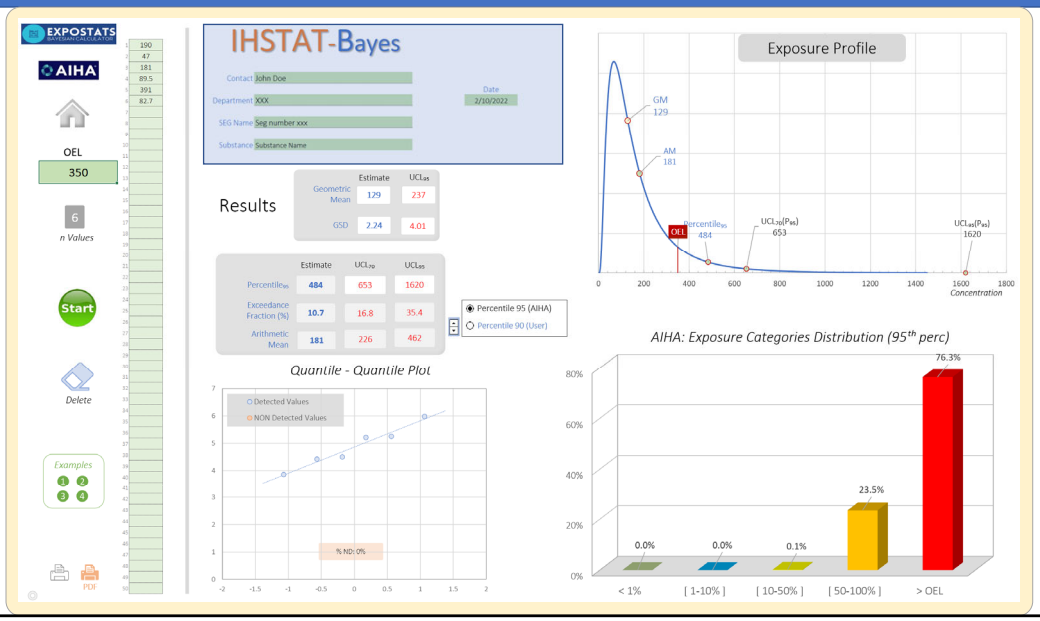
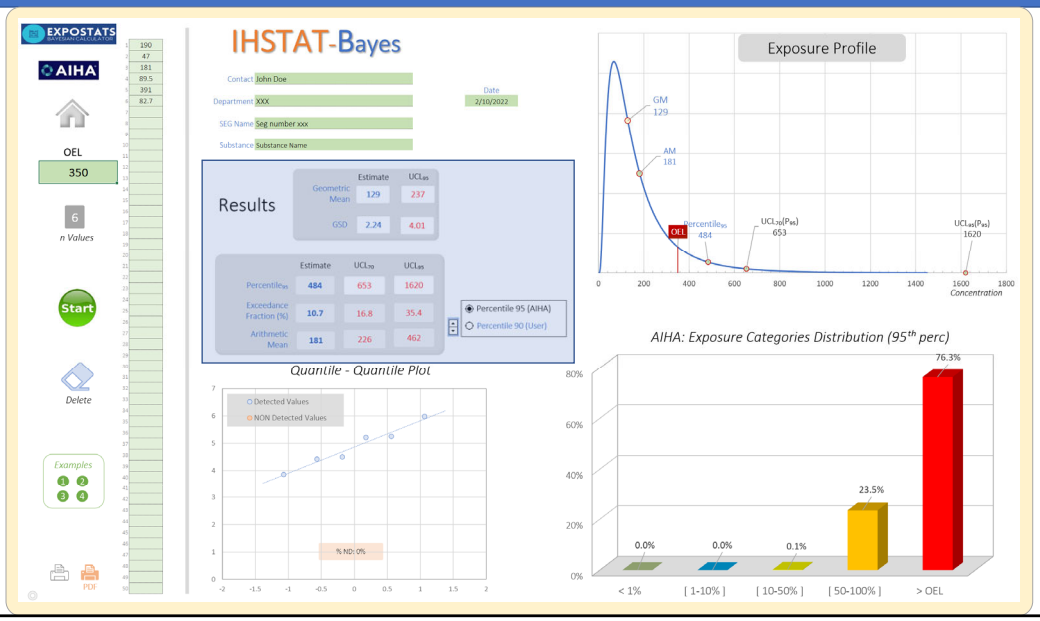
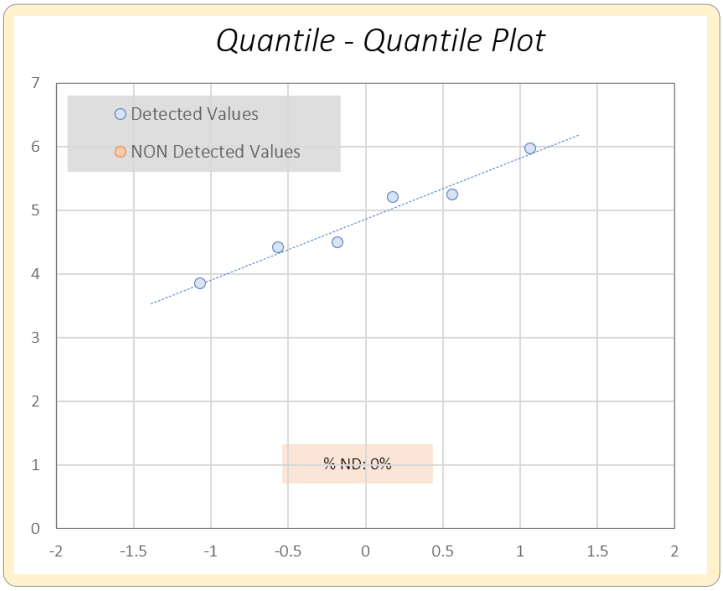
IHSTAT_Bayes main output window



IHSTAT_Bayes main output window



IHSTAT_Bayes quantile quantile plot



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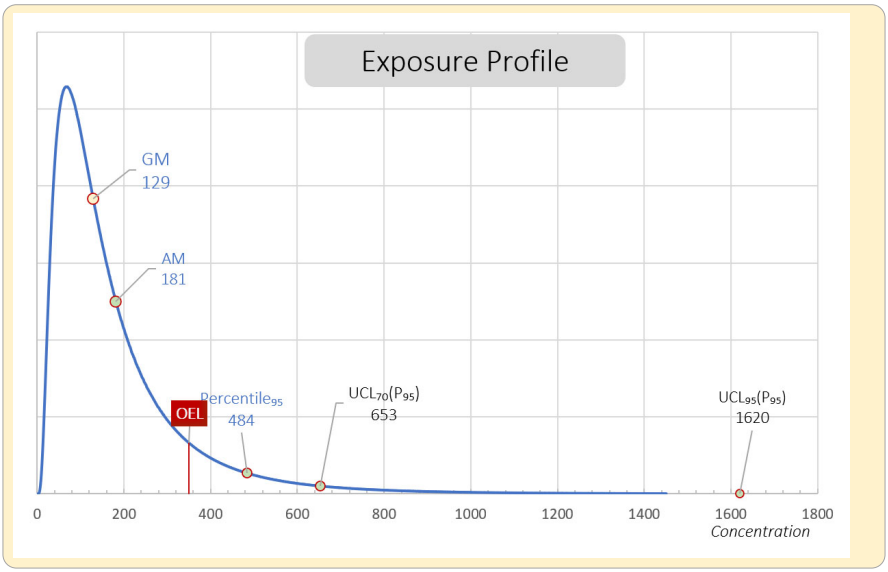
IHSTAT_Bayes Estimated exposure distribution



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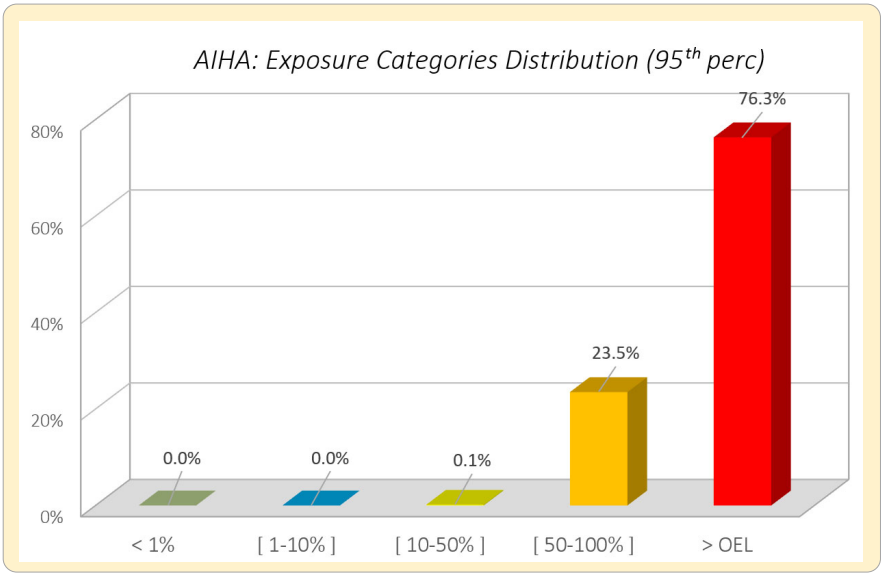
IHSTAT_Bayes AIHA exposure control categories



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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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